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INFLUENCE OF PLANTING DENSITY ON YIELD OF PEACH AND NECTARINE

Gordan ZEC[1*], Slavica SOLIC[2], Todor VULIC[1], Dragan MILATOVIC[1], Boban DJORDJEVIC[1], Dejan DJUROVIC[1], Milovan VELICKOVIC[1]

[1]Faculty of Agriculture, University of Belgrade, Serbia
[2]Institute for Science Application in Agriculture, Belgrade, Serbia
*Corresponding author: zecg2004@yahoo.com

Abstract

The influence of three different planting densities on yield of three peach cultivars: ‘Early O’ Henry’, ‘Sunprince’, and ‘Autumn Glo’, and two nectarine cultivars: ‘Vinčanka’ (clone of ‘Stark Redgold’) and ‘Max 7’ was studied during three-year period (2009-2011). In high density planting, seedlings of vineyard peach were planted at the space of 3.5 x 1 m (2,800 trees ha^{-1}) and grafted at the height of 50 cm. The trees were trained as a new original training system named ‘Sloping Leader’ that is characterized with a central leader that is bent and follows row direction at an angle of 25° to the trunk. In standard experimental plot, one-year old peach trees were planted and trained as ‘Fusetto’ form (4 x 2 m; 1,250 trees ha^{-1}) and Open Vase (4 x 4 m, 625 trees ha^{-1}). The following characteristics were studied: yield per tree and unit area (ha), as well as yield efficiency based on trunk cross-sectional area and on crown projection area. In the first three years of cropping significantly higher yields were achieved in the high-density planting system. Yield efficiency expressed based on the crown projection area, was also significantly higher in the high-density planting system.

Key words: *high density planting, Sloping Leader, peach, nectarine, yield*

Introduction

One of the major prerequisites for the achievement of high and regular yields in peach and nectarine production is the introduction of new training systems along with the application of appropriate cultural practices.

In the high density orchards it is possible to achieve precocity, higher yield, more efficient application of cultural practices and faster return of investments. Fast change of cultivar assortment of peach and nectarine is also factor that has influence on intensification of production. Production of peach and nectarine in high density plantings was researched by many authors (Ninkovski, 1986; Loreti and Pisani, 1992; Costa and Testolin, 1996).

Peach growing in Serbia was mostly based on Open Vase training system, with the large planting distance, such as 4 x 4 m. However, today the planting distance tends to decrease to 4 x 2 m (1,250 trees ha^{-1}).

Peach production is directed towards increasing the planting density in order to obtain earlier coming into bearing and achieving the full yield, increase of yield and fruit quality, while keeping the largest amount of fruits within easy reach (Corelli-Grappadelli et al., 1997). The diversity of a large number of peach and nectarine cultivars provides the possibility of selection of those cultivars which would achieve good production results in a high-density system (Zec, 2010).

The main objective of the present study was the establishment of the original training system for growing peaches and nectarines in a high-density orchards in order to increase fruit yield per unit area.

Materials and methods

The experimental orchard (0.5 ha) was established in Padinska Skela (near Belgrade). Three training systems with different planting distances were studied. The first system is Sloping Leader, a new original training system with high-density planting. This system has one central leader that is bent and follows row direction at angle of 25° to the trunk. The bending was done in a row direction (North-South), by binding of the future leader to trunk of the neighboring tree. The rootstocks (vineyard peach seedlings) were planted in the orchard in 2007, at the beginning of June, at the spacing of 3.5 x 1 m (2,800 trees ha^{-1}). The seedlings were budded at the height of 50 cm, at the beginning of September. Two other applied training systems were 'Fusetto' – form of Slender Spindle (4 x 2 m; 1,250 trees ha^{-1}) and Open Vase (4 x 4 m, 625 trees ha^{-1}). In these two systems, one-year old nursery trees were used, and they were planted in November 2007.

Three peach cultivars: 'Autumn Glo', 'Early O' Henry' and 'Sunprince', and two nectarine cultivars: 'Vinčanka' (clone of 'Stark Redgold') and 'Max 7' were used in this experiment. The trees were grown under standard cultural practices, without irrigation. Dormant pruning (in February) was combined with summer pruning (in June). Medium vigourous and well – lignified fruiting shoots that were uniformly distributed in the canopy were left for yield.

During a three-year period (2009-2011) the following traits were studied: yield per tree and per unit area (ha), as well as yield efficiency based on trunk cross-sectional area (TCSA; kg cm^{-2}) and on crown projection area (kg m^{-2}).

Statistical analysis was performed with 'Statistica' (StatSoft, Inc., Tulsa, Oklahoma, USA) program using a three-factor factorial experiment design. The significance of the differences between means was tested using LSD test at the probability levels of 1% and 5%.

Results and discusion

Yield

Yield per tree in studied cultivars planted at the distance of 4 x 4 m was higher from 84% ('Max 7') to 171% ('Sunprince') in comparison with trees in the high-density planting (Table 1). However, regardless of the lower yields per tree, in the high-density system higher yields per hectare were achieved.

Lower yield per tree that is obtained in high-density planting is the result of reduced area for the development of the fruit tree. This is in accordance with previous findings (Caruso et al., 1999, DeJong et al., 1999).

Table 1. Yield per tree and hectare of peach and nectarine cultivars in different training systems.

Cultivar	Planting distance (m)	Yield per tree (kg)				Yield per area unit (t ha^{-1})			
		2009	2010	2011	Mx	2009	2010	2011	Mx
Sunprince	4 x 4	3.90	7.48	22.90	11.42	2,437	4,680	14,312	7,143
	4 x 2	3.59	6.70	16.4	8.89	4,487	8,375	20,500	11,120
	3.5 x 1	2.02	2.70	7.90	4.21	5,660	7,560	22,120	11,780
	Mx	3.17	5.62	15.73	8.17	4,195	6,872	18,977	10,014
Early O' Henry	4 x 4	3.33	8.53	15.10	8.98	2,080	5,330	9,437	5,616
	4 x 2	2.69	7.80	11.60	7.36	3,362	9,750	14,500	9,204
	3.5 x 1	1.90	3.60	6.20	3.90	5,320	10,080	17,360	10,920
	Mx	2.64	6.64	10.96	6.74	3,587	8,387	13,766	8,580
Autumn Glo	4 x 4	4.68	8.94	24.90	12.84	2,925	5,590	15,562	8,026
	4 x 2	3.91	8.40	17.90	10.07	4,887	10,500	22,375	12,587
	3.5 x 1	2.27	5.20	11.20	6.22	6,360	14,560	31,360	17,426

	Mx	3.62	7.51	18.00	9.71	4,724	10,217	23,099	12,680
Vinčanka	4 x 4	3.22	8.32	16.50	9.35	2,015	5,200	10,312	5,842
	4 x 2	3.00	7.30	12.90	7.73	3,750	9,125	16,125	9,667
	3.5 x 1	1.80	5.10	9.80	5.56	5,040	14,280	27,440	15,586
	Mx	2.67	6.90	13.06	7.55	3,602	9,535	17,959	10,365
Max 7	4 x 4	3.43	5.62	14.10	7.72	2,145	3,510	8,812	4,822
	4 x 2	2.70	5.10	11.05	6.28	3,375	6,375	13,812	7,853
	3.5 x 1	1.80	2.40	6.90	3.70	5,040	6,720	19,320	10,360
	Mx	2.64	4.37	10.68	5.90	3,520	5,535	13,981	7,678
Means of years		2.95	6.21	13.69			3,926	8,109	18,624
Means of training systems	4 x 4 m	3.71	7.78	18.70	10.06	2,320	4,862	11,687	6,290
	4 x 2 m	3.18	7.06	13.97	8.07	3,972	8,825	17,642	10,146
	3.5 x 1 m	1.96	3.80	8.40	4.72	5,484	10,640	23,520	13,215
Training systems (TS)	LSD 0.05				1.90				1,860
	LSD 0.01				2.57				2,511
Years (Y)	LSD 0.05				1.90				1,862
	LSD 0.01				2.57				2,578
Cultivars (C)	LSD 0.05				2.46				2,390
	LSD 0.01				3.31				3,242
Interaction (TS x C)	LSD 0.05				N.S.				N.S.
	LSD 0.01				N.S.				N.S.

N.S. – Not significant.

During the initial three years of cropping the highest average yield was obtained in peach cultivar ‘Autumn Glo’ in the high-density planting (2,800 trees ha^{-1}) and it amounted to 17,426 kg ha^{-1} (Table 1). In the same cultivar under dense planting in 2011, the highest yield in the experiment was recorded (31,360 kg ha^{-1}). The lowest average yield was obtained in nectarine cultivar ‘Max 7’ on trees trained as Open Vase (625 trees ha^{-1}; 4,822 kg ha^{-1}).

In studied cultivars average yield in the dense planting was from 65% (‘Sunprince’) to 167% (‘Vinčanka’) higher comparing to Open Vase trained trees (4 x 4 m). The trees grown in the dense planting in the form of ‘Sloping Leader’ had higher average yield than trees trained in the form of ‘Fusetto’ (4 x 2 m) from 6% (‘Sunprince’) to 66% (‘Vinčanka’). In the dense planting, on trees trained in the form of ‘Sloping Leader’ significantly higher yields were achieved compared to semi-dense planting and standard-density planting.

High yields achieved in a dense planting in the first years of cropping can be explained by the large number of trees per unit area and shorter period of crown formation. These are the benefits of dense planting and ‘Sloping Leader’ as the training system.

Several authors found that the planting distance has greater influence on the yield than the training system (Bargioni et al., 1983; Grossman and DeJong, 1998; Marini and Sowers, 2000). They stated that fruit trees at low densities have higher yields per tree, but lower yields per hectare, which emphasizes the planting density as a factor that significantly affects the yield.

Yield efficiency

The lowest average value of the yield efficiency per trunk cross-sectional area (0.165 kg cm^{-2}) had trees of nectarine cultivar ‘Max 7’ planted at the space of 4 x 2 m, while the trees of peach cultivar ‘Autumn Glo’ in the high-density training system (3.5 x 1 m) had the highest value (0.319 kg cm^{-2}) (Table 2).

Loreti and Massai (1998) reported that the yield efficiency in peach cultivar ‘Springcrest’ grafted on different rootstocks ranged from 0.35 to 0.76 kg cm^{-2} in the sixth year after planting. The obtained results of the yield efficiency per TCSA in this study were close to the

lower values reported in the literature. This is due to lower yields, which are characteristic for initial bearing years.

All cultivars in the experimental orchard (except ‘Sunprince’) had a slightly higher value of this parameter in a dense planting. However, the differences between training systems were not statistically significant. The obtained results are in accordance with the findings of Caruso et al. (1999).

The lowest average value of the yield efficiency per crown projection area (1.77 kg m^{-2}) had trees of the peach cultivar ‘Early O’ Henry’ grown at the planting distance 4 x 4 m with a form of Open Vase (Table 2). Trees of the peach cultivar ‘Autumn Glo’ in the dense planting (3.5 x 1 m) and trained in the form of ‘Sloping Leader’ had the highest value of this parameter (4.30 kg m^{-2}). Trees of nectarine cultivar ‘Vinčanka’ trained in the form of ‘Sloping Leader’ had 78% greater yield efficiency per crown projection area comparing with trees trained in the form of Open Vase.

In the dense planting significantly higher yield efficiency per crown projection area was achieved compared to semi-dense planting and standard-density planting. The obtained result can be explained by the rapid covering of productive area and a quick coming into full bearing using smaller planting spaces and the ‘Sloping Leader’ training system.

Table 2. Yield efficiency per trunk cross-sectional area (TCSA) and per crown projection area in different training systems.

Cultivar	Planting distance (m)	Yield efficiency per TCSA (kg cm^{-2})				Yield efficiency per crown projection area (kg m^{-2})			
		2009	2010	2011	Mx	2009	2010	2011	Mx
Sunprince	4 x 4	0,170	0,189	0,434	0,264	1,17	1,65	4,67	2,49
	4 x 2	0,176	0,215	0,371	0,254	1,62	2,19	4,95	2,92
	3,5 x 1	0,178	0,149	0,345	0,224	1,77	1,81	4,96	2,84
	Mx	0,175	0,184	0,383	0,247	1,52	1,88	4,86	2,75
Early O’ Henry	4 x 4	0,140	0,188	0,243	0,190	1,13	1,49	2,68	1,77
	4 x 2	0,122	0,215	0,237	0,191	1,11	2,40	3,41	2,30
	3,5 x 1	0,158	0,176	0,252	0,196	1,53	2,35	3,69	2,52
	Mx	0,140	0,193	0,244	0,192	1,25	2,08	3,26	2,20
Autumn Glo	4 x 4	0,212	0,246	0,483	0,314	1,69	2,06	5,19	2,98
	4 x 2	0,191	0,288	0,416	0,298	1,77	2,81	5,34	3,31
	3,5 x 1	0,200	0,287	0,472	0,319	2,02	3,66	7,21	4,30
	Mx	0,201	0,274	0,457	0,311	1,82	2,84	5,91	3,52
Vinčanka	4 x 4	0,146	0,285	0,374	0,268	1,21	1,97	3,53	2,24
	4 x 2	0,153	0,319	0,378	0,283	1,47	2,63	3,90	2,66
	3,5 x 1	0,151	0,271	0,384	0,269	1,74	3,64	6,66	4,01
	Mx	0,150	0,292	0,379	0,274	1,47	2,74	4,69	2,96
Max 7	4 x 4	0,162	0,150	0,267	0,193	1,28	1,31	2,87	1,82
	4 x 2	0,138	0,113	0,244	0,165	1,17	1,62	3,07	1,95
	3,5 x 1	0,151	0,138	0,325	0,205	1,63	1,64	4,04	2,43
	Mx	0,150	0,134	0,279	0,188	1,36	1,52	3,32	2,06
Proseci godina		0,163	0,215	0,348		1,48	2,21	4,41	
Mx	4 x 4	0,166	0,212	0,360	0,246	1,30	1,70	3,79	2,26
	4 x 2	0,156	0,230	0,329	0,238	1,43	2,33	4,13	2,63
	3,5 x 1	0,168	0,204	0,356	0,243	1,74	2,62	5,31	3,22
Training systems (TS)	LSD 0,05				N.S.				0,46
	LSD 0,01				N.S.				0,63
Years (Y)	LSD 0,05				0,035				0,46
	LSD 0,01				0,047				0,63

Cultivars (C)	LSD 0,05	0,041	0,60
	LSD 0,01	0,055	0,81
Interaction (TS x C)	LSD 0,05	N.S.	N.S.
	LSD 0,01	N.S.	N.S.

N.S. – Not significant.

Conclusion

All cultivars of peach and nectarine had significantly lower yield per tree in a dense planting. The obtained result is a consequence of the reduced space for the development of the tree and significantly lower habit of trees in a dense planting.

In a dense planting all cultivars achieved significantly higher yield per unit area (ha) and reach full bearing earlier compared with semi-dense planting and standard-density planting. These benefits of ‘Sloping Leader’ training system are expressed in particular in the first three years of cropping.

The yield efficiency expressed per unit of the trunk cross-sectional area was not significantly different depending on the planting density.

The obtained values of the yield efficiency expressed per crown projection area pointed to the benefits of the training system ‘Sloping Leader’ which is significantly more efficient in the use of land, resulting in a higher yield. The architecture of the new training form occupies less space, which allows increase of the planting density and earlier coming into full bearing.

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