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THE INFLUENCE OF TIME AND FRUITLET INTERSPACE THINNING ON YIELD AND FRUIT QUALITY OF PEACH AND NECTARINE GROWN IN MONTENEGRO

SUMMARY

The study results over a three year period (2007-2009) on three cultivars of peach and nectarine (Early Crest, May Crest, Springbelle, Adriana, Rita Star and Caldesi 2000) has been presented in the paper. The study includes: time of flowering, pollen germination percentage, the percentage of fruit set, interspaces and time of fruit thinning and their influence on fruit weight and total yield of the examined cultivars. The study found a high percentage of fruit set especially in cv. May Crest (86.60%) and the lowest was in cv. Springbelle (80.51%). Interspace thinning of 5.0 cm gave the highest average of fruit weight (119.0 g) in cv. Caldesi 2000 and the lowest (54.3 g) in cv. Early Crest. At a distance of 10 cm interspace thinning the highest fruit weight was again in cv. Caldesi 2000 (141.0) and the lowest in cv. Early Crest (59.3 g). Our research shows that the most favorable period for thinning of peaches in our agroecological conditions is at the end of April, when the initial fruit weight is 3-5 g.

Keywords: peach, cultivar, thinning, fruit quality, yield

INTRODUCTION

Peach - *Prunus persica* L. Batsch., a plant of the *Rosaceae family*, originating from China, although it could be concluded otherwise according to its Latin name *(Persian plum*). It began to grow in China 4000 years ago. From its homeland it was first transferred to Iran (ex Persia) by which it was named "persica". Then it was transferred in Europe at the beginning of a new era. Peach is one of the most important fruit species in the world, which besides Europe, it is represented in North and South America, Australia, Africa and Asia. It is grown in the subtropical zone and in areas with moderate continental climate.

The observances of the production of the fruits from temperate areas, with the exception of tropical and subtropical fruits, then peach ranks in the third place behind apples and pears. Currently (according to FAO data) Europe is the largest producer of peaches in the world (48.6%), North America (22.9%), Asia (17.1%), South America (6.9%), and Africa (3.3%). Among the European

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countries the largest producers are Italy, then Greece, Spain and France. In the world Italy and the United States are considered as the biggest producers and together they achieve over 40% of total world production (Bulatović-Danilović, 2007).

In Montenegro the peach arrived through Minor Asia, Greece and Italy, in the second half of the 19th century. Organized cultivation of cultivated peach cultivars in Montenegro started in the middle of the last century, mainly by private holdings. The first cultivars were imported from Italy, with European and American origin. In the initial stages cultivars with white and later with yellow mesocarp were imported, and they were ´frestone´ cultivars with high quality.

Peach is present in the surroundings of Podgorica and the Adriatic coastal area, mainly early and medium early cultivars. In Montenegro, the peach had a turbulent and dynamic development as only a few other fruit species which clearly indicates its importance and the future perspective. Of the total peach production, 60% applies to consumption of fresh peach, 25% of nectarine and 15% of peach for processing. In the structure of fruit growing in Montenegro, peach orchards are in fifth place and in the structure of stone fruits, immediately after the plums. It should be noted that it is in the group of fruits that are grown on intensive and semi-intensive plantations in the country (Prenkić et al. 2010).

Peach contains 87% of water, 12% carbohydrates, very low fat (0.1%) and proteins (0.5%). Cellulose fibres are about (2.3%), but mainly in the cortex. Among the vitamins peach contains mostly beta-carotene, vitamin C, group B, PP and provitamin A (antioxidant).

The peach also contains minerals such as potassium, phosphorus, magnesium, sodium, sulfur and calcium. Peach is among the rare fruits that contain selenium, which helps in reducing free radicals. Peaches not only have a refreshing effect on the human organism, but also curative (diuretic, lowers blood pressure, purifies the body, encourages and facilitates digestion, etc.) (Jovanović, 1987).

Peach trees reach full productivity in their fifth and sixth year after planting. In good ecological conditions it bears abundantly and regularly (30 - 40 t ha), which is more than enough that a yield covers the investment already in the second harvesting year. Peach has a quite short period of exploitation (15-16 years) (Medin, 1998).

Peaches and nectarines in a full crop form several thousands of flower buds which 20 - 50% of them give a fruit. For a high and quality yield it is enough 15% of them is enough. Such abundant yield decreases the quality of the fruit. Branches are more susceptible to breakage and growth of fruit shoot holders in the coming year is compromised, which may lead to alternate bearing (Ognjanov, 2005).

The aim of this study was to determine the time and thinning interspace for some peach and nectarine cultivars, in order to get the greatest amount of first class fruits, and thus more stable and quality yield that will achieve a significantly higher price at the market.

MATERIAL AND METHODS

Investigations were carried out in productive – experimental plantation DD "Plantaze" at Ćemovsko field in the period 2007 - 2009. Plantation of newly introduced peach cultivars was set up in the spring of 1993 and nectarine plantation in spring of 1998. The planting space was 4.5 x 2.0 m (1.111 trees ha), where each tree has 9 m² area. Planting direction among the experimental plots is north - south. Growing form is the slender spindle (Fusseto), and in cultivars that were set up in 1998 are modified palmettes. All varieties are grafted at the vineyard peach.

The study comprised the following cultivars of peaches and nectarines: Early Crest, May Crest, Springbelle, Adriana, Rita Star and Caldes 2000. Each cultivar was presented 5 trees per variety. Beginning of flowering was recorded when 10% of flowers was opened. Full flowering was noted when 90% of flowers were opened and the end was when 90% of petals had fallen (Slović, 1972).

Pollen germination was tested in a nutrient medium with 1% of agar, supplemented with 15% sucrose at 25^0C, according to Warner and Chang (1981). After three hours pollen grains were counted under the microscope, and the percentage of germination was determined by mathematical proportion.

Fruit set was determined by counting the open flowers on five trees per cultivars of each cultivar studied. Then fruit set was counted before their natural falling off the tree.

Fruit thinning was done according to time and on three occasions: in peach on 22 April, 29 April and 6 May and in nectarine on 29 April, 6 May and 13 May and the most favorable moment for carrying out thinning in peach and nectarine plantation was determined. Also it was determined thinning of fruit, depending on the distance (at 5 and 10 cm) and its impact on the number of fruits per branch and per tree, fruit weight and yield of tested peach and nectarine cultivars, expressed in kg/tree and t/ha. They were mathematically calculated by multiplying the number of fruits on the tree with their average weight and number of trees per ha. All cultivars were grouped according to time of their maturity. Statistical analysis of the observed characteristics (should be specify which, like fruit mass etc.) performed by analysis of variances a two-factorial trials. The comparison of means was tested by LSD for the level of 95 and 99%.Fruit mass of 50 fruit were measured in three trees per cultivars replicates.

Fruit maturity in peach and nectarine were recorded according to Gvozdenović (1990), based on visual changes of basic and additional color skin, easiness of separation of fruit from a branch. The organoleptic evaluation and determination of dry matter content was done by refractometer and calculation of its index.

Agro ecological conditions

Podgorica is located at 42 m above sea level and 42° 26' N latitude, and 19º15' E longitude. It is characterized by a Mediterranean climate, modified by

the influence of peripheral high mountains; opposed to the narrow coastal area, which are hotter with drier summers and wetted winters.

Temperature is an important factor affecting the growth of peach, its yield and the quality of fruits. Annual course of air temperature in this region has elements belonging to temperate latitudes, because the typical minimum and maximum points are located in the central summer (July-August) and winter months (January-February). The mean annual air temperature for a period of 10 years (1990-2000) was 17.6°C and 18.2°C during the study, which is 0.6°C higher than the ten-year average. Mean temperature in the vegetation period of investigation (01st March – 30th November) was 20.7°C (Table 1).

Table 1. Mean monthly, annual and vegetation air temperatures in Podgorica, °C.

	I	II	III	IV	V	VI	VII	VIII	VIII	IX	X	XI	XII	Average
2007	8.0	9.8	12.2	17.6	21.2	26.1	30.1	28.2	20.3	16.2	9.2	5.4	17.0	18.4
2008	6.6	7.7	11.1	15.1	21.0	25.0	27.3	28.7	21.4	16.8	12.0	7.6	16.7	18.1
2009	6.3	6.3	9.9	17.0	22.0	23.5	27.5	28.6	23.0	15.1	10.7	9.1	16.6	18.0
Average 2000-2009	5.8	7.1	10.7	15.3	20.9	25.0	27.8	27.3	21.3	16.7	11.0	7.1	16.3	18.2

Besides temperature conditions precipitation is certainly the most important for intensive and cost-effective cultivation of peach. Podgorica region, in regard to precipitation, is characterized by specific features of the Mediterranean climate. Maximum rainfall is in the last two months of the year (November-December), and minimum in July and August.

The average amount of precipitation during the vegetative period of study was only 142.2 mm/m², while the amount of annual rainfall was extremely high (1357.6 to 2036.3 mm/m²), but not so useful because of the soil is skeleton and has a little water capacity. Due to all the water from rainfall sinks and washes the nutrients into the deeper layers, while the capillary rise of water is very small.

Unfortunately, distribution of the precipitation is unfavorable, so their deficit appears in the period of June-August, which negatively affects the process of growth and fruiting of peach, especially in mid-growing season (Table 2).

The soil where the research was conducted is formed on conglomerate of fluvio - glacial sediments transferred from the mountain massif from the east of "Ćemovsko field." the sediments are mostly composed of lime or dolomite rocks, gravel and sand. The main characteristic of this soil is that it is sandy and relatively shallow. Granulometric composition is characterized by a high content of skeleton which is 80% throughout the soil profile with small soil particles less than 20%.

Table 2. Mean monthly, annual and vegetation sum of precipitation in the Podgorica, mm m².

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
2007	95.6	228.5	194.8	32.2	72.6	40.4	0.2	43.9	119.7	139.8	273.7	116.2	1357.6
2008	209.1	63.1	326.4	98.4	40.8	142.4	28.9	14.8	75.6	150.8	221.7	353.9	1725.9
2009	343.6	134.6	202.0	33.9	31.2	234.9	17.6	12.9	62.6	260.3	331.0	371.7	2036.3
Average 2000-2009	187.2	151.5	177.6	111.1	62.3	82.1	31.2	57.9	176.4	156.2	255.4	248.8	1697.6

RESULTS AND DISCUSSION

Flowering time and duration of studied cultivars were quite uniform in the years of research (Table 3.). The shortest interval of flowering energy was recorded in the cultivar Adriana (11 days) and the longest in the cultivar Rita Star (16 days). The earliest beginning of flowering was in cultivar Rita Star (09.03.), and the latest in cultivars Early Crest and Springbelle (29.03.).

Pollen germination of studied cultivars (Table 4.) was in average 77.52%. Cultivar Adriana had the highest pollen germination (79.00%) and cultivar May Crest the lowest (75.20%).

Fruit set was in average (83.07%), (Table 4.). The greatest number of fruit set was in variety May Crest (86.60%) and the lowest in cultivar Springbelle (80.51%). The favourable climatic conditions (Table 1 and 2) prevent the risk of late spring frosts which caused a high percentage of fruit set in the years of research. Lučić et al. (1996) state that for a normal peach yields it is necessary to set 10-20% of comparison or fruitless. Ripening of tested cultivars (Table 4.) shows that the earliest harvest date arrived in the cv. Early Crest (28.05.), and the latest in Caldesi 2000 (22.06.).

Table 3. The time of flowering of summer peaches cv., 2007-2009.

Cultivar	Beginning of flowering	Full flowering	End of flowering	Flowering duration
Early Crest	16.03	22.03	29.03	12
May Crest	12.03.	19.03.	26.03.	14
Springbelle	16.03.	22.03.	29.03.	13
Adriana	17.03	23.03.	28.03.	11
Rita Star	09.03.	17.03.	25.03.	16
Caldesi 2000	16.03	22.03.	28.03.	12
X				13

According to the time of ripening all tested cultivars belong to early to mid-early cultivars (Bellini, 1984). Time of ripening in peaches varied slightly in the three-year period of investigation (Table 2.). Namely, the favourable environmental conditions at the time of flowering until fruit maturation influenced to relatively uniform maturation of the tested peach and nectarine cultivars.

Table 4. Pollen germination, fruit set up and fruit ripening, %, 2007-2009.

Cultivar	Pollen germination	Fruit set up	Time of ripening	
			X	(0)
Early Crest	78.40	84.36	28.05.	-16
May Crest	75.20	86.60	06.06.	-6
Springbelle	77.66	80.51	12.06.	0
Adriana	79.00	81.33	15.06.	+3
Rita Star	76.33	82.30	19.06.	+7
Caldesi 2000	78.50	83.33	22.06.	+10
X	77.52	83.07		

Influence of fruit thinning on initial fruit weight: Thinning of peach fruits was performed three times: 22. 04. (I, Table 5), 29. 04.(II), and 06. 05.(III), and in nectarines 29. 04.(I), 06. 05.(II), and 13. 05(III). During the first peach thinning, fruit weight was 1.2 g in Early Crest to 1.1 g in May Crest and Springbelle (Table 5.). In second thinning of fruit weight has increased by 2.5 times, so the cultivar Early Crest had fruit weight of 3.7 g, May Crest 3.2 g and Springbelle 3.0 g. In third thinning, peach fruits weight reached 10.6 g in Early Crest, 9.3 g in May Crest and 8.6 g in Springbelle. Statistical analysis of comparation of means shows no significant differences in initial fruit weight within the varieties and the time of fruit thinning.

Table 5. Influence of fruit thinning on initial fruit weight, g, 2007-2009

Cultivar / Date of thinning	Early Crest	May Crest	Springbelle	Adriana	Rita Star	Caldesi2000
I	1.2	1.1	1.1	1.2	1.4	1.1
II	3.7	3.2	3.0	3.2	4.4	2.4
III	10.6	9.3	8.6	11.6	12.6	8.5
LSD 005	2.45	3.23	2.07	2.55	3.58	3.3
LSD 001	3.51	5.18	2.8	3.28	5.25	5.18

In the first thinning in nectarine fruit mass was 1.2 g in Adriana. 1.4 g in Rita Star and 1.1 g in Caldesi 2000. In the second thinning fruit weight was 3.2 g in Adriana. 4.4 g in Rita Star and 2.4 g in Caldesi 2000. In the third thinning fruit weight was 11.6 g in Adriana. 12.6 g in Rita Star and 8.5 g in Caldesi 2000.

During thinning in nectarines average fruit weight was similar as in peach except in the third thinning when the fruits were slightly larger due to favorable weather conditions. Namely temperatures were from 20 to 25°C in that period which influenced intensive fruit growth. Also the soil moisture in this period was very favourable due to heavy winter and spring rainfall. and soil was enriched with nitrogen fertilizer in March.

Influence of interspace thinning on fruit weight and yield: The average number of fruits that were not been thinned in three-year period ranged from 305.4 in cultivar Adriana to 560.3 in Springbelle (Table 6.).

After the thinning was done at 5.0 cm. the most numerous fruits were recorded in Springbelle (175.5). and the least in Rita Star (151.8). The greatest number of fruits in thinning made at 10 cm was in cv. Springbelle (121.5). and the smallest in Rita Star (105.1).

These interspaces thinning affected the fruit weight of tested cultivars and their yield. In thinning at 5.0 cm interspace. maximum average fruit weight had a Caldesi 2000 (119 0 g) and lowest Early Crest (54.3 g). At a thinning distance of 10 cm the highest fruit weight was also in Caldesi 2000 (141.0 g) and the lowest in cultivar Early Crest (59.3 g). Biometric data processing did not show significant differences in fruit mass within cultivars or fruit thinning space of 5 and 10 cm. The average yield of tested peach and nectarine cultivars at a distance of 5.0 cm was significantly higher and ranged from 9.65 t/ha in cultivar Early Crest to 18.3 t/ha in cultivar Caldesi 2000. At a thinning distance of 10.0 cm the highest average yield was recorded in Caldesi 2000 (15.0 t/ha) and the lowest again in Early Crest cultivar (7.28 t/ha).

The influence of favourable agricultural conditions in the investigated region has contributed to the fact that tested cultivars of peaches and nectarines are classified into groups of early and medium flowering cultivars (Bellini *et al*. 1984). Agro-ecological conditions in the locality Ćemovsko field. primarily slightly lower temperature and relatively high precipitation in the years of research have influenced later flowering of tested peach and nectarine cultivars. According to Ognjanov (1991) it is necessary that the temperature from 1st of March should be 8ºC or higher in a 14-15 day period in order to begin flowering phenophase which totally agrees with our studies. Observing the time of flowering and ripening time of tested peach and nectarine cultivars. can be concluded that there was no correlation between them. as it is the case with other fruit species (Baldini and Scaramuzzi. 2005). Flowering duration of studied cultivars is 3-5 days longer than in studies done by Bulatović and Mratinić (1996). They carried out their research in the areas with lower annual temperature. while the mean temperature in Podgorica is 18.2 ºC.

Table 6. The influence of thinning interspace on fruit weight and yield. g. kg/ tree. t/ha. 2007-2009.

Thinning	Variety	Early Crest	May Crest	Spring belle	Adriana	Rita Star	Caldesi 2000	LSD 005 LSD 001
The average number of fruit branches per tree		61.3	58.7	67.5	63.7	58.4	60.8	2.62 3.90
Before thinning	The average number of fruits per fruit branch	8.2	7.6	8.3	4.8	5.4	6.1	4.26 7.28
Before thinning	The average number of fruits per tree	502.7	446.1	560.3	305.8	315.4	370.9	2.62 3.9
After thinning	The average number of fruits per tree at 5.0 cm	159.4	152.6	175.5	165.6	151.8	158.1	2.74 3.95
After thinning	The average number of fruits per tree at 10 cm	110.3	105.7	121.5	114.7	105.1	109.4	2.42 3.70
After thinning on 5.0 cm	Average fruit weight (g)	54.3	107.0	75.7	93.3	105.0	119.0	2.81 3.95
After thinning on 10 cm	Average fruit weight (g)	59.3	122.7	85.0	105.0	119.7	141.0	4.02 7.68
After thinning at 5.0 cm	The average yield per tree (kg)	8.67	16.3	13.3	15.5	15.9	18.8	2.42 3.75
After thinning at 10 cm	The average yield per tree (kg)	6.54	13.1	10.3	12.0	12.6	15.4	2.25 3.38
After thinning at 5.0 cm	The average yield per ha	9.65	17.3	14.6	16.6	17.6	18.3	2.4 3.55
After thinning at 10 cm	The average yield per ha	7.28	11.9	11.3	13.0	13.8	15.0	2.07 2.9

All tested peach and nectarine cultivars had high pollen germination (over 70.00%). which fully agrees with literature data of Bulatović (1992). According to Ognjanov (1991) great importance to germination of pollen has the same environmental conditions that influenced on the flowering time but the microsporogenesis of peach starts in most of our areas in the second half of February or at the beginning of March and lasts 2-3 days.

In this study a high percentage of fruit set (83.07%) was recorded so the thinning was necessary. which completely corresponds with the data presented by Nicotra *et. al.* (1994). It is important to note that the natural fruit drop represents a preliminary thinning. and thus an intentional thinning should be considered. in order to ensure an optimum yield of peach and nectarine.

It could be concluded that the moment of peach ripening in Mediterranean conditions differed in regard to different localities of peach growing in our country and in the world. Our tested peach cultivars arrived earlier about 15 days to harvest in comparison to studies done by Basssi and Intrieri (1983) near Bologna. Kupci (2000) noted that the differences in time of ripening of early ripening cultivars are greater between continental and Mediterranean areas than in late varieties of middle and late ripening time.

It could be concluded that the peach fruit growth was almost identical with the growth of nectarine fruit although peach thinning was done a week earlier. Therefore if we compare early varieties of peaches and nectarines, peaches are still ripening earlier and are holders of the first income. It is very important to note that the most favourable period for peach thinning is the second thinning which is done at the end of April in our agroecological conditions due to the danger of natural fruit falling. Therefore, deliberate thinning must be taken into account. so the optimal yield can be ensured. This agrees with the allegations of Cross - Raynaud (1985), which referred to three periods of fruit falling: falling of small fruits that have not been fertilized, the second falling in June when embryos abort at certain points and the third falling after the pit hardening.

According to IBPGR all tested peach cultivars were classified in three groups of productivity: low, medium and high. The yield of peaches depends on hereditary characteristics, as well as of agro-ecological conditions in a given locality. Since the examined peach and nectarine cultivars were in a declining productivity. their yield was lower than in the research of Della Strada (1992). For each year there was no linear increase observed in yield of all cultivars. but the yield decreased slightly, depending on research year. However, some of the test cultivars such as Caldesi 2000. Rita Star. May Crest and Adriana have shown relatively high yields in years of research. Although, environmental conditions were favorable and can also be considered that other biological-physiological factors, such as moderate vigour and optimum load of mixed fruit bearing branches after thinning at 5.0 cm. have positive impact on this phenomenon (Odalović. 2002). The thinning at 10 cm significantly influenced to lower yield of tested peach and nectarine cultivars, that were at the end of their ontogenetic cycle.

CONCLUSIONS

Based on the results obtained in the three-year period (2007-2009). it can be concluded the following:

Beginning of flowering of studied cultivars largely depends on agroecological conditions in the locality. The earliest flowering beginning was in cultivar Rita Star (09.03.), and the latest end of flowering was in cultivar May Crest (26.03.). Research results showed that in terms of flowering time tested cultivars are in the range of medium early to medium flowering cultivars.

Tested peaches and nectarines have a high percentage of pollen germination that is over 70%. The highest pollen germination was in cv. Adriana (79.00%) and the lowest in cultivar May Crest (75.20%).

In our research there was a high percentage of set up fruits (83.07%). so their thinning was necessary. The greatest number of fruit set was in cultivar May Crest (86.60%) and the lowest in cultivar Springbelle (80.51%).

It is important to note that the most favorable period for peach thinning is the second one, which in our agroecological conditions was in late April when the initial fruit weight ranged from 3-5 g. The reason for this is in fact that earlier thinning increases the danger of natural fruit falling off and therefore the deliberate spacing must be taken into account in order to ensure the optimum yield.

Thinning spaces of 5.0 and 10 cm influenced to fruit weight of tested cultivars and their yield. At the thinning of 5.0 cm. the highest average fruit weight was in cv.Caldesi 2000 (119. 0 g) and the lowest in Early Crest (54.3 g). At a thinning of 10 cm the highest fruit weight was also in Caldesi 2000 (141.0 g) and the lowest in Early Crest (59.3 g). The average yield of tested peach and nectarine cultivars at a distance of 5.0 cm was significantly higher and ranged from 9.65 t ha in cultivar Early Crest to 18.3 t ha in cultivar Caldesi 2000. The thinning distance of 10 cm resulted in the highest average yield in cultivar Caldesi 2000 (15.0 t ha) and the lowest also in cultivar Early Crest (7.28 t ha).

Some of the studied cultivars such as Caldesi 2000. Rita Star. May Crest and Adriana have shown relatively high yields in years of research at thinning distance of 5.0 cm even though they were at the end of their ontogenetic cycle and their exploitation period can significantly be extended. On the other hand, thinning space of 10 cm significantly influenced on lower yield in the tested cultivars of peach and nectarine.

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