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Application of NAA and BA in chemical thinning of some commercial apple cultivars

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Abstract: This paper presents the fruit thinning response of some commercial apple cultivars to NAA and BA plant regulators. The experiment was designed to evaluate NAA applied separately at three concentrations – 13.2 ppm, 17.82 ppm and 26.73 ppm, and BA + NAA combinations (BA - 60 ppm, 100 ppm, 120 ppm or 140 ppm + NAA 4.29 ppm) for thinning the assessed apple cultivars. All treatments with NAA and BA + NAA adequately thinned 'McIntosh' and 'Jonathan', whereas the application of NAA 17.82 ppm and 26.73 ppm and the combined treatment BA 140 ppm+ NAA 4.29 ppm were effective fruit thinners for 'Prima'. In terms of the average fruit weight, number of fruits categorized as large (> 75 mm or > 65 mm), and number of fruit per trunk cross-sectional area, the treatment BA 140 ppm + NAA 4.29 ppm was most effective on 'McIntosh' and 'Prima', whereas BA 100 ppm + NAA 4.29 ppm had the best effect on 'Jonathan'.
Key words: alfa-naphthaleneacetic acid, benzyladenine, chemical fruit thinning.

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Introduction

For the fresh market, fruit size, appearance, flavor, firmness and storability are of main interest. The grower, therefore, will have to focus his/her orchard practices to satisfy these market demands in order to produce high quality fruit consistently at maximum yields. It is impossible to maximize all quality factors simultaneously due to their positive and negative interrelations (Link 2000). The chemical thinning of apple fruits is an extremely important management practice in profitable fruit production. Labor costs required for manual fruit thinning are reduced, but at the same time, fruit size and fruit quality are increased. Chemical thinning also provides a good yield potential for the following vegetation (Yuan and Greene 2000; Greene 2002; Petracek and Silverman, 2003). Apple flower buds become initiated 30 to 40 days after the period when gibberellins (GA) from developing seeds in growing fruits inhibit floral initiation (Ramirez *et al*., 2004). Therefore, fruit thinning should be performed within 28 days after full bloom to achieve a good fruit size and high return bloom (Koike *et al*., 2003).

Naphthalene-1-acetic acid (NAA) is one of the most common compounds for chemical thinning, although there are different data about its effectiveness, which can be partly explained by weather conditions, primarily temperature, and cultivar sensitivity (Wertheim 2000). Stopar (2002) states that the effectiveness of chemical thinning on 'Golden Delicious' with NAA-based compounds does not depend directly on the concentration of NAA. This report, despite the results of our research and the general knowledge related to synthetic phytohormones, does not diminish NAA effectiveness in fruit thinning. NAA is the most important and most common phytohormone used. Bound (2001) reported that late application of high concentrations of NAA and NAA has a negative effect on fruit size. Benzyladenine (BA) is a steadier and more effective thinning compound (tests were performed mainly on apples) because, despite yield reduction, it increases fruit size and provides regular yields (Greene *et al*. 1990; Ferree 1996). Link (2000) noted that the use of BA increased fruit size without affecting the spacing. In terms of the number of fruits per branchlet, fruit weight, fruit diameter and yield, the best chemical thinning results in apple cultivar 'Golden Delicious' were obtained using BA at a concentration of 200 mg / 1 (Milić *et al*., 2011). The increase in fruit size after BA application is achieved through stimulation of cell division (Wismer *et al*., 1995). Greene (1993) pointed out that the application of BA was most effective when central apple fruits were 10mm in diameter. Thinning with BA gave promising results in 'Golden Delicious Clone B'.

Further research on BA based thinning chemicals and their effects on fruit quality should be conducted under our apple growing conditions (Keserović *et al*., 2008).

The combined use of thinning compounds may result in more intensive thinning compared to a single application of plant regulators (Wertheim 1997).

Bukovac *et al*. (1994) reported that the combination of NAA and BA has the most excessive thinning impact on 'Empire'. In contrast, the combined application of NAA and BA ("tank mix spray") for 'Gala' and 'Golden Delicious' has no cumulative effect compared to single applications of these compounds (Stopar, 2002). Good results in terms of increasing the weight and diameter of fruits of 'Golden Delicious Clone B' were achieved using the BA + Dirager (3.3% NAA) combination (Vračević *et al*., 2008). With ' Summerred', the combination of the two compounds leads to an increase in fruit size (Stopar and Lokar, 2003), and inhibits fruit development in 'Delicious Red Chief' and 'Fuji' (Stopar and Tojnko, 2005). Marini (2002) stated that it was very difficult to adequately thin spur 'Red Delicious' trees, and that the use of NAA obtained satisfactory results in terms of fruit size and percentage of small fruits. The aim of this study was to examine the efficacy of plant regulators, NAA and BA, alone or in combination, in chemical thinning of 'McIntosh', 'Jonathan' and 'Prima' apple fruits.

Materials and methods

The experiment was conducted in 2010, in apple orchards on private land owned by the Šebek family, Bijelo Polje. The trees were five years old, grafted on 'MM 106' vegetative rootstocks. The trees were planted at a distance of 4m x 4 m. The training system used was pyramidal crown. Standard cultural and tree management practices were applied. The experimental design was a completely randomized block system with three replications, with each individual tree as one replication. In order to determine the yield potential of cultivars, we measured the diameter of each tree trunk at 20 cm above the graft union. The trees selected within each cultivar had consistent vigor and abundance of flowering (approximately 125-145 flowers per tree). The following thinning treatments were applied:

1. NAA 13.2 ppm (4 ml Dirager / l0 l of water);
2. NAA 17.82 ppm (5,4 ml Dirager / l0 l of water);
3. NAA 26.73 ppm (8,1 ml Dirager / l0 l of water);
4. BA 60 ppm (15 ml Gerba 4 LG / 10 l of water) + NAA 4.29 ppm (1,3 ml Di rager);
5. BA 100 ppm (25 ml Gerba 4 LG / 10 of water) + NAA 4.29 ppm (1,3 ml Di rager);
6. BA 120 ppm (30 ml Gerba 4 LG / 10 l of water) + NAA 4.29 ppm (1,3 ml Dirager);
7. BA 140 ppm (35 ml Gerba 4 LG / 10 l of water) + NAA 4.29 ppm (1,3 ml Dirager);
8. Control- no treatment.

The commercial names of the agents used to thin the tested apple cultivars were Dirager (NAA 3.3% w/v) and Gerba 4 LG (BA 4% w/v), and they were produced by the L. Gobbi, Italy.

Dirager (3.3% w/v) is an Alfa - Naphthylacetic acid based product, specifically used for fruit tree thinning. It can be used during a further advanced phase as to the use of amide (NAD) and it also removes excess fruit from trees, thus allowing better growth of the rest by improving their quality and breaking periodical rotation, which is typical of some cultivars. Red and yellow apples may be treated with Dirager (Reg. N° 7411, dated 18 February 1988, the Italian Ministry of Health).

Gerba 4 LG (BA 4% w/v) can be used for two different purposes i.e. harmonization of plant growth and fruit thinning of pome fruits. The application of Gerba 4 LG on apple and pear trees, in nursery and young plants, induces and improves lateral sprout growth, ensuring that plants anticipate fruit production, especially in varieties having low ramification potential. In 1-4 year-old nursery-grown plants, it increases the angle of insertion of principal branches. In productive pome fruit plants, its application has a chemical fruit thinning function, both on traditional varieties such as 'Golden' and 'Gala', and on more recent varieties such as 'Fuji' and 'Braeburn' (Reg. n° 12149, dated 14 April 2006, the Italian Ministry of Health).

In all treatments, 1 ml l ^{1} ō surfactant Belol was added. The treatments were performed using a Villager D-25 back atomizer with a 12 l tank volume. The application rate was an average of 0.5 l of solution per tree.

The treatments were conducted when the central fruit on the tree reached a fruit diameter of 8mm to 10 mm. An average sample of 10 fruits was taken from each tree at the stage of physiological maturity. Weight, height, and width of fruit were determined by conventional morphometric methods on a sample of 50 fruits. In all the cultivars, the following parameters were used: number of fruits per tree, number of fruits per unit cross-sectional area of the trunk (number of fruits • cm ō^{2}), total yield (kg • tree ō1), cropping coefficient (kg· cm ō^{2}), yield and number of fruits > 75mm (for 'McIntosh' and 'Jonathan'), yield and number of fruits > 65mm ('Prima'), average fruit weight (g) and the average size of the fruit. The differences between the means of the treatments were evaluated using LSD test at $P < 0.05$ and $P < 0.01$.

Results and Discussion

The research evaluated the effect of single or combined use of products based on NAA and BA in thinning the apple cultivars 'McIntosh', 'Jonathan' and 'Prima'.

'Prima'- The application of NAA did not have a significant effect in increasing the fruit weight of 'Prima' (Table 1).

Table 1. Pomological properties, yield and cropping coefficient of 'Prima' apple trees after the application of fruit thinning agents

Treatments	Fruit (average 2010 -2013)				Fertility (average 2010 - 2013)	
	Fruit weight (g)	Fruit height (mm)	Fruit width (mm)	Fruit shape index	Yield (kg• tree^{-1})	Cropping coefficient (kg· cm $^{-2}$)
NAA 13.2 ppm	120.1	54.8	65.3	0.84**	13.5**	2.1
NAA 17.82 ppm	135.3	59.5	68.0	0.87	6.8**	1.1**
NAA 26.73 ppm	139	58	69.0	0.84**	10.9**	1.7*
BA 60 ppm + NAA 4.29ppm	148.3**	65.1**	75.9**	0.85*	13.7**	2.1
BA 100 ppm + NAA 4.29ppm	109	55.1	63.5	0.86	16.2**	2.6**
BA 120 ppm + NAA 4.29ppm	141.8*	59.4	64.6	0.91**	12.9	2
BA 140 ppm + NAA 4.29ppm	156.8**	67**	74.5**	0.9**	12.2	1.9
Control	121.2	55.7	64.0	0.87	12.5	2
LSD 0.05*	18.1	5.09	6.48	0.019	0.50	0.22
LSD 0.01**	21.3	7.53	8.50	0.022	0.74	0.35

Significantly increased fruit weight resulted from the combined use of BA + NAA (treatments 4, 6 and 7), and its yield was not statistically different from the control treatment. In addition to increasing fruit weight, treatment 6 (BA 120 ppm + NAA 4.29 ppm) and treatment 7 (BA 140 ppm + NAA 4.29 ppm) led to a statistically significant increase in the fruit shape index.

A significant reduction in the yield of 'Prima' apple fruits was caused by NAA 17.82 ppm treatment. Significantly higher yield compared to the control was determined after the combined application of BA 100 ppm + NAA 4.29 ppm. Significantly lower total numbers of fruits per unit cross-sectional area of the trunk were found following the single application of NAA 17.82 ppm, and NAA 26.73 ppm and the combined application of 140 ppm BA + NAA 4.29 ppm. Treatment with BA 100 ppm + NAA 4.29 ppm resulted in a significantly higher total number of fruits per unit cross-sectional area of the trunk.

Number of fruits > 65 mm in treatments 1 and 2 as well as yield of fruits > 65 mm in treatment 2 were not statistically different in comparison to treatment 8 (control). All other treatments resulted in a statistically significant increase in the number and yield of fruits > 65 mm compared to the control (Table 2).

Table 2. Final fruit number per trunk cross-sectional area, fruit number, yield and cropping coefficient of >65 mm fruits of 'Prima' apple trees after the application of fruit thinning agents

Treatments	Average 2010 -2013		Average 2010 -2013	
	Fruit number per trunk cross-sectional area	Fruit number >65mm	Yield of >65mm fruits (kg· tree^{-1})	Cropping coefficient of >65mm (kg· cm $^{-2}$)
NAA 13.2 ppm	17.1	29	5.9 **	0.9
NAA 17.8 ppm	10 **	24	4.7	0.8
NAA 26.73 ppm	13.4 *	37 **	7.1 **	1.1 **
BA 60 ppm + NAA 4.29ppm	15.2	63 **	10.8 **	1.6 **
BA 100 ppm + NAA 4.29ppm	21.1**	35 **	6.1 **	0.9
BA 120 ppm + NAA 4.29ppm	15	46 **	9 **	1.3 **
BA 140 ppm + NAA 4.29ppm	13.4 *	60 **	12.3 **	1.8 **
Control	16.1	25	4.4	0.7
LSD 0.05	2.45	4.8	0.59	0.25
LSD 0.01	4.15	5.5	1.45	0.32

The effect of fruit thinning in 'Prima' was not observed after the combined treatment of BA100 ppm + NAA 4.29 ppm, resulting in a large number of fruits per unit cross-sectional area of the trunk and significantly lower average fruit weight in comparison to untreated trees. In 'Prima', we classified the fruits into the group of cultivars having fruits of 65 mm as opposed to the classification for 'McIntosh' and 'Jonathan' (75 mm). The same was performed for the purpose of this research, because 'Prima' belongs to the category of cultivars with medium-large fruit. 'McIntosh' and 'Jonathan' are classified as cultivars with large fruit.

'Prima' exhibited a positive relation between crop load and yield efficiency. In NAA treatments, the highest yield efficiency was in treatment 1 (NAA 13.2 ppm) and the lowest in treatment 2 (NAA 17.8 ppm). Treatment 3 (NAA 26.73 ppm) had an average yield efficiency, but the largest fruit size. Treatment 5 (BA 100 ppm + NAA 4.29 ppm) gave the greatest crop load and the highest yield efficiency. This is a good result. On the other hand, treatment 5 did not lead to an increase in the average size of the fruit, which was one of the goals of this paper. A greater number of small fruits was recorded in treatment 5, which had an impact on the average size of the fruit. Treatments 4, 6 and 7 resulted in lower yield efficiency and greater average size of the fruit. Conversely, treatment 5(BA 100 ppm + NAA 4.29 ppm) is not recommend for thinning in 'Prima' due to the

negative impact on fruit size. Therefore, in one case in our experiment, the positive effect of BA hormone application on the average fruit size was undermined. If the possibility of experimental error is rejected, this result can be considered a varietal response to treatment 5 (BA 100 ppm + NAA 4.29 ppm).

'McIntosh'- All treatments (individual application of NAA and combination of NAA + BA) in thinning 'McIntosh' led to an increase in fruit weight (Table 3).

Table 3. Pomological properties, yield and cropping coefficient of 'McIntosh'apple trees after the application of fruit thinning agents

Treatments	Fruit (average 2010 -2013)				Fertility (average 2010 - 2013)	
	Fruit weight (g)	Fruit height (mm)	Fruit width (mm)	Fruit shape index	Yield (kg• tree^{-1})	Cropping coefficient (kg• cm $^{-2}$)
NAA 13.2 ppm	162.6	64.2	81.3	0.79**	5.5**	0.9**
NAA 17.82 ppm	177.6**	65.4	78.4	0.83**	3.5**	0.6**
NAA 26.73 ppm	169.7	67.3	82.5	0.82	3.2**	0.6**
BA 60 ppm + NAA 4.29ppm	161.9	64.3	79.2	0.81	5.5**	0.9**
BA 100 ppm + NAA 4.29ppm	169.6	66	81.2	0.81	5.7**	0.9**
BA 120 ppm + NAA 4.29ppm	198.7**	70.1*	83.3	0.84**	4.7**	0.8**
BA 140 ppm + NAA 4.29ppm	194.7**	71.6*	86.2	0.83**	5.1**	0.8**
Control	154.5	64	79	0.81	6.5	1.1
LSD 0.05	17.4	6.01	7.25	0.014	0.48	0.12
LSD 0.01	20.3	8.95	9.45	0.018	0.65	0.18

A significant increase in fruit weight was determined after the single application of NAA 17.82 ppm (treatment 2), and after the combined application of BA + NAA (treatments 6 and 7). Treatment 2 (NAA 17.82 ppm) and treatment 6 (BA 120 ppm + NAA 4.29 ppm) resulted in a statistically significant increase in the fruit shape index. Yield, cropping coefficient and the total number of fruits per unit cross-sectional area of the trunk in all treatments were significantly lower than in untreated trees. However, the treatments that led to a statistically significant increase in fruit weight had greater values for the number and yield of fruits > 75 mm, except the treatment with NAA 17.82 ppm, which was not statistically different from controls (Table 4).

Table 4. Final fruit number per trunk cross-sectional area, fruit number, yield and cropping coefficient of >75 mm fruits of 'McIntos'apple trees after the application of fruit thinning agents

Treatments	Average 2010 -2013		Average 2010 -2013	
	Fruit number per trunk cross-sectional area	Fruit number >75mm	Yield of >75mm fruits (kg· tree^{-1})	Cropping coefficient of >75mm (kg• cm $^{-2}$)
NAA 13.2 ppm	6.1 *	27 **	4 **	0.6 **
NAA 17.82 ppm	3.9 **	15	1.8	0.2 *
NAA 26.73 ppm	3.9 **	18	2.4 **	0.4 *
BA 60 ppm + NAA 4.29ppm	2.9 **	18	2.1 *	0.3
BA 100 ppm + NAA 4.29ppm	6.1 *	18	2.6 **	0.4 *
BA 120 ppm + NAA 4.29ppm	4.5 **	24 **	4.2 **	0.6 **
BA 140 ppm + NAA 4.29ppm	4.8 **	22 **	4.9 **	0.7 **
Control	7.2	15	1.8	0.3
LSD 0.05	0.75	3.8	0.28	0.10
LSD 0.01	1.4	4.3	0.45	0.16

The individual application of NAA 13.2 ppm also resulted in a statistically significant increase in the number and yield of > 75 mm fruit, while the average weight of the fruits under this treatment was not significantly different from the control. 'McIntosh' exhibited a positive relation between crop load and yield efficiency.

'Jonathan'- The application of NAA and NAA + BA combination in all fruit thinning treatments of 'Jonathan' led to a statistically significant increase in fruit weight and a statistically significant decrease in yield and total number of fruits per unit cross-sectional area of the trunk in relation to the control (Table 5).

Table 5. Pomological properties, yield and cropping coefficient of 'Jonathan' apple trees after the application of fruit thinning agents

Treatments	Fruit (average 2010 -2013)				Fertility (average 2010 - 2013)	
	Fruit weight (g)	Fruit height (mm)	Fruit width (mm)	Fruit shape index	Yield (kg• tree^{-1})	Cropping coefficient (kg• cm $^{-2}$)
NAA 13.2 ppm	177.8**	66.2*	73.4	0.90**	7.5**	1.2**
NAA 17.82 ppm	205.4**	73.8**	84**	0.88	7.7**	1.3**
NAA 26.73 ppm	223.3**	76.1**	82.2**	0.93**	6.4**	1.1**
BA 60 ppm + NAA 4.29ppm	199.6**	70.4**	79**	0.89**	7.0**	1.2**
BA 100 ppm + NAA 4.29ppm	221**	73.7**	81.8**	0.90**	9.0**	1.5
BA 120 ppm + NAA 4.29ppm	229.1**	73.4**	79**	0.93**	8.8**	1.4**
BA 140 ppm + NAA 4.29ppm	219.1**	76.4**	83.6**	0.91**	3.8**	0.6**
Control	145.5	59.9	68.9	0.87	10.5	1.6
LSD 0.05	16.5	5.89	7.02	0.013	0.39	0.11
LSD 0.01	19.8	8.05	9.08	0.017	0.60	0.17

The use of 26.73 ppm NAA and the combined application of BA 120 ppm + NAA 4.29 ppm resulted in an increase in the fruit shape index (0.93). In all treatments, except NAA 13.2 ppm, the number and yield of fruits > 75 mm were significantly higher compared to the control where no set of fruit in the aforementioned categories was observed (Table 6).

Untreated trees had a higher number of fruits the average weight of which was lower than in treated trees. In the control, 'McIntosh' and 'Jonathan' also had higher yields per tree compared to the other treatments. In 'Prima' higher yield compared to the control was found after the combined treatment BA 100 ppm + NAA 4.29 ppm. All treatments with NAA and NAA + BA had a positive effect on fruit thinning in 'McIntosh' and 'Jonathan', and these individual treatments showed no statistically significant differences (as seen by the total number of fruits per unit cross-sectional area of the trunk).

A positive effect on thinning in 'Prima' was observed only after the single application treatments with NAA 17.82 ppm and NAA 26.73 ppm, and the combined use of BA140 ppm + NAA 4.29 ppm. Treatments with NAA 17.82 ppm caused a significant reduction in the total number of fruits per unit cross-sectional area of the trunk. 'Jonathan' exhibited a positive relation between crop load and yield efficiency. In treatments with BA + NAA, yield efficiency was highest in treatment 5 (BA 100ppm + NAA 4.29 ppm), and lowest in treatment 7

(BA 140 ppm + NAA 4.29 ppm). Treatment 3 (NAA 26.73 ppm) had an average yield efficiency. Treatment 5 (BA 100ppm + NAA 4.29 ppm) gave the highest values for both crop load and yield efficiency.

Table 6. Final fruit number per trunk cross-sectional area, fruit number, yield and cropping coefficient of >75 mm fruits of 'Jonathan' apple trees after the application of fruit thinning agents

Treatments	Average 2010 -2013		Average 2010 -2013	
	Fruit number per trunk cross-sectional area	Fruit number >70mm	Yield of >75mm fruits (kg· tree^{-1})	Cropping coefficient of >75mm (kg• cm $^{-2}$)
NAA 13.2 ppm	7.2 **	2	0.5**	0.1*
NAA 17.82 ppm	6.3**	38**	7.8**	1.3**
NAA 26.73 ppm	4.7**	26**	5.6**	0.9**
BA 60 ppm + NAA 4.29ppm	6.1**	26**	5.3**	0.9**
BA 100 ppm + NAA 4.29ppm	8.6**	36**	7.9**	1.3**
BA 120 ppm + NAA 4.29ppm	6.3**	19**	4.6**	0.7**
BA 140 ppm + NAA 4.29ppm	2.9**	20**	4.4**	0.7**
Control	12.1	0	0	0
LSD 0.05	0.9	3.9	0.22	0.09
LSD 0.01	1.6	4.4	0.40	0.12

Treatments with BA 140 ppm + NAA 4.29 ppm led to excessive fruit thinning in 'Jonathan', or a significant reduction in the total number of fruits per unit cross-sectional area of the trunk.

In intensive apple growing systems, chemical fruit thinning is necessary for regulation of crop load and biennial bearing. Chemical flower/fruit thinning in apple cultivars is a crop management practice. In order to reduce labor costs, enhance fruit size and return bloom, chemical fruit thinning is a regular practice in apple (Malus x domestica Borkh.) fruit production (Greene, 2002; Petracek and Silverman, 2003). Abscission of immature fruits occurs frequently, varying in magnitude every year depending on fruit set, climatic conditions during flowering, nutritional status, carbohydrate availability, plant hormonal balance, or any combination of these factors (McArtney, 2005).

In addition to plant characteristics, chemical thinning is affected by a large number of environmental factors such as weather conditions during and after treatment, cultivation systems and practices, the active ingredient applied,

formulation and application rate of the treatment, adjuvant, time and method of application (Keserović *et al* . 2008). Literature provides information on the effect of different plant regulators in the chemical thinning of apple cultivars from 'Red Delicious' (Marini 2002; Berlanga Reyes *et al.* 2008). The lowest fruit set was obtained with naphthalene acetic acid sprayed as a chemical thinner in 'Golden Delicious' and 'Red Chief Delicious', and sometimes fruit set was similar to that obtained with early hand-thinning (Berlanga Reyes *et al*., 2008).

In the experiment, after the treatments, the "pigmy" fruit phenomenon was not observed, which can be explained by the fact that the treatment was conducted when central fruits reached a diameter of 8-10 mm. Similar results in terms of the absence of "pigmy" fruits were reported by Stopar (2003), after the single and combined chemical thinning treatments with NAA and BA in 'Golden Delicious' and 'Gala'. The increase in the number of fruits > 75 mm in 'McIntosh' was caused by individual application of NAA 13.2 ppm and combined treatments BA 120 ppm + NAA 4.29 ppm and BA 140 ppm + NAA 4.29 ppm, while most of these fruits in 'Jonathan' were obtained in treatments NAA 17.82 ppm and 100 ppm BA + NAA 4.29 ppm. In 'Prima', the combined use of BA 60 ppm + NAA 4.29 ppm and 140 ppm BA + NAA 4.29 ppm led to an increase in the number of fruits > 65 mm. The results indicate that increasing the concentration of NAA in the examined commercial apple cultivars does not contribute to increasing the number of larger fruits.

The most important aspects of the results of this study can be applied to cultivar 'Jonathan'. The scientific team was able to influence fruit weight in this cultivar, which was followed by an insignificant decrease in total yield of the cultivar. This is of great importance because in our practical work we observed high fruit production of untreated trunks, with a large difference in fruit diameter in terms of fruit weight. The negative aspect the author wanted to improve for 'Jonathan', which in terms of biological characteristics has high yield efficiency, was the dominant presence of small fruits in relation to medium and large fruits in the total yield. The resulting fruit size harmonization at the expense of slightly reduced yield is considered a positive aspect. All treatments did not produce expected positive results; however, some of them were more than succesful.

Conclusion

All applied treatments with NAA and NAA + BA had a positive effect on fruit thinning in apple cultivars 'McIntosh' and 'Jonathan', in terms of fruit weight and number of fruits per unit cross-sectional area of the trunk. The positive effect of fruit thinning in 'Prima' was produced by single application treatments with NAA 17.82 ppm and NAA 26.73 ppm, and the combined application of BA 140 ppm + NAA 4.29 ppm. In 'McIntosh' and 'Prima', high thinning efficiency was exhibited by the combined treatment with BA 140 ppm + NAA 4.29 ppm, as seen through the average weight and number of fruits which were categorized as large

(> 75 mm or > 65 mm), and number of fruits per unit cross-sectional area of the trunk. In 'Jonathan', the combined treatment with BA 100 ppm + NAA 4.29 ppm led to the most efficient thinning. A satisfactory effect was achieved in the average fruit weight, number of fruits per unit cross-sectional area of the trunk and the number of fruits > 75 mm in 'Jonathan' after individual application of NAA 17.82 ppm.

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PRIMENA NAA I BA U PROREĐIVANJU PLODOVA NEKIH KOMERCIJALNIH SORTI JABUKE

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Rezime

U radu je prikazan efekat proređivanja plodova nekih komercijalnih sorti jabuke pomoću NAA and BA biljnih regulatora. Primenjene su sledeće koncentracije: NAA u tri koncentracije - 13,2 ppm, 17,82 ppm and 26,73 ppm; kombinacija BA i NAA (BA - 60 ppm, 100 ppm, 120 ppm or 140 ppm + NAA 4.29 ppm). Svi primenjeni tretmani sa NAA i BA + NAA su adekvatno proredili plodove kod sorti 'McIntosh' i 'Jonathan', dok je primena NAA 17,82 ppm i 26,73 ppm i kombinacija BA 140 ppm+ NAA 4.29 ppm bila efikasna kod 'Prima'. Što se tiče prosečne mase plodova i broja plodova iz kategorije krupnih (> 75 mm ili > 65 mm), kao i broja plodova po površini poprečnog preseka debla varijanta BA 140 ppm + NAA 4,29 ppm je bila najefektivnija kod sorte 'McIntosh' i 'Prima', a BA 100 ppm + NAA 4,29 ppm kod sorte 'Jonathan'.

Ključne reči: alfa-naftil sirćetna kiselina, benziladenin, hemijsko proređivanje plodova.