

JAFES

Vol. 71, No 2

December 2017

ISSN 2545-4315

**JOURNAL OF
AGRICULTURAL, FOOD
AND ENVIRONMENTAL
SCIENCES**

**International Scientific
Journal**

Special Issue: Proceedings

**3rd International Symposium for Agriculture and Food
18-20 October 2017, Ohrid, Republic of Macedonia**

INTERNATIONAL SCIENTIFIC JOURNAL
JOURNAL OF AGRICULTURAL, FOOD AND ENVIRONMENTAL SCIENCES

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The JAFES is an International scientific peer-reviewed Open Access Journal published twice per year
JAFES On line (e-ISSN 2545-4315) offers free access to all articles at <http://www.fznh.ukim.edu.mk/jafes/>

Published by: Издава:
"Ss. Cyril and Methodius" University in Skopje, Универзитет „Св. Кирил и Методиј“ во Скопје,
Faculty of Agricultural Sciences and Food-Skopje Факултет за земјоделски науки и храна - Скопје

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JOURNAL OF AGRICULTURAL, FOOD AND ENVIRONMENTAL SCIENCES

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**THE AUTHORS ARE RESPONSIBLE FOR THE CONTENT AND FOR THE LANGUAGE OF THEIR CONTRIBUTION*

CHARACTERISTICS OF FRUITING SHOOTS OF SOME PEACH AND NECTARINE CULTIVARS

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Abstract

Morphological characteristics of fruiting shoots: length, diameter, internode length, length of the basal part without flower buds, number of flower buds (per shoot, node and 1 m of shoot length) were studied in 12 peach and 12 nectarine cultivars. The study was conducted at the Experimental farm “Radmilovac” of the Faculty of Agriculture in Belgrade during the two-year period (2016-2017). Control cultivar for peaches was ‘Redhaven’, and for nectarines ‘Stark Redgold’. For all studied traits statistically significant differences between cultivars were found. The average length of shoots varied from 62.4 to 76.8 cm, diameter from 5.9 to 8.0 mm, and internode length from 2.45 to 3.00 cm. The length of basal part of a shoot without flower buds was on average lower in nectarines (3.9 cm) than in peaches (9.1 cm). Peach cultivar ‘Tardibelle’ is characterized by the longest basal part of a shoot without flower buds (22.2 cm). All studied peach cultivars are characterized by lower flower bud density compared to control (‘Redhaven’). In nectarines, most of the studied cultivars had flower bud density similar to control (‘Stark Redgold’). Cultivars with higher flower bud density such as peaches: ‘Redhaven’, ‘Maria Marta’, ‘Autumn Glo’, and nectarines ‘Rita Star’, ‘Maria Carla’, ‘Orion’ require severe pruning in order to obtain better fruit size. On the other hand, cultivars with lower flower bud density e.g. ‘Tardibelle’, ‘Flavorcrest’, ‘Royal Glory’, ‘Bolero’, ‘Maria Lucia’ should be pruned slightly in order to obtain higher yield.

Keywords: *Prunus persica*, flower bud density, internode length, pruning.

Introduction

Achieving high yield and good quality of peach fruits requires the regular application of cultural practices. Among them, one of the most important is the pruning. In order to perform the pruning properly, it is necessary to know the characteristics of the fruiting shoots of different cultivars. The main fruiting shoots of peach are long shoots. They are also called „mixed“ shoots because on the nodes they have both leaf and flower buds. These shoots are located on the periphery of the crown and give the best quality fruits. The length of shoots and arrangement of flower buds are cultivar-specific traits (Mratinić, 2012). Quality of peach shoots is affected by training system, planting density and rootstock (Loreti et al., 1991). Shoot quality is especially important in high density plantings because of the competition between vegetative and reproductive activity. Perez-González (1993) states that the flower bud density of peach can be expressed as a number of buds per node or per 1 m length of the shoot. The former is the better indicator because it allows the separation of standard genotypes from those with short internodes. The density of flower buds is strongly correlated with the density of flowers and the density of the fruits. Okie and Werner (1996) found that the density of flower buds is under the stronger influence of genetic factors than the environmental factors. In the conditions of the continental climate it is better to choose cultivars with a higher density of flower buds. This increases the survival of generative organs due to the frost occurrence and ensures higher yields. Fournier et al. (1998) studied the arrangement of flower buds on peach shoots of different length. They found that, in the long shoots, in the middle part there is a zone in which usually two flower buds are formed. Above and below it are the zones in which one flower bud is formed, while the flower buds are not formed at the base and the top of the shoot. Milatović and Đurović (2010) studied morphological characteristics of fruiting shoots in 15 peach and 10 nectarine cultivars. For all traits statistically significant differences between the cultivars were

found. Some cultivars, such as 'Suncrest', 'Pegaso' and 'Carolina Belle' were characterized by high flower bud density, while other cultivars like 'Summerset', 'Sunprince' and 'Goldcrest' had low flower bud density. The study of the fruiting shoot characteristics of peach and nectarine is important because it can point to the potential productivity of cultivars. This research can also contribute to determining the intensity of the pruning in certain cultivars.

Material and methods

The study was conducted in the peach collection orchard at the Experimental farm "Radmilovac" of the Faculty of Agriculture in Belgrade during the two-year period (2016-2017). The training system is Sloping Leader, a new original system with high-density planting (Zec et al., 2013). This system has a central leader that is bent and follows the row direction at the angle of 25°. The rootstocks (vineyard peach seedlings) were planted in the orchard in June 2010, at a spacing of 3.5 m × 1 m (2800 trees ha⁻¹). The seedlings were budded at a height of 50 cm in September 2010. The study included 12 cultivars of peach and 12 cultivars of nectarine. Control cultivar for peaches was 'Redhaven', and for nectarines 'Stark Redgold'. All cultivars are represented by seven trees. Shoots were taken for examination in the spring, before flowering. Of all cultivars, 20 long („mixed“) fruiting shoots were taken. The length of the shoots was measured by a measuring tape and the diameter was measured by a calliper at the base of the shoot (1 cm from the basal end). The number of flower buds was recorded on each node. The density of flower buds has been calculated per node (Werner et al., 1988) and per 1 m of a shoot length (Lombard et al., 1988). The coefficient of variation (CV) was calculated for the studied traits. The results were analyzed using the two-factorial analysis of variance. The significance of differences between means was determined using the LSD test for probabilities of 0.05 and 0.01.

Results and discussion

The length of shoots in peach cultivars was 68.0 cm in average, with a variation from 62.4 cm in the 'Maria Marta' cultivar to 76.8 cm in the 'Redhaven' cultivar (Table 1). Nectarine cultivars had a slightly smaller average length of shoots of 66.9 cm, which varied from 63.9 cm ('Maria Carla') to 70.2 cm ('Max 7'). Differences in the length of shoots between cultivars were statistically significant. The values obtained in our study were higher than the results of Mitreski (1984), who reported an average length of 53.2 cm for 42 cultivars of peach and nectarine. These differences can be due to different age of trees, training system, and pruning intensity. Our results on the length of shoots are in line with the results of Klenyán et al. (1998), who reported an average length of shoots of 57.6 – 73.8 cm in 36 cultivars of nectarine, as well as Milatović and Đurović (2010), who reported the average length of shoots of 53.7 – 78.3 cm in 25 cultivars of peach and nectarine. The diameter of the shoots varied in the interval from 5.9 mm ('Sirio') to 8.0 mm ('Flavorcrest') and in nectarines it was somewhat smaller than in peaches. The obtained values were higher than the results of Mitreski (1984), and similar to the results of Milatović and Đurović (2010). The average length of the internode ranged from 2.45 cm in the 'Bolero' cultivar up to 3.00 cm in the 'Max 7' cultivar. This parameter showed the lowest variability (CV = 15.0%). The length and the diameter of the shoots also showed a relatively small variation (18.1% and 19.5% respectively). At the base of peach fruiting shoots there is a shorter or longer part in which flower buds are not formed, but only incompletely differentiated leaf buds (Fournier et al., 1998). The shoot length without flower buds varied from 1.3 cm in the 'Pegaso' cultivar to 22.2 cm in the 'Tardibelle' cultivar (Table 2). Nectarines had a significantly smaller share of the shoot length without flower buds (6% of the total length in average) compared to peaches (13% in average). The largest share was found in the 'Tardibelle' cultivar (35%). Based on the classification of peach cultivars into three groups according to the arrangement of flower buds along the shoot, this cultivar belongs to the group "B", which has flower buds at 2/3 at the top of the shoot (Veličković, 2004). All other studied cultivars belong to the group "A" which has flower buds almost along the entire length of the shoot.

The average number of flower buds per shoot in peach cultivars ranged from 14.3 ('Tardibelle') to 29.8 ('Autumn Glo'). All studied peach cultivars are characterized by lower flower bud density compared to control ('Redhaven'). In nectarines, the average number of flower buds per shoot was lowest in the 'Maria Lucia' cultivar (22.3), and highest in the 'Rita Star' cultivar (39.1). Most of the studied cultivars had the flower bud density similar to control ('Stark Redgold'). The number of flower buds per shoot was about two times lower in 2016 compared to 2017. The reasons for this can be the absence of summer pruning and strong attack of *Monilinia laxa* in 2015.

Table 1. Characteristics of fruiting shoots of peach and nectarine cultivars

Cultivar	Length (cm)			Diameter (mm)			Length of internode (cm)		
	2016	2017	Mx	2016	2017	Mx	2016	2017	Mx
Peach cultivars									
Autumn Glo	72.4	68.1	70.3	7.3	7.5	7.4	2.75	2.35	2.55
Bolero	59.9	70.4	65.2	6.9	7.9	7.4	2.50	2.39	2.45
Flavorcrest	67.8	74.5	71.2	7.1	8.8	8.0	2.69	2.30	2.50
Maja	73.4	65.1	69.3	6.3	6.5	6.4	3.02	2.51	2.77
Maria Marta	66.5	58.3	62.4	6.1	6.1	6.1	2.70	2.23	2.47
Redhaven	71.8	81.8	76.8	6.7	8.2	7.5	2.90	2.60	2.75
Rich Lady	63.7	66.9	65.3	5.5	7.8	6.7	2.64	2.46	2.55
Romestar	66.9	59.8	63.4	6.2	8.5	7.4	2.93	2.30	2.62
Royal Gem	60.9	71.3	66.1	6.6	8.1	7.4	2.67	2.27	2.47
Royal Glory	65.2	83.0	74.1	5.3	7.2	6.3	2.61	2.54	2.58
Spring Red	64.8	71.2	68.0	6.6	9.0	7.8	2.67	2.29	2.48
Tardibelle	68.2	60.0	64.1	7.1	7.4	7.3	3.45	2.43	2.94
Average	66.8	69.2	68.0	6.5	7.8	7.1	2.81	2.42	2.62
Nectarine cultivars									
Caldesi 2000	67.6	68.1	67.9	6.3	8.8	7.6	2.74	2.51	2.63
Caldesi 85	68.4	60.4	64.4	6.6	6.1	6.4	3.12	2.34	2.73
Maria Carla	66.4	61.4	63.9	5.7	7.4	6.6	2.63	2.39	2.51
Maria Lucia	64.9	75.1	70.0	6.7	8.5	7.6	3.07	2.63	2.85
Max 7	73.8	66.5	70.2	6.9	5.7	6.3	3.38	2.61	3.00
Morsiani 51	60.1	72.0	66.1	5.9	8.6	7.3	2.54	2.68	2.61
Orion	64.6	65.4	65.0	6.1	6.7	6.4	2.57	2.53	2.55
Rita Star	63.2	71.9	67.6	6.7	8.1	7.4	2.38	2.59	2.49
Sirio	71.9	64.4	68.2	6.6	5.2	5.9	3.35	2.61	2.98
Stark Redgold	72.0	60.7	66.4	6.6	7.2	6.9	3.41	2.42	2.92
Venus	63.0	71.5	67.3	6.4	8.0	7.2	2.57	2.78	2.68
Vinčanka	68.0	61.9	65.0	7.2	7.5	7.4	3.12	2.48	2.80
Average	67.2	66.6	66.9	6.4	7.3	6.9	2.79	2.39	2.59
CV (%)			18.1			19.5			15.0
LSD 0.05			5.2			0.5			0.15
LSD 0.01			6.8			0.7			0.19

The number of flower buds per node varied from 0.64 in the 'Tardibelle' cultivar to 1.29 in 'Redhaven' and 'Rita Star' cultivars. This parameter had higher average value in nectarine cultivars compared to peach cultivars. Cultivars in which this parameter has values of about 1.0 or more can be characterized as potentially very productive, while cultivars with lower values (below 0.8) have a potentially lower productivity. The values obtained for the number of flower buds per node are consistent with the results of Werner et al. (1988) who studied this parameter in 36 cultivars of peach and nectarine in the United States and obtained values in the range from 0.35 to 1.59. They concluded that cultivars originating from the California breeding program had lower values of this indicator than cultivars originating from the eastern part of the United States. This indicates that in the eastern part of the United States, greater attention is paid to the flower bud density in the peach

breeding because of the higher risk of frost. Our results of the number of flower buds by node are approximate to those obtained by Klenyán et al. (1998) for nectarine cultivars in the conditions of Hungary (0.33 – 1.50), as well as Milatović and Đurović in the Belgrade area (0.41 – 1.28). The number of flower buds per 1 m of the shoot length is an important indicator of the potential yield of stone fruits (Pérez-González, 1993; Thurzó et al., 2006; Milatović et al., 2014; Milatović et al., 2015). The average number of flower buds per 1 m varied from 23.4 in the 'Tardibelle' cultivar to 51.5 in the 'Rita Star' cultivar. Our results are in line with those obtained by Szabó et al. (1998) that the number of flower buds per 1 m in peach cultivars was 22 – 65, and for nectarine cultivars 25 – 110. The same authors for the conditions of Hungary recommend the cultivars with higher density of flower buds, given the frequent exposure of peach trees to frost damage. In this study, a slightly smaller number of flower buds per 1 m of shoot length was obtained compared to the results of Milatović and Đurović (2010), where the average number for peach cultivars was 44, and for nectarine cultivars 46. The reason for this is a smaller number of flower buds in 2016 year. The largest variability of the tested traits was found in the length of the shoots without flower buds (CV = 94.8%). Also, high variability was found in the number of flower buds per shoot (CV = 42.4%).

Table 2. Distribution and number of flower buds on fruiting shoots of peach and nectarine cultivars

Cultivar	Shoot length without flower buds (cm)			No. of flower buds per shoot			No. of flower buds per	
	2016	2017	Mx	2016	2017	Mx	Node	1 m shoot length
Peach cultivars								
Autumn Glo	10.9	7.9	9.4	23.3	36.2	29.8	1.07	42.7
Bolero	9.2	4.2	6.7	16.0	24.3	20.2	0.75	30.6
Flavorcrest	19.6	6.5	13.1	11.1	31.1	21.1	0.73	29.1
Maja	11.1	5.2	8.2	15.5	27.2	21.4	0.85	31.4
Maria Marta	4.5	3.6	4.1	23.0	32.2	27.6	1.08	44.9
Redhaven	4.3	3.7	4.0	26.3	46.5	36.4	1.29	46.7
Rich Lady	12.5	1.9	7.2	17.0	37.3	27.2	1.06	41.2
Romestar	15.0	5.6	10.3	10.6	32.7	21.7	0.86	35.3
Royal Gem	11.2	5.3	8.3	11.6	31.8	21.7	0.80	31.8
Royal Glory	12.1	13.9	13.0	19.5	24.7	22.1	0.77	29.8
Spring Red	4.8	1.6	3.2	12.4	38.3	25.4	0.91	36.5
Tardibelle	38.6	5.8	22.2	4.1	24.5	14.3	0.64	23.4
Average	12.8	5.4	9.1	16.3	31.4	23.9	0.90	34.8
Nectarine cultivars								
Caldesi 2000	2.9	3.1	3.0	18.6	35.8	27.2	1.04	40.0
Caldesi 85	7.6	3.0	5.3	16.7	33.3	25.0	1.04	39.8
Maria Carla	7.0	2.5	4.8	18.6	36.3	27.5	1.08	43.6
Maria Lucia	3.9	2.7	3.3	14.5	30.7	22.6	0.90	31.6
Max 7	5.3	5.9	5.6	20.8	31.9	26.4	1.10	38.1
Morsiani 51	2.8	4.4	3.6	18.1	28.8	23.5	0.92	35.1
Orion	2.3	2.8	2.6	21.4	35.3	28.4	1.11	43.6
Rita Star	0.6	2.8	1.7	24.7	45.9	35.3	1.29	51.5
Sirio	2.8	4.4	3.6	21.6	28.9	25.3	1.09	37.5
Stark Redgold	5.2	1.8	3.5	19.0	34.6	26.8	1.15	41.7
Venus	1.3	3.0	2.2	21.4	30.4	25.9	1.03	38.2
Vinčanka	2.9	2.1	2.5	20.5	32.7	26.6	1.13	41.5
Average	4.5	3.2	3.9	15.9	32.2	24.1	1.07	35.3
CV (%)			94.8			42.4		
LSD 0.05			2.7			3.0		
LSD 0.01			3.6			3.9		

Conclusions

Cultivars with higher flower bud density (higher number of flower buds per node and per 1 m of shoot length) such as peaches: 'Redhaven', 'Maria Marta', and 'Autumn Glo', and nectarines 'Rita Star', 'Maria Carla', and 'Orion' require severe pruning in order to obtain better fruit size. In these cultivars, during the pruning a smaller number of shoots should be left on the tree. On the other hand, cultivars with lower flower bud density e.g. 'Tardibelle', 'Flavorcrest', 'Royal Glory', 'Bolero', and 'Maria Lucia' should be pruned slightly in order to obtain higher yield. In areas where there is a greater risk of frost, cultivars with higher density of flower buds should be grown, because they can provide a more secure productivity. In contrast, in areas where there is a small risk of frost could be grown cultivars with a lower density of flower buds which require less work for fruit thinning.

Acknowledgements

This study was supported by the Ministry of Education and Science of the Republic of Serbia through the project TR 31063.

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