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The Response of 'Golden Delicious' Apple Grafted on M 9 and MM 106 Rootstock to Chemical Fruit Thinning

Dragana Drobnjak[1]

[1]*Faculty of Applied Ecology - Futura, Belgrade, Serbia*

Abstract

The effect of plant growth regulator in early stages of fruit development is to slow or stop the growth of lateral fruits and to cause their early drop. Two commercial plant growth regulator formulations naphthalene-acetamide (NAD) and naphthaleneaceticacid (NAA) were used. The applied doses of plant growth regulator were in accordance with the manufacturer's recommendations, for Amidthin 100-130 g/hl and Nokad 20-25 ml/hl. The first treatment was applied after full bloom, and the second when central fruit was 9-12 mm in size. The biggest effect on fruit weight and size was recorded on treated Golden Delicious fruits grafted on M 9 rootstock. It was found that minimum number of fruits per branch was on M 9 rootstock. Also, the most pronounced effect of fruit thinning regarding fruit weight and size was on trees grafted on M 9. Results showed that fruits had decreased firmness and increased dry matter content. However, it did not show significant differences in values of iodine - starch test and acid content.

Key words: apple, thinning, chemicals, fruits

Introduction

Fruit production is one of the most important contributors in the total agricultural production of the Republic of Srpska. Selection of apple varieties for commercial cultivation is the basic question that arises before initiating to raise new plantations and must be in accordance with the climatic and soil conditions of the site (Keserović et al., 2012). Knowledge about different varieties of apple in the world, Europe and in our country is a prerequisite for the proper selection of varieties for planting. Growing apples in modern intensive plantations usually involves the application of long pruning. In the first years of establishment, long pruning increases the proportion of mixed buds, which significantly increases the yield potential (Mićić et al., 2005). High fruit load, however, significantly decreases formation and differentiation of flower buds. In the coming year, due to the small number of normally differentiated flower buds, fruit set is poor (Vulić et al., 2011).

Thinning of flowers and fruits is a regular pomological and technical measure in the intensive system of cultivation of apples. Flowers and fruitlets thinning increases fruit quality and differentiation of flowers and has become the standard measure of the manufacturing process of many fruit species (Wertheim, 1998). Fruit thinning is used for thousands of years, and has multiple benefits (Dennis, 2000).

Chemical thinning response depends on many factors such as treated variety, the type and concentration of the chemical thinner used, the environmental factors during and after application, tree factors, the timing of application, etc. Naphthaleneacetic acid (NAA) and ethephon have been widely used chemicals for apple thinning for many years, although they both give variable results in thinning response. Part of this can be attributed to a weather/ temperature dependent thinning response and to cultivar sensitivity as well (Wertheim, 2000). The effectiveness of ethephon also depends on flower/ fruitlets stage of development (Wertheim, 1997; Greene, 2002). Ethephon has demonstrated a good effect on return bloom in the following spring (Stopar, 2000). A disadvantage of NAA could also be its negative effect on fruit growth since NAA application may not increase the fruit size even though the thinning response occurred and crop load is substantially reduced (Ferree, 1996; Link, 2000; Stopar & Lokar, 2003). Some reports indicate that higher concentrations or late applications of NAA tend to depress the fruit size (Bound, 2001).

The main objective of this study was to investigate the effect of plant growth regulators on yield and quality of 'Golden Delicious' apples grafted on M 9 and MM 106 rootstock.

With proper use of plant growth regulators, our fruit producers would have continuity in the yield and quality of harvested products, and therefore greater market competitiveness in relation to the environment.

Material and Methods

The field trial was set up in eight years old apple orchards "Fruit Eco" in Gornji Podgradci, Gradiška municipality. Training form was solax with long pruning system and trees were not irrigated. The trees grafted on MM 106 rootstock were planted at 1.2 m within a row and 4 m between rows and trees grafted on M 9 rootstock were planted 4 m between rows and 1 m within a row. Apple trees grafted on M 9 rootstock were set up in ten repetitions with each tree representing one repetition. Ten trees grafted on M 9 rootstock were left as control in order to evaluate the efficiency of fruit thinners (Figure 1).

Fig. 1 Apple orchard on M 9 rootstock
Засад јабуке на подлози М 9

In addition, apple trees grafted on MM 106 rootstock were set up in ten repetitions, one tree representing one repetition. Ten untreated apple trees grafted on MM 106 rootstock were also left as a control (Figure 2).

Golden Delicious was the apple cultivar used in this trial. Plant growth regulator used for fruit thinning were Amidthin (*naphthaleneacetamide*) and Nokad (*naphthaleneaceticacid*).

Applied doses of plant growth regulator were in accordance with the manufacturer's recommendations, for Amidthin 100-130 g/hl and Nokad 20-25 ml/hl.

Fig. 2 Apple orchard on MM 106 rootstock
Засад јабуке на подлози ММ 106

Treatment dates were determined based on the average size of the central fruit on the fruiting branch. The first treatment was applied after full bloom, and the second when central fruit was 9-12 mm in size. Prior to the first treatment the average number of flowers per inflorescence was determined by sampling 20 branches of each variant and the control. The number of flowers and inflorescences were counted. The remaining number of fruits per fruiting twig was counted before the June apple drop and prior to harvest.

After the harvest, weight and size of the fruits were measured as well as the parameters of quality and maturity such as: dry matter content, acidity, firmness and starch iodine test. The effect of chemical thinning on the increase of fruit weight was determined based on the average weight of 15 fruit sampled per tree. Data were statistically analyzed by using analysis of variance (ANOVA). In order to compare the average values of the treatments in the cases where the analysis of variance showed significant difference among treatments, Duncan's multiple range test with critical value of 0.05 was used. Software STATISTICA 9 was used for statistical processing of the data (StartSoft Inc., Tulsa, USA).

Results and Discussion

Fruit set and the number of remaining fruits per branch were determined three times: before treatment, before June apple drop and prior to the harvest (Table 1). In terms of the number of remaining fruits per branch, best results were observed on rootstock M 9, where prior to June apple drop the average number of fruit per branch was one, and prior to the harvest 0.6.

Tab.1. The average number of treated and control fruits of 'Golden Delicious' apples per fruiting branch
Просјечан број третираних и контролних плодова "Златног Делишеса" по грани

Rootstock *Подлога*	The number of fruits before June fruit drop *Број плодова прије опадања у јуну*	The number of fruits before harvest *Број плодова прије бербе*
M 9 treated trees	1.0 a	0.6 a
M 9 control trees	1.5 b	1.1 c
MM 106 treated trees	1.0 a	0.7 a
MM 106 control trees	1.3 b	1.0 b

Note: means followed by the same letter within the same column are not significantly different according to Duncan's multiple range test at $P \leq 0.05$ level.

The effect of chemical thinning on the average fruit weight of 'Golden Delicious' grafted on M 9 and MM 106 rootstock is shown in Table 2. In all treatments the average value of the fruits weight was significantly greater compared to the control. The highest average fruit weight and the largest statistical differences were recorded with apple trees grown on M 9 rootstock.

Tab.2. Effect of chemical thinning on the average fruit weight of 'Golden Delicious' apples grafted on M 9 and MM 106 rootstock
Утицај хемијског проређивања на просјечну тежину плода "Златног Делишеса" калемљеног на подлоге М 9 и ММ 106

Rootstock *Подлога*	Average fruit weight (g) *Просјечна тежина плода (g)*	The increase in weight compared to the control (%) *Повећање у тежини у односу на контролу (%)*
M 9 control trees	106.5 a	-
M 9 treated trees	163.9 c	53.9
MM 106 control trees	113.5 a	-
MM 106 treated trees	152.9 b	34.7

Note: means followed by the same letter within the same column are not significantly different according to Duncan's multiple range test at $P \leq 0.05$ level.

The effect of chemical thinning on the fruit size increase was determined based on the average size of 15 fruits sampled per tree. Chemical thinning of 'Golden Delicious' apples on both rootstocks resulted in significant increase in fruit size, i.e. width and height (Table 3).

There were significant differences in fruit height between treatments and the control on both M 9 and MM 106 rootstock. However, there was no significant difference between the control plots of both rootstocks.

Tab.3. Fruit dimensions of 'Golden Delicious' apples grafted on M 9 and MM 106 rootstock
Димензије плода јабуке "Златног Делишеса" калемљене на подлогама М 9 и ММ 106

Rootstock *Подлога*	Fruit height *Висина плода*	Fruit width *Ширина плода*
M 9 control trees	56.7 a	60.7 a
M 9 treated trees	65.6 b	70.3 c
MM 106 control trees	57.7 a	62.8 b
MM 106 treated trees	65.2 b	70.7 c

Fruit firmness. Chemical thinning of 'Golden Delicious' resulted in lower fruit firmness compared to the control. The highest fruit firmness had control trees on M 9 rootstock, and minimum fruit from treated trees on MM 106.

Dry matter content. Higher dry matter content was achieved with chemical treatment compared to the control. The dry matter content in treatments with both tested rootstocks was 12.2 Brix.

Acid content. There was no significant difference in the acid content in treated fruits compared to control trees, and there was no difference in acid content among fruits from control trees on both rootstocks (Table 4).

Tab.4. Fruit firmness, dry matter content and acid content in 'Golden Delicious' apples grafted on M 9 and MM 106 rootstock
Тврдоћа плода, садржај суве материје и садржај киселина у плодовима јабуке "Златни Делишес" калемљене на подлоге М 9 и ММ 106

Rootstock *Подлога*	Fruit firmness *Тврдоћа плода*	Dry matter content *Садржај суве материје*	Acid content *Садржај киселина*
MM 106 treated trees	7.7 a	12.2 b	4.6 a
M 9 treated trees	7.9 a	12.2 b	4.5 a
MM 106 control trees	8.1 b	11.0 a	4.5 a
M 9 control trees	8.7 c	10.8 a	4.5 a

Note: means followed by the same letter within the same column are not significantly different according to Duncan's multiple range test at $P \leq 0.05$ level.

Conclusion

Plant growth regulators increased intensity of fruit drop and reduced the number of fruits per fruiting branch. Combinations of thinning agents may cause stronger thinning response than the compounds used separately (Wertheim, 1997). Combining BA and NAA caused overthinning of 'Empire' (Bukovac et al., 1994). A major advance in fruit thinning was the report by Burkholder and McCown that naphthalene acetic acid (NAA) applied at full bloom reduced fruit set of apple (Burkholder & McCown, 1941). By counting the number of fruits prior to harvest, it was determined that the lowest number of fruits per fruiting branch was on treated trees grafted on M 9 rootstock.

The fruit thinning is regularly applied in apple in order to achieve regular yield and uniform quality. Application of chemical thinners is justified for three reasons: they reduce biennial bearing effect, they reduce need for expensive manual thinning and they improve the quality of the remaining fruits (Vercamen, 1997). The biggest effect on fruit weight and size was recorded on treated Golden Delicious fruits grafted on M 9 rootstock. By combining preparations with NAA and NAD active matter, apple trees grafted on both rootstocks achieved fruits having a diameter over 65 mm.

Hess et al. (1996) present lower firmness and sugar content in chemically thinned apples. Johnson (1994) presents the increased fruit firmness as a direct result of the reduction in fruit number and yield. In this research plant growth regulator as chemical thinning agents significantly affect fruit quality parameters: firmness, value of iodine - starch test, sugar and acid content. There have been contradictory reports in literature due to a number of factors. Nevertheless, this research did not show any significant differences in quality parameters except the reduced fruit firmness and increased dry matter content.

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Утицај хемијског проређивања на плодове јабуке златни делишес гајене на подлози ММ 106 і М 9

Dragana Drobnjak[1]

[1]*Faculty of Applied Ecology - Futura, Beograd, Serbia*

Sažetak

Већина препарата за хемијско проређивање дјелује тако што нарушавају ендогени хормонски систем биљке и редукују транспорт ауксина ка латералним плодовима. Након употребе биорегулатора успорава се или зауставља пораст латералних плодова, те долази до њиховог опадања. За хемијско проређивање су кориштени препарати Amidthin (*naphthaleneacetamide*) и Nokad (*naphthaleneace-ticacid*). Примјењена доза Amidthin-a је 100-130 g/hl, а Nokad-a 20-25 ml/hl. Термини за третирање су одређени на основу димензије централног плодића у цвасти. Amidthin је примијењен у фази прецвјетавања, Nokad је примјењен када је централни плодић имао димензије од 9-12 mm. Пребројавањем плодова непосредно пред бербу је утврђено да је најмањи број плодова био на родним гранчицама третираних стабала на подлози М 9. Најизраженији ефекат на масу и крупноћу плода имали су третирани плодови на подлози М 9. У овом огледу третирани плодови су имали смањену чврстину и повећан садржај суве материје. Нису добијене значајне разлике у вриједности јодно-скробног теста и садржају киселина.

Кључне ријечи: јабука, хемијско проређивање, плодови

Dragana Drobnjak
E-mail address: dragadrobnjak@gmail.com

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