THINNING OF 'GALA' AND 'GOLDEN DELICIOUS' APPLES WITH BA, NAA AND THEIR COMBINATIONS

REDČENJE PLODIČEV JABLANE SORT GALA IN ZLATI DELIŠES Z BA, NAA IN NJUNIMI KOMBINACIJAMI

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IZVLEČEK

Sedem let stare jablane sorte Gala/M.9 in štiri leta stare jablane sorte Zlati delišes/M.9 smo redčili s 6-benziladeninom (BA) v koncentraciji 50 ppm, 100 ppm in 200 ppm, nadalje z 1-naftilocetno kislino (NAA) v koncentraciji 5 ppm, 10 ppm in 20 ppm, ter s kombinacijo obeh sredstev, to je z mešanico BA 50 ppm + NAA 5 ppm, ter BA 20 ppm + NAA 5 ppm. Sredstva za redčenje smo nanesli v času poprečnega premera plodičev 9-10 mm. BA in NAA sta redčili obe preskušani sorti značilno in s približno isto stopnjo trebljenja plodičev. Trebljenje plodičev po nanosu različnih koncentracij BA oziroma NAA ni bilo odvisno od uporabljenih koncentracij. Pridelek plodov večjega velikostnega razreda se je pri obeh sortah povečal pri vseh nanosih BA ali NAA. Pri sorti Zlati delišes smo opazili učinek koncentracij uporabljenega sredstva na poprečno težo plodov. Po nanosu večje koncentracije BA je bila tudi poprečna teža plodov sorte Zlati delišes večja. Obratno pa je nanos večje koncentracije NAA povzročil manjšo poprečno težo plodov (statistično neznačilno) sorte Zlati delišes. V primeru škropljenja mešanice BA + NAA, sta obe obravnavani sorti reagirali z enako intenziteto trebljenja plodičev, kot v primeru samostojnega nanosa enega od obeh sredstev. Povratno cvetenje je bilo značilno boljše pri vseh redčenih drevesih sorte Gala, pri sorti Zlati delišes pa se je nastavek cvetja izboljšal le po nanosih BA 200 ppm, NAA 5 ppm, NAA 20 ppm in pri mešanici BA 20 ppm + NAA 5 ppm.

KLJUČNE BESEDE: redčenje plodičev jablane, povratno cvetenje, NAA, BA

ABSTRACT

Apple trees, eight-year-old 'Gala'/M.9 and four-year-old 'Golden Delicious'/M.9 have been thinned with 6-benzyladenine (BA) 50 ppm, 100 ppm and 200 ppm, with 1-naphthaleneacetic acid (NAA) 5 ppm, 10 ppm and 20 ppm, and with the tank mix combinations of BA 50 ppm + NAA 5 ppm or BA 20 ppm + NAA 5 ppm, all at 9-10 mm fruitlet diameter. All applied concentrations of BA and NAA thinned both cultivars significantly and no significant difference was found between BA or NAA thinning action. No concentration response on thinning was observed with neither BA nor NAA application. All BA or NAA separate treatments caused yield of fruit to shift to bigger size class. The only concentration response effect was found on evaluation of mean fruit weight data on 'Golden Delicious'. The higher concentration of BA was used, the higher was the weight of 'Golden Delicious' fruit. On the opposite, the higher concentration of NAA was used, the lower was the weight of 'Golden Delicious' fruit (not significantly). When BA and NAA were sprayed on 'Gala' or 'Golden Delicious' as a tank mix combination, similar effect on thinning or fruit growth occurred comparing to BA or NAA when sprayed alone. Return bloom was enhanced on all thinned 'Gala' trees while flower formation of 'Golden Delicious' was better in the case of BA 200 ppm, NAA 5 ppm, NAA 20 ppm or tank mix spraying of BA 20 ppm + NAA 5 ppm.

KEY WORDS: apple thinning, return bloom, NAA, BA

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INTRODUCTION

Apple fruit trees frequently form too many flowers and set too much fruit to obtain regular marketable crops throughout the years. Alternate bearing and low fruit quality occurred on overcropping apple trees. Thinning of flowers or fruitlets improves fruit appearance and return bloom and has become a standard practice in the growing of many fruit crops [17]. Thinning of fruitlets by hand is often impossible due to labour cost and availability.

1-naphthaleneacetic acid (NAA) is an old thinning compound which is based on its hormonal action as a synthetic auxin. NAA performs best when applied to 7 to 10 mm fruitlet diameter [18]. The problem of this agent is that its effectiveness varies on the yearly basis [12]. NAA activity is ecologically dependent and overthinning was observed in some years [9,16]. In addition, some authors reported that the growth of fruit after NAA application was not enhanced enough if the thinning intensity in crown was considered [1, 5, 15]. Synthetic cytokinin 6-benzyladenine (BA) has recently been found to be a good thinning agent. BA thins fruitlets best at 10 mm fruitlet diameter and has a positive influence on return bloom [7, 8]. The advantage of BA as a synthetic cytokinin is its influence on hastened cell division so that the fruit enlargement should be greater than we could expect from its thinning action [4, 6, 19]. In 2001 BA was still not registered as a thinning agent in any of EU countries. The combination spraying of chemicals is sometimes recommended to get a stronger thinning response or to use lower rates of each thinner [7]. Multiple application or mixtures are sometimes used to adjust fruit load in case the initial rate does not remove enough fruit [3]. When the tank mix combination of NAA and BA was sprayed on Red 'Delicious' and ‘Empire’ apple trees, it resulted in severe fruit growth inhibition known as 'pygmy' fruit [2]. The European Working Group for Fruit Thinning searches for new environment friendly thinning methods with consistent performance. The concentration response of BA, NAA and a tank mix spraying with low concentrations of BA + NAA were investigated on the most important European cultivars. The trials conducted on ‘Gala’ and ‘Golden Delicious’ apple trees, described in this study, were part of the common European experiments.

MATERIAL AND METHODS

The experiments were conducted in the experimental orchard of Agricultural Institute of Slovenia, Brdo pri Lukovici, in 2000. Eight-year-old apple trees ‘Gala’/M.9 and four-year-old 'Golden Delicious' /M.9 of the same intensity of flowering and homogenous vigour were used. The trees were trained as slender spindle and ‘Golden Delicious’ had just started with full bearing. The crowns were about 1 m wide and 2 m high. Pest control and other orchard management were the same as for the production in the rest of this intensive orchard, only the chemical thinning was not performed. Both experiments were designed as a randomized block with seven replications and a single tree per plot.

The spraying treatments were as follows:

1.) Control – no thin
2.) Hand thin – at the time of June drop
3.) BA 50 ppm (Accel 2.8 ml / l water; Abbott Laboratories, Long Grove, USA)
4.) BA 100 ppm (Accel 5.6 ml / l water)
5.) BA 200 ppm (Accel 11.2 ml / l water)
6.) NAA 5 ppm (Nokad 0.125 ml / l water; Isagro, Mozzanica, Italy)
7.) NAA 10 ppm (Nokad 0.250 ml / l water)
8.) NAA 20 ppm (Nokad 0.500 ml / l water)
9.) BA 50 ppm + NAA 5 ppm (tank mix spraying of Accel and Nokad)
10.) BA 20 ppm + NAA 5 ppm (tank mix spraying of Accel and Nokad)

All thinning treatments were applied to 9.8 mm average fruitlet diameter for ‘Gala’ or 9.0 mm fruitlet diameter for ‘Golden Delicious’. Chemicals were applied on trees using a hand sprayer to the drip point with 0.5 l water per tree. The yield was estimated at harvesting time. Fruit was divided into two size category according to equatorial diameter smaller or bigger than 70 mm. The return bloom was estimated in the following year (1 = no flowers, 9 = snow ball). Data were subject to statistical analysis using the statistical program Statgraphics 5.0 (STSC, Rockville, USA). Analysis of variance and LSD for mean comparisons at $p = 0.05$ was used.

RESULTS

Cultivar Gala:

There was a strong need for thinning of 'Gala' trees. Just 7 % of fruit was in bigger size class (> 70 mm). Good results were obtained with hand thinning. We lost the yield but there was much more fruit from bigger size class (>70 mm). The fruit weight of hand thinned trees was 144 g on average (Table 1).

All BA treatments resulted in significant thinning (Table 1 - fruit no./cm^2). Although the average fruit weight was still not sufficient, fruit was shifted to bigger size class (fruit >70 mm). We could not observe any concentration response effect of BA on thinning or fruit size. The total yield (kg/tree) stayed unchanged in comparison to control trees.

Thinning of fruitlets after all three NAA applications was significant. Fruit became significantly bigger but the share of fruit from bigger size class was still insufficient. No concentration response of NAA on thinning or fruit size was observed (Table 1).

The tank mix spraying of BA and NAA influenced significant thinning of fruitlets. Fruit was shifted to bigger size class, similar to BA or NAA separate (alone) spraying treatments. The average weight of fruit was the biggest with the combination spraying probably because the tank mix thinning affected the strongest abscission too (Table 1 – not significantly comparing to BA or NAA separate treatments).

Return bloom was enhanced on all thinned 'Gala' trees.

Table 1: Final fruit number, total yield, yield of bigger fruit, mean fruit weight and the return bloom estimation of 'Gala' trees after the application of thinning agents.

Treatments [x]	Fruit [y] (no./cm^2)	Yield (all fruit) (kg/tree)	Fruit >70mm (kg/tree)	Mean fruit weight (g)	Return bloom (1-9) [z]
1) Control	20.6 c	17.7 bc	1.2 a	91 a	2.5 a
2) Hand thin	9.2 a	10.8 a	7.3 d	144 d	4.1 b
3) BA 50 ppm	15.7 b	16.4 bc	4.7 bcd	114 bc	4.5 bc
4) BA 100 ppm	15.6 b	16.4 bc	5.1 bcd	117 bc	4.5 bc
5) BA 200 ppm	16.1 b	16.4 bc	3.0 abc	111 bc	4.7 bc
6) NAA 5 ppm	16.7 b	15.8 bc	5.8 d	117 bc	5.7 cde
7) NAA 10 ppm	16.3 b	14.8 b	2.6 ab	107 b	6.0 cde
8) NAA 20 ppm	15.2 b	17.9 bc	5.2 cd	117 bc	6.5 cde
9) BA 50 ppm + NAA 5 ppm	14.6 b	15.4 bc	4.9 bcd	122 c	7.1 e
10) BA 20 ppm + NAA 5 ppm	14.9 b	18.4 c	6.5 d	123 c	5.1 bcd

[x] Mean separation within column by LSD multiple range test, P = 0.05.,
[y] Number of fruit on tree per square cm cross sectional area of trunk, measured 30 cm above ground,
[z] 1 = no flowering; 9 = abundant flowering

Cultivar Golden Delicious:

The need for thinning of this cultivar was strong. On non-thinned trees 83 % of fruit was in size class smaller than 70 mm. By hand thinning we enhanced the % of bigger fruit and increased mean fruit weight significantly. The total yield was not changed comparing to control trees because better fruit growth compensated for smaller amount of fruit per tree (Table 2).

Application of BA 50 ppm and 200 ppm thinned the fruitlet significantly, while the application of BA 100 ppm affected thinning to the border of significance. The share of fruit from bigger size class was enhanced significantly for all three BA treatments. Mean fruit weight was bigger and increased with the used amount of BA concentration (Table 2).

Thinning of fruitlets with NAA was mostly significant or on the border of significance. Fruit was shifted to bigger size class with all three sprayed concentrations. However, NAA 5 ppm spraying resulted in biggest yield of good-size fruit. Application of NAA 20 ppm did not enhance fruit weight as strongly as NAA 5 ppm spraying (Table 2).

Table 2: Final fruit number, total yield, yield of bigger fruit, mean fruit weight and the return bloom estimation of 'Golden Delicious' trees after the application of thinning agents.

Treatments [x]	Fruit [y] (no./cm^2)	Yield (all fruit) (kg/tree)	Fruit >70mm (kg/tree)	Mean fruit weight (g)	Return bloom (1-9) [z]
1) Control	14.8 d	15.5 ab	2.8 a	109 a	1.1 a
2) Hand thin	11.8 c	15.5 ab	7.7 bc	135 bc	1.5 ab
3) BA 50 ppm	10.3 abc	12.9 ab	9.1 bc	132 b	2.1 ab
4) BA 100 ppm	11.9 cd	16.1 b	6.9 bc	135 bc	1.7 ab
5) BA 200 ppm	8.0 a	12.1 a	8.3 bc	152 c	3.4 c
6) NAA 5 ppm	11.4 bc	16.2 b	10.0 c	140 bc	2.4 bc
7) NAA 10 ppm	10.1 abc	13.2 ab	6.3 b	139 bc	1.7 ab
8) NAA 20 ppm	12.7 cd	15.8 ab	7.4 bc	126 ab	2.5 bc
9) BA 50 ppm + NAA 5 ppm	10.7 abc	16.0 ab	8.3 bc	136 bc	1.9 ab
10) BA 20 ppm + NAA 5 ppm	8.8 ab	13.5 ab	8.6 bc	151 c	2.5 bc

[x] Mean separation within column by LSD multiple range test, P = 0.05.,
[y] Number of fruit on tree per square cm cross sectional area of trunk, measured 30 cm above ground,
[z] 1 = no flowering; 9 = abundant flowering

The tank mix spraying of both concentrations of BA in combination with NAA 5 ppm significantly effected the thinning of fruitlets. The percentage of fruit from bigger size class was significantly enhanced (Table 2).

Return bloom was very bad for non-thinned trees. Flower bud formation was significantly improved just in the case of BA 200 ppm application, NAA 5 ppm, NAA 20 ppm and with a tank mix spraying of BA 20 ppm + NAA 5 ppm.

DISCUSSION

Non-thinned trees of both cultivars in this experiment were overloaded. Therefore, only a small share of fruit was in bigger size class. The application response of BA and NAA was similar for both 'Gala' and 'Golden Delicious' apple trees. All applied concentrations of BA and NAA thinned significantly and no significant difference was found between BA or NAA thinning action (no. of fruit in the crown at harvest). All BA or NAA separate applications caused 'Gala' and 'Golden Delicious' fruit to shift to bigger size class significantly while the yield of the bigger size fruit was still not increased enough to meet the commercial demand. When higher concentration of BA or NAA was applied on the trees, neither agent acted as a stronger thinner. In similar experiment on 'Golden Delicious' [13], no influence on fruitlet abscission was found after BA 50 ppm application while BA 100 ppm thinned best. In the same experiment performed on 'Gala' [14], no significant thinning was found after the application of BA 50 ppm or BA 100 ppm, while on the other 'Gala' trial, BA 50 ppm thinned adequately and BA 100 ppm overthinned [10]. For both cultivars in this experiment no concentration response of BA or NAA was found neither for thinning (no. of fruit per tree / cm^2 trunk) nor for the yield of bigger fruit (>70 mm).

The only concentration response effect was found for the mean fruit weight data after BA application on 'Golden Delicious'. The higher concentration of BA was used, the higher weight of 'Golden Delicious' fruit was found. These results confirm the thesis of additional fruit growth (independent of thinning) after BA application [6,19]. The opposite happened with NAA spraying where the mean fruit weight of 'Golden Delicious' was decreased when the concentration of NAA was increased (not significantly). The inhibiting effect of NAA on fruit growth was found in the past on Redchief 'Delicious' [1] and on 'Jonagold' apples [15]. No inhibiting effect of NAA or the promoting effect of BA on fruit growth was found on 'Gala ' trees.

The tank mix spraying of BA + NAA thinned the fruitlets of 'Gala' and 'Golden Delicious' trees similar to that of BA or NAA separate spraying. The

yield of bigger size fruit was enhanced but not significantly more than when BA or NAA alone spraying treatments were applied. Similarly, the mean fruit weight after BA + NAA tank mix spraying of 'Gala' or 'Golden Delicious' was not significantly different from other treatments. The common belief is that the mixture spraying of thinning agents influences greater response than the separate application of thinners [7,11]. Similar experiments on 'Golden Delicious' with higher rates of both agents (BA 100 ppm + NAA 10 ppm or BA 50 ppm + NAA 10 ppm) overthinned experimental trees and the fruit growth did not follow the reduction of fruit number as expected [9,13]. Particularly strong thinning happened on 'Gala' after tank mix spraying of BA 50 ppm and NAA 10 ppm [14]. In our experiment no excessive thinning occurred and no pygmy fruit was found on 'Gala' or 'Golden delicious' after BA + NAA tank mix spraying.

During the three year long period of thinning 'Jonagold', 'Elstar' and 'Golden Delicious' trees with NAA 15 ppm or BA 50 ppm sprayed alone, the consistent response of both thinners on return bloom was not confirmed [12]. While some authors found a positive influence of BA on return bloom [7,8], in other trial the application of BA 50 ppm or BA 100 ppm did not increase the return bloom of 'Golden Delicious' trees [13]. In this experiment all spraying treatments significantly enhanced flower bud formation of 'Gala' trees, while on 'Golden Delicious' only BA 200 ppm, NAA 5 ppm, NAA 20 ppm and a tank mix of BA 20 ppm + NAA 5 ppm improved return bloom.

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