

Integrated Production of Sour Cherry (*Prunus cerasus*) in Croatia

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Summary

The integrated sour cherry production in Croatia was monitored over a three year period. It was found that in the continental Croatia dominates Oblačinska cherry cultivar, followed by Csengőd and Gipsy cultivars, while in the Mediterranean Maraska cherry clones are present. Number of producers and production areas varied depending on purchase possibilities of cherries from the integrated production. The most common integrated sour cherry production in the continental Croatia is in Osijek – Baranja County, while in the Mediterranean area it is in Zadar County. Results have shown that the majority of cherry producers produce in accordance with prescribed Technical Guidelines for the integrated production. Within the integrated cherry pest management (IPM), control of aphids, was performed by pirimicarb and neonicotinoides. *Rhagoletis cerasi* was controlled by dimethoate. Diseases *Stigmina carpophila* and *Blumeriella jaapii* were commonly controlled by active substances: captan, copper hydroxide – Ca-chloride complex + zinc sulfide and dodine. *Monilinia laxa* was controlled mainly by the: boscalid, cyprodinil and carbendazim, while copper oxide was the most common substance in controlling *Pseudomonas mors-prunorum*. Weed control included total herbicides application: glyphosate and glufosinate. The occurrence of mentioned harmful organisms was expected due to favorable climate conditions characterized by above – average temperatures and variations of extreme precipitation and droughts.

Key words

IPM, sour cherry cultivars, cherry producers

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Introduction

Sour cherry growing has a long tradition in Croatia. This confirms the first written record of sour cherry growing in Zadar back in 1399 (Ražov and Montabelo, 2012). Unlike the world's largest sour cherry producers, which produce: Turkey 192,705 t, 190,000 t Russia, Poland 189 t (Milinović et al, 2012); Croatia produces 2,762 t of sour cherries per year. Sour cherry production takes the fifth place in the overall fruit production in Croatia (Državni zavod za statistiku, 2014). Sour cherry is grown both, in the continental and in the Mediterranean part of Croatia. There are several cultivars that dominate in production and these are: Oblačinska, Cygany Meggy, Debreceni bötermö, Érды bötermö, Kelleris 16 i 14, Rexelle, and Ungarische Traubige. In the Mediterranean part of Croatia, Maraska cherry clones (*Prunus cerasus* var. *Marasca*) are grown. The advantage of the Mediterranean growing cherries lies in better production profitability. Climatic factors affect up to a month earlier fruit ripening in the Mediterranean area when compared with the fruit ripening in the continental part of Croatia. The above would result in higher market price of sour cherries produced in the Mediterranean part of Croatia.

In the integrated agricultural production, fruit production by share follows dominant crop production (Pohajda et. al., 2015 b). Within the integrated fruit production, sour cherry takes the second place, right after predominant apple production (Pohajda and Prnjak, 2014). Integrated production in Croatia has been under the umbrella of Agriculture Act and corresponding Ordinance since 2010. Producers engaged in the integrated production are obliged to produce in accordance with the principles of integrated production prescribed by the Ordinance on integrated production of agricultural products (NN 137/12, 59/14) and Technical Guidelines for the integrated production. Once the professional supervision affirms compliance with the principles of the integrated production, producers are allowed to mark their products with the label of the integrated production (Pohajda and Ševar, 2014). The Advisory Service carries out professional supervision which precedes a product labeling process. Professional supervision enables monitoring of producers compliance with the requirements of the integrated sour cherry production.

Results obtained with the basic indicators of the representation of sour cherry production, allow the determination of the limiting factors fulfillment of prescribed requirements on the integrated production. Further selection of adequate measures follows identification of existing problems. The above will eventually contribute to the improvement of the integrated sour cherry production in Croatia.

Materials and methods

Integrated sour cherry production in Croatia was monitored over a three – year period via professional supervision. In the continental part of Croatia, professional supervision of the integrated sour cherry production was carried out in the following counties: Brod – Posavina, Koprivnica – Križevci, Osijek – Baranja, Požega – Slavonia, Vukovar – Srijem and Virovitica – Podravina. In the Mediterranean part of Croatia, professional supervision was carried out in Zadar County.

In this study following parameters were monitored: agricultural land share under integrated sour cherry production, number of producers that produce sour cherries according to the requirements on the integrated production, assortment representation in the integrated sour cherry production, IPM in the integrated production of sour cherries in order to determine the occurrence of the most common diseases, pests and weeds, and adequate measures in their control, climatological factors that influenced occurrence of harmful organisms.

Pesticide usage within Integrated pest management (IPM) was estimated according to the Phytosanitary Information System (FIS) by Ministry of Agriculture (Ministarstvo poljoprivrede, 2016 a). The data were collected by professional supervision from the production records of each producer. The following data were collected: harmful organism presence, active pesticide substance usage and biodiversity maintenance. Biodiversity maintenance includes: at least 5% agricultural areas are tillage – free and are kept as environmental infrastructure (drywalls, hedges, inter – row cover cropping), are implemented at least two measures for conservation of natural enemies and their habitats (bird houses, beneficial insects houses, etc.), safe distance between production area and sensitive habitats is ensured (buffer zones of water courses, water springs, ponds, protected species, etc.), soil fertility is maintained by adequate measures (liming, green manure, etc.), various agro – technical, mechanical, physical, biological, biotechnical and other non – chemical plant protection measures are implemented.

In 2013 professional supervision was undertaken on 89.871,15 ha of agricultural areas. Integrated production of sour cherry took 0.63% out of the total integrated production in 2013. During 2014 professional supervision of the integrated production was undertaken on 100,783.18 ha of agricultural areas, of which 0.53% areas were under sour cherry production. In 2015 professional supervision of the integrated production was undertaken on 101,379.54 ha of agricultural areas of which 0.56 % areas were under sour cherry production. At the beginning of 2013 in the Register of integrated production 683 agricultural producers were registered, after producers application for the integrated production, professional supervision of the integrated sour cherry production included 34 farms. Out of 740 producers registered in the Register of integrated production at the beginning of 2014, 37 farms were engaged in professional supervision of the integrated sour cherry production. Out of 804 producers registered in the Register of integrated production at the beginning of 2015 (Ministarstvo poljoprivrede, 2016 b), professional supervision in the integrated sour cherry production included 48 farms according to the applications received for the integrated production.

Since the IPM of sour cherry is influenced by climatological factors, there is a need of climatological data obtained by the Meteorological and Hydrological Service (Državni hidrometeorološki zavod) to be presented throughout investigated seasons. Results have shown that a year 2013 in the continental area was very warm and rainy. Spring was rainy along with normal temperatures. Extremely hot summer months were followed by drought. Autumn was warm and rainy. Winter was very rainy with normal temperatures. In the Mediterranean area 2013 was extremely warm and rainy. Spring was warm and very rainy. Extremely warm summer months were followed by

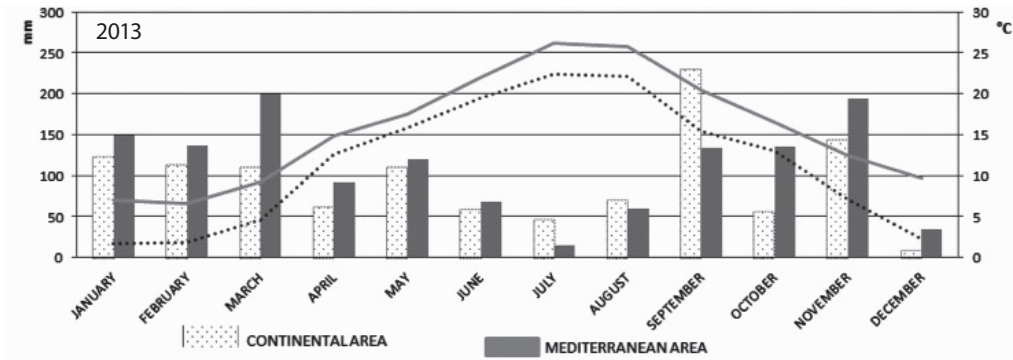


Figure 1. Climate diagrams for year 2013 in Continental and Mediterranean area

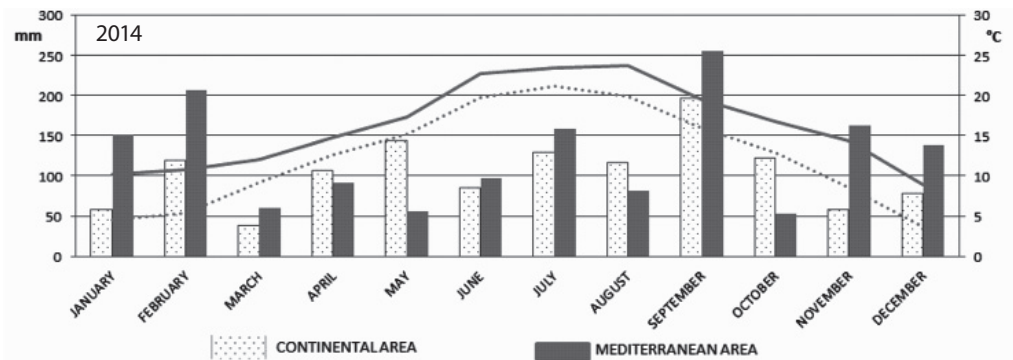


Figure 2. Climate diagrams for year 2014 in Continental and Mediterranean area

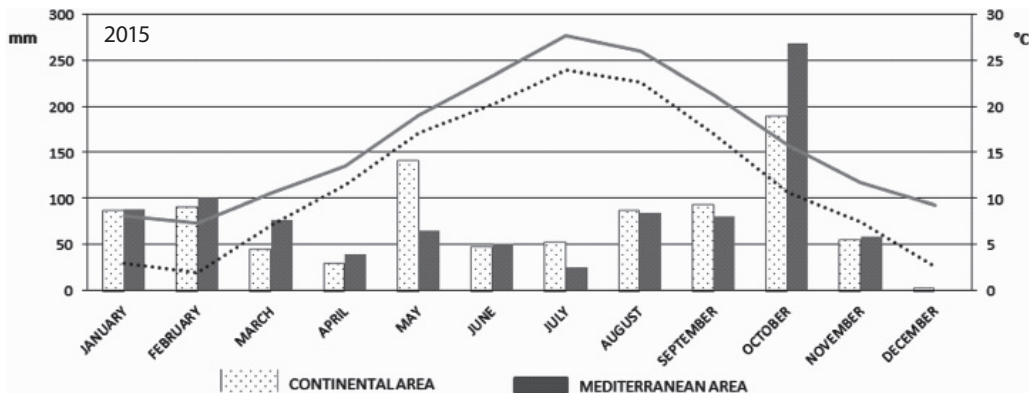


Figure 3. Climate diagrams for year 2015 in Continental and Mediterranean area

normal precipitation. Autumn was warm and rainy. Winter was very rainy with normal temperatures as was the situation in the continental area (Figure 1).

Climatological data for the year 2014 in the continental area include extremely hot temperature and very rainy precipitation. Spring was warm and rainy, summer normally warm and normally rainy, autumn warm and rainy and winter was very warm with normal amount of precipitation. Extremely warm and rainy was a year 2014 in the Mediterranean area. Spring was warm and normally rainy, summer warm and rainy, autumn very warm and rainy and winter was warm with normal amount of precipitation (Figure 2).

Based on the climate diagrams for 2015 (Figure 3), it is evident that this season in the continental area was extremely hot with normal amount of precipitation.

Normal precipitation was recorded during the hot spring. Summer was extremely hot and very dry. It was very rainy during the warm autumn and rainy during the warm winter. In the Mediterranean area in 2015 was extremely hot with a normal precipitation amount. Spring was warm with normal precipitation amount, summer was extremely hot with normal precipitation amount. Autumn and winter were both warm and rainy.

Results

During the professional supervision of the integrated production in 2013, there were 555.99 hectares of sour cherry orchards in Croatia. In the continental part of the Croatia during the first research year there was a 367.5 ha, and in the Mediterranean area 188.49 ha. In 2014 research included 549.08 ha under integrated sour cherry production. The second research year, included

Table 1. Share of the integrated production of sour cherry in Croatia (ha) per season

	2013	2014	2015
Continental area			
Osijek - Baranja	328.88	307.87	290.31
Koprivnica - Križevci	14.21	7.91	6.85
Požega - Slavonia	13.21	12.62	20.55
Brod - Posavina	8.71	8.74	8.74
Vukovar - Srijem	1.83	0	5.2
Virovitica - Podravina	0.75	6.97	2.13
Sisak - Moslavina	0	9	9
Mediterranean area			
Zadar	188.49	195.97	222.28
Total (ha)	555.99	549.08	565.06

Table 2. Share of the integrated production of sour cherry cultivars in Croatia (ha) per season

	2013	2014	2015
Continental area			
Oblačinska	365.37	349.34	340.54
Csengőd	0.46	1.11	1.11
Gipsy	1.67	2.46	1.11
Mediterranean area			
Maraska	188.49	195.97	222.28
Total (ha)	555.99	549.08	565.06

353.11 ha in the continental Croatia, and in the Mediterranean area 195.97 ha under integrated sour cherry production. During the investigation of the integrated production in 2015, there were 565.06 ha of sour cherry orchards recorded. In the continental part of Croatia during the third research year 342.78 ha were recorded. In the Mediterranean area, 222.28 ha under integrated sour cherry production were recorded. Areas under integrated sour cherry production are given in Table 1.

During 2013, professional supervision of the integrated sour cherry production was carried out on 34 farms. The largest number (20) of producers was in Osijek – Baranja County, and the lowest number, by 1 producer in each county: Virovitica – Srijem and Zadar. Results have shown that 33 of integrated producers in the continental part of Croatia were engaged in sour cherry production. In 2014 research of the integrated sour cherry production was undertaken on a total of 35 farms. In the second season, the largest number (16) of producers was in Osijek – Baranja County, and the lowest number, by 1 producer in each county: Sisak – Moslavina and Virovitica – Podravina. In the continental part of Croatia during 2014, 29 producers were engaged in the integrated sour cherry production, while in the Mediterranean area there were 6 integrated sour cherry producers. In 2015, the professional supervision of the integrated sour cherry production included a total of 48 farms. During the third year of research, the largest number (17) of producers was in Osijek – Baranja County, and the lowest number (1 producer) was in Sisak – Moslavina County. Results have shown that in the third year of research, 33 producers in the continental area together with 15 producers in the Mediterranean area were engaged in the integrated sour cherry production.

After having carried out research of the integrated production it became clear that the sour cherry assortment consists of: Oblačinska, Cigančica and Csengőd cultivars, whereas in the Mediterranean area, Maraska cherry clones are grown. Sour cherry assortment representation, within the integrated production according to results, is given in Table 2.

Analysis of the IPM within sour cherry production revealed that the highest percentage of producers in the continental area controlled diseases: brown rot – blossom blight caused by *Monilia laxa*, shot hole caused by *Stigmia carpophila*, cherry leaf spot caused by *Blumeriella jaapii* and bacterial canker of stone fruits caused by *Pseudomonas mors – prunorum*. Referring to pest control, the highest share of producers controlled aphids *Aphidae spp.* and cherry fruit fly *Rhagoletis cerasi* (Daniel and Grunder, 2012). While controlling *Monilia laxa* following fungicides were used: copper oxide, cyprodinil, boscalid and carbendazim (Dubuis et al. 2012). Control of *Stigmia carpophila* was performed mostly by: captan, copper oxide, mancozeb and copper + calcium and zinc sulphide. Control of *Blumeriella jaapii* was performed mostly by: dodine, mancozeb and thiophanate methyl. Control of *Pseudomonas mors – prunorum* was performed by copper oxide. While controlling aphids, following insecticides were used: imidacloprid, pirimicarb and dimethoate. In cherry fruit fly control dimethoate was used. Figure 4 shows active pesticide substance usage within a certain percentage of producers aiming disease and pest prevention of sour cherry in the continental part of Croatia. Figure 5 shows active pesticide substance usage within a certain percentage of producers aiming disease and pest prevention of sour cherry in the Mediterranean area of Croatia.

Sour cherry weed management throughout three year research period included application of non – selective herbicides only: glyphosate and glufosinate. Thus, glyphosate usage share was 84% and of glufosinate was 16%.

Although the majority of producers in concerned vegetation seasons used registered plant protection products in accordance with prescribed doses/concentrations within the integrated sour cherry pest management, a few irregularities were recorded. During 2013, in the continental part of Croatia in Koprivnica – Križevci County on the single farm exceeded concentration of the active substance captan was recorded in *Stigmia carpophila* control. Moreover, in above mentioned County, pyrethroid usage was recorded on the single farm: active substance tau – fluvalinate in aphid control not allowed within IPM of sour cherry. In 2014 both, in the continental and in the Mediterranean part of Croatia it was found that four farms exceeded recommended concentration of copper fungicides. In the continental area in Osijek – Baranja County, concentration of copper hydroxide was exceeded when controlling sour cherry diseases during the winter dormancy. In the Mediterranean area in Zadar County, concentration of copper oxide was exceeded when controlling sour cherry diseases *Blumeriella jaapii* and *Pseudomonas mors – prunorum*. In 2015 research year, control of sour cherry diseases was performed with the plant protection products registered on sour cherry and allowed within IPM. However, deviations in this season have been noticed in the continental part of Croatia while exceeding the recommended concentration of plant protection products. Thus, in Požega – Slavonia County exceeding

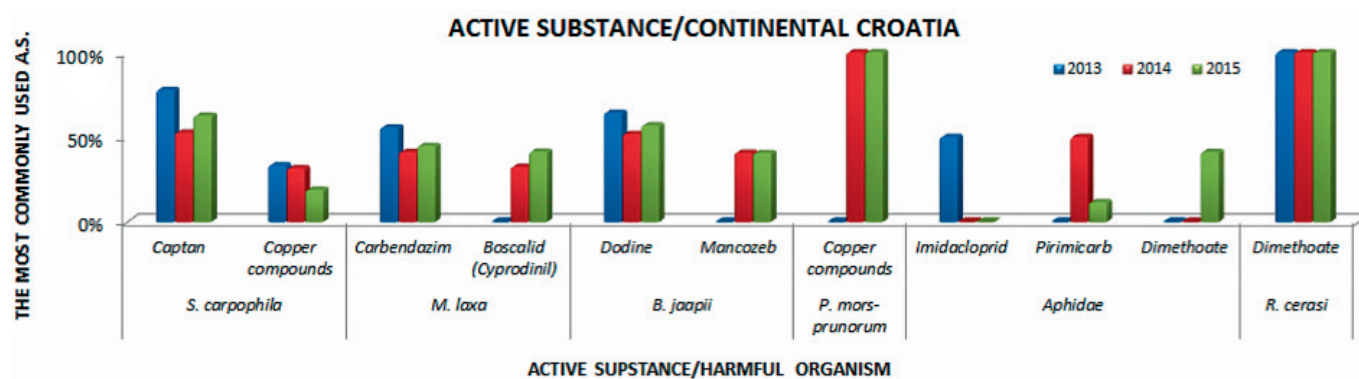


Figure 4. IPM pesticide usage in the integrated sour cherry production in the continental area of Croatia

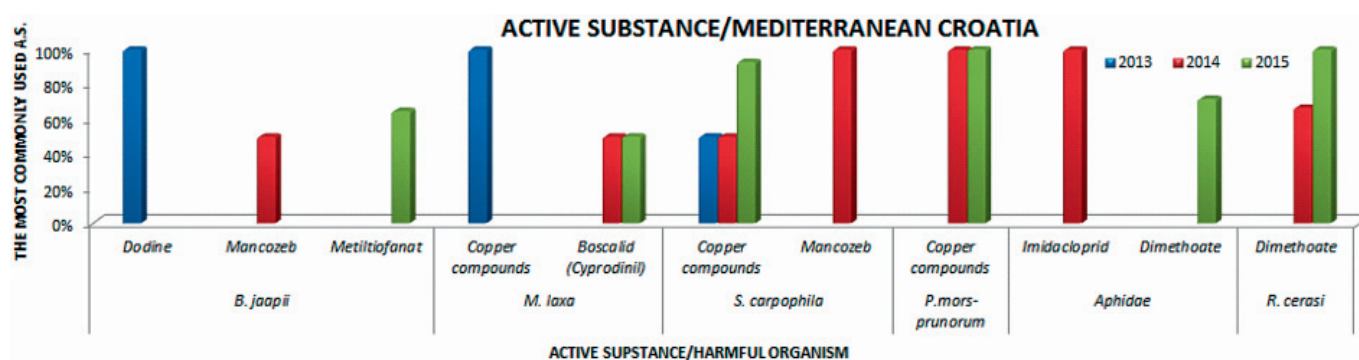


Figure 5. IPM pesticide usage in the integrated sour cherry production in the Mediterranean area of Croatia

Table 3. The implementation share of the listed requirements for maintaining biodiversity through the researched seasons

Season	Requirement 1	Requirement 2	Requirement 3	Requirement 4	Requirement 5	Total
2013	76.47%	70.58%	82.35%	82.35%	85.29%	79.14%
2014	83.78%	78.37%	91.89%	94.59%	94.59%	88.64%
2015	85.41%	79.16%	91.66%	93.75%	93.75%	88.75%
Total	81.89%	76.04%	88.63%	90.23%	91.21%	

Requirement 1 At least 5% agricultural areas are tillage – free and are kept as environmental infrastructure (drywalls, hedges, inter – row cover cropping); Requirement 2 Are implemented at least two measures for conservation of natural enemies and their habitats (bird houses, beneficial insects houses, etc.); Requirement 3 Safe distance between production area and sensitive habitats is ensured (buffer zones of water courses, water springs, ponds, protected species, etc.); Requirement 4 Soil fertility is maintained by adequate measures (liming, green manure, etc.); Requirements 5 various agro – technical, mechanical, physical, biological, biotechnical and other non-chemical plant protection measures are implemented.

was recorded in the usage of: mancozeb (on two farms), carbenazim (on two farms), boscalid (on a single farm), captan (on a single farm). In Osijek – Baranja County exceeded application of copper hydroxide was observed on a single farm. During the sour cherry pest treatment in above mentioned season, concentration of active substance dimethoate was exceeded while controlling *Rhagoletis cerasi* on a single farm in the continental part of Croatia and so was the situation with the single farm in the Mediterranean part of Croatia in Zadar County.

Safety and sustainability of the ecosystem is maintained by increasing biodiversity, which is achieved via prescribed

requirements related to: maintaining ecological infrastructure within at least 5% of the farm area, implementation of at least two measures for conservation of natural enemies and their habitats, ensuring a safe distance from production area and sensitive habitats, maintaining soil fertility with an adequate measures, implementation of agro – technical, mechanical, physical, biological, biotechnical and other non – chemical plant protection measures. The implementation share of the listed requirements for maintaining biodiversity through the researched seasons is given in Table 3.

Discussion

Research done on the integrated sour cherry production revealed that the areas under sour cherry as well as the number of sour cherry producers varied throughout investigated seasons. The number of producers is mostly proportional to the agricultural areas. Thus, the conducted research has shown an increase in areas under sour cherry in the Mediterranean area, whereas in the continental part of Croatia these parameters are in a decrease. Earlier sour cherry ripening in the Mediterranean area compared with the continental part of Croatia favors the higher market price of sour cherry and contributes to its stable repurchase. Providing advice and information, Advisory Service recorded the highest sour cherry production in Osijek – Baranja and Koprivnica – Križevci County in the continental Croatia. In these two counties, from one season to another (precisely), data obtained via professional supervision have shown decrease in areas under integrated sour cherry production. The reason for the above is in the low purchase price of a kilogram of sour cherries (3.80 kn) and delays in the payment of purchase up to two years. In Brod – Posavina County integrated sour cherry production regarding areas and the number of producers stagnates, while only in Požega – Slavonia County shows an increase in areas under sour cherry during the investigated seasons. One reason is in the favorable micro – climate hilly areas of Požega – Slavonia County. Another is motivation of young sour cherry producers, who accept modern trends in agriculture with the presence of local buyers.

Through this research, it was found that Oblačinska is the most commonly grown sour cherry cultivar in the continental part of Croatia, while in the Mediterranean area solely grown is Maraska cultivar. Massive growing of Oblačinska populations took place after 1970, while a year 1971 was a record year of Maraska production in Croatia (Medin, A., 1997). Croatian population of Oblačinska sour cherry is characterized by the presence of mixture of the related genotypes which came into existence by spontaneous mutations and as a result of environmental abiotic and biotic factors (Viljevac et al 2009).

The occurrence of all the harmful organisms recorded in the integrated sour cherry production is linked to favorable climatic conditions present during the studied seasons. Therefore, in all three seasons consecutively above average high temperature, with the shorter dry and longer humid periods during the growing season were recorded; this is also in accordance with the annual average air temperature measurements at the Observatory Zagreb – Grič in the period 1862 – 2015.

Disease occurrence in season 2013 was influenced by climatic conditions. During March and April 2013 deviation in the average precipitation measured was in the category rainy and very rainy. That favored the development of the disease *Monilinia laxa*, both in the continental and in the Mediterranean part of Croatia (Holb and Schnabel, 2005, Fazekas et al. 2014). There was no deviation in temperature or in precipitation during May in the continental area. Therefore, climatic conditions were favorable for cherry fruit fly (*Rhagoletis cerasi*) emergence (Kovanci and Kovanci 2006). During 2014, in the continental and in

the Mediterranean area, deviation in the average precipitation amounts, in late March and in April, has led to *Monilinia laxa* occurrence. Very warm and warm periods with precipitation from category normal and rainy in March and April, were favorable for the aphid (*Aphidae*) emergence. Season 2015 was different from the previous two, being characterized by normal precipitation, with a rainy spring. Therefore, the presence of harmful organisms also differed from the previous two seasons. Thus, disease *Blumeriella jaapii* significantly occurred in the continental and in the Mediterranean areas due to the warmer and rainy spring periods (Holb et al, 2010, Barić 2011). It is thereby also important to mention the aphid (*Aphidae*) emergence. The results have shown that the majority of producers (95%) used plant protection products allowed in the integrated sour cherry production and applied them in accordance with the prescribed doses and concentrations.

In this research it was observed the successful implementation of measures for maintaining biodiversity by the 86% of producers engaged in the integrated sour cherry production. The most represented measure was the implementation of various agro – technical, mechanical, physical, biological, biotechnical and other non – chemical plant protection measures. The reason for it was that producers had been educated on the importance of maintaining and increasing biodiversity. This research also confirmed beneficial effect of continuous education of producers in the integrated production.

Conclusions

Sour cherry production takes the fifth place in the overall fruit production in Croatia and the second place in the integrated fruit production in Croatia. Integrated sour cherry production in Croatia is the most represented in the continental area with Oblačinska cultivar being the most commonly grown sour cherry cultivar. Maraska cherry on the other hand is predominant cultivar in the Mediterranean area. Slight increase in the number of sour cherry producers and in areas under sour cherry was recorded in the Mediterranean area while in the continental area decrease in areas under sour cherry was observed. The most common harmful organisms were plant diseases *Monilinia laxa* and *Blumeriella japii* and the most important insect pest was *Rhagoletis cerasi*. Pesticide usage was in accordance with the IPM in 95% of producers whereas improper pesticide usage was observed in 5% of producers. Regarding improper pesticide usage, there was a single case of pyrethroid usage banned in the integrated sour cherry production recorded in 2013 in the continental part of Croatia. Otherwise, improper pesticide usage refers mainly to the fungicides allowed in IPM but used in exceeded concentrations and doses. Requirements for maintaining biodiversity were kept by 86% of sour cherry producers. Implementation of IPM had a beneficial effect on sour cherry production especially regarding pesticide application. It is necessary to continue education of producers primarily in order to improve overall sour cherry production and sour cherry quality. Moreover, it is important to stay up to date with innovative IPM approaches in order to minimize pesticide application and to increase biodiversity.

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