

INTEGRATED AND ORGANIC APPLE PRODUCTION

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SUMMARY: Implementation of Integrated apple production provides high yields of high quality and health safe fruits. If compared to the conventional fruit production, integrated production is environmentally acceptable because it sets specific approach to plant protection, nutrition and production technology. In order to provide apple export on European market, implementation of integrated production in Serbia is needed on the large scale. The paper presents integrated apple production on the plantation of „Atos Fructum“ company, located in Mala Remeta on Fruška Gora. Integrated fruit production allows strictly controlled application of synthetic chemicals, which are listed in Guidelines for integrated pome production (AGRIOS). On contrary, application of any synthetic chemicals in organic apple production is not allowed. Such approach eliminates any potential risk of chemicals application to the environment. Organic production principles point out the importance of apple cultivars with genetic resistance to pests and diseases. Since organic apple production in Serbia is very limited, the purpose of the paper is to point out the importance of organic concept and review its basic principles.

Key words: *apple trees protection, fertilization, fruit quality, resistant apple cultivars.*

INTRODUCTION

According to the quantity of production, it is apples that stand as the most important continental fruit. The world's annual apple fruit production in 2009 was 71.286.000 tons. Major apple producers are China (31.684 million tons), the United States (4,514 million tons), Turkey (2.782 million tons), Poland (2.626 million tons), Iran (2.432 million tons). The leading producers of apples in Europe are Poland (2.626 million tons),

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Italy (2.313 million tons), France (1,953,600 tons), Russia (1.596 million tons) and Germany (1.07 million tons), making apple production in Europe comprise 22.6% of the world's apple production. However, there is no clear statistic evidence on the production of apples in Serbia, but according to FAO, the annual apple production in this country is around 281,800 tones (FAO, 2009).

Apples are the leading fruit species in Vojvodina, and have recently had a significant part in the total export of agricultural products. Due to increasing market demands and the inclusion in the European market, fruit growers should accept new production technologies such as integrated and organic production which will ensure obtaining high quality yields (Keserović et al., 2011).

The consumption of apples in the European Union is relatively low (19 kg per capita), but it does vary, making the consumption in Denmark 45 kg per capita and in Romania 5 kg per capita (EUROSTAT, 2011). The annual consumption of apples in Serbia is 14.33 kg per capita (FAO, 2001-2003). Low consumption of apples means that there is a longer period of time between instances of eating apples. Thus, the memory of quality can play an important role throughout the next purchase (Hacker, 2001). In order to keep consumers opt for apples during the purchase of fruits, it is necessary to maintain a constant quality of production, as it is certain that the quality of the fruits has a significant effect on consumers' decision when purchasing (Keserović et al, 2003). Integrated and organic apple production can provide a constant quality in production which may provide apple growers with safe placement of fruit on the market. Integrated fruit production allows strictly controlled application of synthetic chemicals, which are listed in Guidelines for Integrated Apple Production (AGRIOS, 2011). On the contrary, application of any synthetic chemicals in organic apple production is not allowed. (Law on Organic Production, Službeni glasnik no. 30/2010). The aim of organic production is to meet the demands of preserving natural resources (Keserović et al., 2008). Due to the goals that organic agriculture is based on, the limited choice and mode of action of pesticides allowed in organic production, the fight against diseases and pests has its advantages over integral and conventional production.

INTEGRATED APPLE PRODUCTION IN ORCHARD OF “ATOS FRUCTUM” COMPANY IN MALA REMETA AND GROWING SYSTEM IN ORGANIC FRUIT PRODUCTION

PLANTING SYSTEM

Integrated production of apples in “Atos Fructum“ company in Mala Remeta is located on the northern slope of Fruška gora mountain. The orchard is established on monocultivar principle at a distance of 3.20 x 0.65 to 0.80 m. The monocultivar apple orchard means that there is only one cultivar in each plot in the orchard, whereas every 25th tree stands for a pollinator. When it comes to the orchard in Mala Remeta, its pollinators are either certain apple or wild species, resistant to two economically important diseases - powdery mildew and apple scab. Orchards like this provide lower production costs and therefore make the protection of apples and chemical thinning easier and more efficient, as well as fruit picking much faster.

In organic fruit production, the planting density has also increased during past several years, but on average, it is still lower than in integrated production. Organic production suggests greater distances between and within the rows (3.0 – 3.5 m x 1.0 – 1.3 m) than in the integral production (Lind et al., 2003), all of which in order to achieve better ventilation and exposure to light and easier and better protection from diseases. This sort of a high density planting system implies using M9 rootstock for standard cultivars, M26 rootstock for spur types and slender spindle canopy system.

CULTIVARS AND ROOTSTOCKS

The orchard in Mala Remeta consists of the following cultivars: Golden Delicious clone B and Reinders®, clones of Jonagold DeCosta and Wilton's Red Jonaprince, Granny Smith clone Challenger® Dalivar, Red Delicious clones Campspur, Sandidge, Top Red and Early Red One, Breaburn Mariri Red, Fuji Kiku 8 and Gala Schniga. The rootstock is a clone of the M-9 337 for standard cultivars and M-26 for spur type Red Delicious.

Similar to integrated apple production, the main rootstock in organic production is M9 (Lind, 2003). However, there are significant differences in choosing cultivars in integrated and organic apple production. Due to the principles it is based on, the organic production requires the planting of tolerant and resistant apple cultivars. The most acceptable way to achieve the aims of organic production is breeding and introduction of new cultivars with genetic resistance to pathogens. This means that the metabolic products of plants prevent infection and pathogen development. Such an approach reduces the treatment of plants with chemicals to minimum, makes the production cheaper, nutritive values of fruits higher and provides a healthy environment.

Breeders around the world mostly use *Malus floribunda* 821 germplasm (Siebold ex. Van Houtte) (V_f gene) in order to make apple cultivars resistant to apple scab. The gene encoding this resistance is dominant (vertical resistance), which means that there is a danger of pathogen mutations and loss of resistance. The resistance provided by the V_f gene was considered permanent for years, as it could not have been overcome at that time. However, new cultivars that carry the V_f gene have not been cultivated in large areas. Parisi and Lespinasse (1993) suggest the existence of another cultivar 6 which causes the apple scab and has brought to question the stability and resistance provided by the V_f gene. On the other hand, the researches conducted by Parisi and Lespinasse (1999) showed that cultivar 6 *V. inaequalis* has caused russetting on most of the cultivars containing the V_f gene. The researches of Bénaouf and Parisi (2000), however, imply that *M. floribunda* has another dominant gene apart from the V_f gene, and that it was marked as V_{fh} gene. The same authors suggest the existence of V_g dominant gene which is held responsible for resistance of the Golden Delicious to cultivar 7 which causes the apple scab.

There are a few more major genes used worldwide as donors of resistance to apple scab beside the V_f gene, and they are: V_r , V_a , V_b , V_{bj} i V_m from another *Malus* species (Gessler et al., 2006). These genes have been used in a breeding program for decades in order to create resistant apple cultivars. In time, however, new pathogen types have overcome the monogenic resistance (Parisi and Lespinasse, 1993, 1999). Durable disease resistance is one of the main objectives of apple breeding worldwide. In order to achieve durable resistance to apple scab in the breeding of new apple cultivars for or-

ganic production, it is necessary to combine polygenic and monogenic resistance (Kellerhals and Duffy, 2006).

Even though the principles of organic agriculture propose usage of resistant and less sensitive cultivars, most organic fruit growers opt for cultivars that do not belong to these groups, as well as the ones commonly used when we talk about conventional and integral production. It is because the resistant cultivars are of a poorer quality and storage capability (Weibel et al., 2007). Apart from Topaz, no other leading apple cultivars in the system of organic fruit production in Europe (Golden Delicious, Jonagold, Elstar, Gala, Braeburn) belongs to the group of resistant cultivars (Trapman, 2008). Also, there are leading cultivars in the field of organic production in South Tyrol, commonly used in conventional and integral production. They are: Gala, Braeburn, Golden delicious, Crips pink, Fuji. Topaz, Red Topaz and Santana represent cultivars potentially good for organic production because they contain the V_f gene, have solid storage capability and are of equal or even better quality than cultivars frequently used in conventional production (Trapman and Jansonius, 2006).

PRUNING AND THINNING

The integrated production in apple orchards in Mala Remeta has changed the ways of traditional pruning. As opposed to short pruning, the long pruning suggests that a two-year old branch – the carrier of the native tree – is not shortened during the second year. Instead, only growth competitors at its end get removed. Such pruning reduces the vigour of fruit trees, provides better floral buds formation, easier chemical thinning, better colour of the fruits and reduction of fruit drops. Appropriate pruning enables moderate vigor of trees which is desirable in organic farming as it makes controlling apple scab easier (Leser and Treutter, 2005; Rühmann et al., 2002).

Along with pruning, thinning apples is a pomotechnical measure which is used to control the crop load and to prevent biennial bearing (Keserović et al., 2007). A heavy crop load reduces flower bud initiation, resulting in low yields the following year (Keserović et al. 2005). Following the guidelines of integrated concept, two or three thinning bioregulators are applied and manual correction must also be provided in order to achieve the objectives in terms of size and fruit quality (Stopar, 2002; Link, 2000), thus increasing the proportion of extra and first-class fruits. Protection against codling moth is performed easily with sparse trees, where the fruits are not clustered. The usual bioregulators applied are naphthalene acetamide (NAD), naphthyl acetic acid (NAA) and benzyladenine (BA) (Keserović et al., 2011).

Ammonium (ATS) and potassium thiosulfate (PTS) are experimentally used in apple orchards in Mala Remeta as flower thinners since they are considered user-, environment- and consumer-safe (Milić et al, 2011). Flower thinning with ATS and PTS significantly decreases the number of fruits, while at the same time increases the average fruit weight, although the highest chemical rates (3% ATS, 1.5% PTS) retards fruit growth. ATS and PTS do not affect fruit shape and substance, but they definitely do increase starch degradation, total soluble solids content and titratable acidity. Based on the research of Milić et al. (2011), ATS and KTS may be recommended as the first step in a chemical thinning program.

In organic apple production, the usage of chemical-synthetic thinning agents for crop regulation is not allowed. There are several different ways of performing the thin-

ning operation in organic fruit production: manual thinning, mechanical thinning and chemical thinning with organic pesticides, as well as some other organic compounds. Given that manual thinning demands a huge number of working hours, this type of thinning is basically used as a correction measure after mechanical or chemical thinning only. Lime sulphur is used in organic production as a fungicide against apple scab on one hand (Kunz et al, 2008), while on the other hand it can also cause the thinning effect (Clever, 2006). In Switzerland, however, neither of the mentioned products is allowed. In a nutrition experiment in organic apple production, using the N-vinasse (a by-product of molasses) as a foliar fertilizer, Weibel et al. (2008) have accidentally discovered that N-Vinasse has a considerable thinning effect when applied during flowering period.

RUSSETING

Russeting is the formation of cork cells in the apple (*Malus × domestica* Borkh.) skin. For most apple cultivars appearance of russet is unfavourable as it results in a poorer fruit quality and substantial economic losses to growers. Golden Delicious, a very important apple cultivar grown in Serbia, is susceptible to russeting. In apple orchards in Mala Remeta, the influence of commercial agents based on gibberellins (GA4+7) and gibberellic acid and cytokinins (GA4+7 + BA) was examined to prevent the russeting on Golden Delicious clone B. Using these products is permitted in integrated production since their use is a practical method for prevention or reduction of the russeting incidence (Taylor and Knight, 1986) caused by climatic factors (Yuri and Castelli, 1998). In addition to preventing the russeting occurrence using phytohormones, it is possible to get bigger and elongated fruits (Barandoozi and Talaie, 2009) along with a better market price.

The biggest problem for organic apple growing, however, is the appearance and, in particular, the amount of russet on the fruit. While the usage of phytohormones is not allowed in organic fruit production, using copper for apple protection is probably the most important factor in russeting. When it comes to apple cultivar protection, it has been noticed that better results are obtained when copper gets replaced with sulphur, lime sulphur (Jong and Mass, 2008) or potassium bicarbonate (Mitre and Mitre, 2009). In addition to this, a product for the suppression of *Erwinia amylovora* based on yeast *Aureobasidium pullulans* has been registered in organic fruit production. This product is prone to lead to the formation of russet on fruits (Matteson Heidenreich et al., 1997).

FERTILIZATION

The system of fertilization in the apple orchard in Mala Remeta is established in accordance with the integral concept of production, particularly with the content analysis of mineral elements in plants and soil. Every three years one soil analysis and every year two foliar analyses are conducted to determine the amount of nutrients which should be added. Fertilization is done through the irrigation system whilst any correction is done by a foliar fertilizer. Given the fact that an irrigation system is installed in this apple orchard, the soil between rows is covered with grass and the soil in rows is treated with herbicides. To maintain the soil, a rotary mower is used, leaving grass mowed and in-rows treated with herbicides simultaneously.

It is not allowed to use readily soluble mineral fertilizers in organic production. Instead, it is possible to use farm-produced natural fertilizers (manure, compost), green manure, mulches, varied crop rotations and careful tilling of the soil. For new orchards it is necessary to choose sites with quality soil, especially in organic production, which must be of good quality with adequate organic matter content (Granatstein, 2000).

The biggest problem in organic production is fertilization during fruit bearing due to the fact that the amount of nutrients in organic fertilizer is not precisely dosed as in synthetic fertilizers, and the nutrients are released longer. Nitrogen is easily leaching from the rhizosphere and in the organic production nitrogen deficiency can be a problem (Rosen and Allen, 2007; Nagy et al., 2009). The low content of nitrogen in organic apple production is associated with weed competition and inadequate accessibility of nitrogen from manure and compost (Nagy et al., 2010).

Nevertheless, in an organic orchard, nutrients can be added to the soil though manure, compost, green manure as well as any other organic substances that are allowed in organic production. Nmin method should be used to determine precisely the annual amount of required nitrogen. The basic principle of this method is fertilizing in accordance with the real needs of fruit trees for nitrogen, thus achieving a good quality of fruits while avoiding the risk of using excessively high doses of nitrogen and preventing pollution.

APPLE TREES PROTECTION

Integrated fruit production allows strictly controlled application of synthetic chemicals, which are listed in Guidelines for integrated pome production (AGRIOS, 2011). The introduction of integrated apple production in the intensive growing system (mono cultivar blocks, antihail nets, irrigation, nutrition based on the analysis of soil and leaves, grass belts, dense planting, etc.) is changing the conditions for the appearance of diseases and pests. Being familiar with some useful entomoacarofauna as well as predator/prey relationship is a prerequisite for the introduction of integrated pest management in apples as means of protection are chosen according to these relations. In order to determine these relationships, several methods are used in integrated pest management: a visual overview of 50 branches, 50-branch shakings in entomological catcher, examination of 25 leaves on each variety, determining the number of insects on pheromone traps and determination of the economic damage threshold, the use of corrugated hunting traps to monitor development of *C. pomonella* and monitoring conditions of leaf wetness. The need for spraying is determined by the thresholds for spraying, set for the integrated protection as they are adjusted to predator/prey ratio. Thus, the threshold for treatment against phytophagous mites is 50-60% of leaves with mite presence, 15% of the peak shoots with colonies of *A. pomi*, 6 cumulative caught moths of *C. pomonella* during one week and so on. Each variety is strictly monitored at intervals of 10-14 days and eventually, if the orchard age is uneven, each block is monitored separately. Quantities of protection agents in most cases are determined by a meter of tree height per ha. While apple scab and powdery mildew were significantly suppressed before leaf wetness by combining contact and penetrative fungicide, fire blight (*E. amylovora*) is suppressed by reducing inoculum with agents based on copper. To conclude, this brings us to a total of 11 sprays being conducted with each cultivar on average.

Due to the principles on which the organic production is based, as well as the lim-

ited choice and modes of action of pesticides whose usage is allowed in organic production (all in favour of quality protection), it is necessary to:

- 1) obey the basic principles of planting organic orchard,
- 2) apply appropriate cultural measures,
- 3) preserve and introduce population of natural predators,
- 4) perform monitoring in the orchard, and
- 5) establish protection by using products allowed in organic production.

In order to prevent major apple diseases (*Venturia inaequalis*, *Podosphaera leucotricha*, *Erwinia amylovora*), it is possible to use products based on copper and sulphur in organic production. In addition, organic producers use lime sulphur at the moment when the fungus needs to germinate on the leaf surface (Jamar, 2008; Kunz et al., 2008). On the other hand, a wide range of viruses (Granulosisvirus CpGV), bacteria (*Bacillus thuringiensis*), plant extracts (azadirachtin, pyrethrin, quassia, rotenone), and other substances permitted in organic production can also be used so that the most important pests are repelled. In this matter, it is also important to introduce and preserve beneficial organisms such as earwig (*Forficula auricularia*), predatory mites (*Amblyseius andersoni*, *Typhlodorus pyri*), parasitoid wasp (*Aphelinus mali*), blue-tits and coal-tits (*Cyanistes caeruleus*, *Periparus ater*), as well as birds of prey.

CONCLUSION

The implementation of integral apple production would have an enormous impact on fruit production in Serbia as this modern type of technology enables reaching a high level of quality yields by using a minimal amount of pesticides. Given the various experiences throughout the years in Mala Remeta, integral production can be suggested as the best way of apple production in Serbia. However, the most acceptable way of achieving goals in organic production is creation and implementation of new cultivars that have genetic resistance to pathogens. Nevertheless, new cultivars which would be resistant or even more tolerant to some of the most important diseases and pests, but yet of the same quality as the leading ones in conventional production, are yet to be created. Together with this fact, it is the range and the mode of action of products used in organic production that make this type of production still less worth than conventional and integral production. Still, according to the demands of the European market and the advantages of agroecological conditions for apple breeding, more attention to apple organic production should be paid. It is inevitable for thorough research to be conducted before implementing new technology. Finally, to conclude with, it should be emphasized that different experiences from developed countries where organic production has been represented for years can undoubtedly prove handy in this matter.

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INTEGRALNA I ORGANSKA PROIZVODNJA JABUKE

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Izvod

Integralni koncept proizvodnje voća omogućava dobijanje visokih prinosa kvalitetnih i zdravstveno ispravnih plodova. U odnosu na konvencionalnu, integralna proizvodnja je ekološki prihvatljiva jer nalaže poseban pristup zaštiti, ishrani i tehnologiji proizvodnje voća. Da bi se obezbedio plasman na Evropsko tržište neophodno je intenzivirati uvođenje integralnog koncepta proizvodnje voća u Srbiji. U radu je predstavljen integralni koncept proizvodnje jabuke u zasadu „Atos Fructum“ u Maloj Remeti na Fruškoj gori. U integralnoj proizvodnji dozvoljena je strogo kontrolisana upotreba sintetičkih hemijskih sredstava, navedenih u Uputstvu Radne grupe za integralnu proizvodnju jabuke Južnog Tirola (AGRIOS). U organskoj proizvodnji, primena sintetičkih hemijskih sredstava nije dozvoljena. Ovakvim pristupom eliminiše se svaka potencijalna opasnost od primene hemijskih sintetičkih sredstava. Principi organske proizvodnje nalažu uvođenje sorti jabuke koje poseduju genetsku otpornost prema parazitima. Ovakav način proizvodnje u Srbiji je veoma slabo zastupljen, te se u radu razmatra značaj organske proizvodnje i dat je pregled osnovnih elementa organske proizvodnje jabuke.

Ključne reči: zaštita voćaka, ishrana voćaka, kvalitet plodova, otporne sorte jabuke.

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