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Evaluation of growth and morphological traits of strawberry (Fragaria × ananassa Duch.) cultivars under field conditions

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Abstract

Seven cultivars of strawberry (Paros, Ventana, Queen Elisa, Camarosa, Selva, Mrak and Kurdistan) were evaluated under field conditions. Different growth and morphological parameters and plant yield were studied in this experiment. The greatest amount of plant yield was obtained from Queen Elisa cultivar and the lowest rate of plant yield was recorded by Selva cultivar. Plant yield was significantly correlated with flowers and fruits number, whereas the correlation between plant yield and fruit weight was low and not significant. Furthermore fruit weight was negatively correlated with flowers and fruits number indicating a reverse relationship between the number and the weight of fruits suggesting that strawberry plant yield is a function of fruits number rather than fruit size. In conclusion selection for high yielding strawberries based on high numbers of fruits and flowers can be more effective rather than fruit size or weight.

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Introduction

The cultivated strawberry (*Fragaria* × *ananassa* Duch.) is a unique plant species with highly valuable fruits rich in vitamin C, folic acid, potassium, manganese, anthocyanins, flavonoids, fiber and sugars (Perez *et al.,* 1997; Hannum, 2004; Ozuygur *et al.,* 2006; Da Silva Pinto *et al.,* 2007; Azzini *et al.,* 2010; Caulet *et al.,* 2013). Strawberry is grown throughout the world but the United States is the world's largest producer of strawberries, producing nearly 1.3 million metric tons in 2010 and accounting for 30 percent of the total world strawberry production (Morgan, 2012). In Iran the main region of strawberry cultivation is the province of Kurdistan, west of Iran. Strawberry is one of the most economical and important fruit products in Kurdistan province. This province ranks first in strawberry production among provinces in Iran (Anonymous, 2013). The most common cultivated strawberry genotype by the farmers in the region is Kurdistan local cultivar. The fruits of this variety are small in size with an excellent taste and odor but with a soft tissue resulting in a remarkable perishes during handling and processing. In the recent years different cultivars of strawberry with various productivity and different growth traits have been introduced in the region.

Evaluating the growth and agronomic traits of strawberry varieties and determining the interrelationships between the traits under different climatic conditions can be useful in breeding programs, therefore this study was aimed to assess the morphology, yield and growth characteristics of strawberry cultivars under climatic conditions of Sanandaj region, in Kurdistan.

Materials and methods

Field conditions

This experiment was carried out during 2011-2012 cropping season at the agricultural research station of Gerizeh, Sanandaj, west of Iran, located at 35˚ 16′ N and 47˚ 1′ E with an altitude of 1405 m above sea level. The long-term values of mean temperature and annual rainfall in this region are 13.35 ˚C and 471 mm respectively. Soil texture of experimental site was clay loam and the electrical conductivity and pH were 1.1 dS/m and 7.7 respectively. The field was fertilized before the planting of strawberry seedlings and the operation of seedlings planting was done in autumn 2010.

Experimental design and plant material

The arrangement of this experiment was a randomized complete block design with 3 replications and 7 treatments or strawberry cultivars including: Paros, Ventana, Queen Elisa, Camarosa, Selva, Mrak and Kurdistan local cultivar. The strawberry seedlings were obtained from Agricultural & Natural Resources Research Center of Kurdistan. The cultivars of Mrak and Selva are classified as day neutral (DN) whereas the other 5 genotypes are classified as short-day (SD) varieties. Each experimental plot contained two planting rows with 6 plants on each row and 40 cm space between plants.

Data collection and sampling

During the experiment different parameters including leaves number per plant, leaf area, petiole length, inflorescences number per plant, flowers number per inflorescence, fruits number per plant, fruit weight, fruit size and plant yield were determined.

Statistical analysis

The collected data of the experiment were subjected to analysis of variance (ANOVA) and means comparison operation was conducted by Duncan's Multiple Range Test (DMRT) at P≤0.05 level. The statistical calculations were performed by SAS and Minitab softwares.

Results and discussion

Results showed that differences among cultivars were significant regarding all measured parameters (Table 1).

Leaves number

The highest numbers of leaves per plant (29.6 & 26.8 leaves/plant) were recorded by Ventana and Kurdistan cultivars respectively and the lowest number of leaves per plant (13.3 & 14.4 leaves/plant) were obtained from Mrak and Selva cultivars (Table 2).

Table 1. Analysis of variance of different strawberry traits.

Source of variation	df	Mean squares								
		LN	LA	PL	INP	FNI	FrN	FrW	FrS	Y
Replication	2	0.96^{ns}	295.6^{ns}	3.42^{ns}	0.302^{ns}	0.753^{ns}	17.54^{ns}	3.39^{ns}	2.88^{ns}	0.1^{ns}
Cultivar	6	112.32^{**}	1571.7^{*}	14.97^{**}	8.173^{**}	3.076^{*}	378.16^{**}	9.17^{**}	13.14^{**}	26288.8^{**}
Error	12	4.61	390.2	1.85	0.871	0.784	11.97	1.66	2.24	0.7
CV (%)		10.3	26.7	8.1	15.5	22.3	15.2	14.5	16	0.5

ns, * and **: Non significant and significant at 5 and 1% levels of probability, respectively. LN: leaves number per plant, LA: leaf area, PL: petiole length, INP: inflorescences number per plant, FNI: flowers number per inflorescence, FrN: fruits number per plant, FrW: fruit weight, FrS: fruit size, Y: plant yield.

Leaf area

The cultivars Mrak and Camarosa were statistically superior than other cultivars in terms of leaf area wherease the lowest leaf areas were recorded by Kurdistan and Ventana cultivars (Table 2).

Petiole length

According to the analysis of variance results the cultivar effect on petiole length was significant. The highest and the lowest rates of petiole length were recorded by Camarosa and Paros cultivars respectively (Table 2).

Table 2. Means comparison of different traits in strawberry cultivars.

Cultivar	LN	LA (cm^2)	PL (cm)	INP	FNI	FrN	FrW (g)	FrS (cm^3)	Y (g/plant)
Paros	17.4de	61.1bc	12.5c	4.5c	3.8b	14.1c	9.53ab	9.83ab	111.9f
Ventana	29.6a	52.7c	16.2b	6.4b	3.3b	18.0c	10.6a	11.7a	163.0c
Queen Elisa	23.0bc	79.4abc	17.9ab	7.7ab	6.2a	43.9a	9.23ab	10.2a	378.6a
Camarosa	20.9cd	97.9ab	19.9a	6.1bc	3.1b	16.6c	10.5a	11.2a	150.3d
Selva	14.4ef	78.5abc	16.8b	4.4c	4.6b	16.1c	7.60bc	7.17bc	103.2g
Mrak	13.3f	104.8a	16.5b	4.7c	4.4b	17.8c	9.40ab	9.75ab	139.9e
Kurdistan	26.8ab	43.1c	17.6ab	8.6a	4.2b	33.0b	5.67c	5.92c	170.3b

Different letters in each column indicate significant differences at $P \leq 0.05$ according to Duncan's multiple range test. LN: leaves number per plant, LA: leaf area, PL: petiole length, INP: inflorescences number per plant, FNI: flowers number per inflorescence, FrN: fruits number per plant, FrW: fruit weight, FrS: fruit size, Y: plant yield.

Inflorescences number

Comparison of inflorescences mean number showed that the greatest numbers of inflorescence per plant were obtained from Kurdistan and Queen Elisa cultivars (Table 2).

Flowers number per inflorescence

Results of means comparison calculations indicated that the maximum number of produced flowers per inflorescence was recorded by Queen Elisa cultivar and other cultivars with no significant difference were placed in a single statistical group (Table 2).

Fruits number

Mean comparison of fruits number per plant revealed that Queen Elisa cultivar produced the highest number of fruits per plant as compared with other cultivars (Table 2).

Average fruit weight and size

The lowest amounts of fruit weight and size (5.67 g and 5.92 cm^3 respectively) were recorded by Kurdistan cultivar (Table 2).

Plant yield

The greatest amount of yield (378.6 g/plant) was produced from Queen Elisa cultivar which was significantly superior than other genotypes and the lowest yield was recorded by Selva cultivar significantly different from other cultivars (Table 2).

Correlation coefficient analysis

The calculated correlation coefficients among the studied traits are shown in Table 3. The plant yield was significantly and positively correlated with inflorescences number/plant, flowers number/inflorescence and fruits number/plant. Ukalska *et al.,* (2006) similarly reported a strong and positive correlation between strawberry yield and flowers number/inflorescence. On the other hand the correlation coefficients between plant yield and some traits such as fruit weight and fruit size were not significant (Table 3).

Table 3. Correlation coefficients among different traits of strawberry cultivars.

	LN	LA	PL	INP	FNI	FrN	FrW	FrS	Y
LN	1.00								
LA	-0.47*	1.00							
PL	0.19ns	0.35ns	1.00						
INP	0.62**	-0.43ns	0.45*	1.00					
FNI	-0.06ns	0.17ns	-0.05ns	-0.01ns	1.00				
FrN	0.39ns	-0.17ns	0.26ns	0.70**	0.69**	1.00			
FrW	-0.03ns	0.31ns	0.06ns	-0.25ns	-0.44*	-0.42ns	1.00		
FrS	0.10ns	0.18ns	0.07ns	-0.12ns	-0.40ns	-0.30ns	0.97**	1.00	
Y	0.35ns	0.02ns	0.30ns	0.56**	0.60**	0.87**	0.05ns	0.16ns	1.00

ns, * and **: Non significant and significant at 5 and 1% levels of probability, respectively. LN: leaves number per plant, LA: leaf area, PL: petiole length, INP: inflorescences number per plant, FNI: flowers number per inflorescence, FrN: fruits number per plant, FrW: fruit weight, FrS: fruit size, Y: plant yield.

The significance of correlation between yield and traits related to reproductive organs number including the number of inflorescences, flowers and fruits and vice versa the nonsignificance of correlation between yield and fruit weight and size, indicated that the influence of fruit number on plant yield was more pronounced as compared with the influence of fruit size. Similarly Acuna-Maldonado and Pritts (2008) declared that strawberry yield was a function of fruits number rather than size. Furthermore fruit weight was negatively correlated with inflorescences number/plant and fruits number/plant (Table 3) suggesting a reverse relationship between the number and the size of fruits reffered to the competition among fruits for assimilates during fruit filling period. Gawronski and Hortynski (2011) also found a negative correlation between the number of flowers per inflorescence and fruit weight. They concluded that search for genotypes with high numbers of inflorescences and fruits per plant may be more effective because of high correlation of these traits with fruit yield. According to our results the selection

of genotypes based on producing high numbers of flowers and fruits per plant is recommended to achieve a high plant yield of strawberries.

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