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## Effect of 6-benzyladenine application time on apple thinning of cv. 'Golden Delicious' and cv. 'Idared'

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### ABSTRACT

Apple thinning of cv. 'Golden Delicious' and cv. 'Idared' was studied after the application of 6-benzyladenine (BA) 100 mg l<sup>-1</sup> and 50 mg l<sup>-1</sup> respectively, applied at different time of blooming period and over a wider range of fruitlet diameter. When BA 100 mg l<sup>-1</sup> was applied on cv. 'Golden Delicious', significant reduction in final fruit number per tree was observed if applied at the end of blooming period or when fruitlet diameters were 6 mm, 15 mm or 20 mm, but thinning was not significant if applied at full bloom or at 10 mm or 25 mm fruitlet diameter. The share of bigger fruits of cv. 'Golden Delicious' (> 65mm) was increased at all BA application time treatments, but significantly only in the treatment of hand thinned trees. Regarding the BA applications carried out on cv. 'Idared', significant thinning response was noticed in the case of BA sprayed at the end of bloom and at 10 mm of fruit diameter. The mean fruit weight of cv. 'Idared' apples was increased significantly only if BA was applied at 10 mm fruitlet diameter. Although the thinning results were inconsistent for two studied cultivars it was demonstrated from the trial that BA could be active as a thinner if applied over a wider phenological interval, at the end of blooming period up to 20 mm fruitlet diameter.

**Key words:** apple (*Malus x domestica* Borkh.), 6-benzyladenine, flower thinning, fruit thinning, fruitlet diameter

### IZVLEČEK

#### VPLIV ČASA APLIKACIJE 6-BENZILADENINA NA REDČENJE PLODIČEV JABLANE PRI SORTAH 'ZLATI DELIŠES' IN 'IDARED'

Redčenje plodičev jablane smo proučevali po aplikaciji pripravka 6-benziladenina (BA) v koncentraciji 100 mg l<sup>-1</sup> pri sorti 'Zlati delišes' ter 50 mg l<sup>-1</sup> pri sorti 'Idared', škropljenega ob različnem času cvetenja ter pri različni velikosti plodičev. Pri sorti 'Zlati delišes' je tretiranje z BA vplivalo na statistično značilno zmanjšanje števila plodov ob obiranju, če je bilo izvedeno ob koncu cvetenja ter pri velikosti plodičev 6 mm, 15 mm in 20 mm, medtem ko v primeru tretiranja v času polnega cvetenja ter pri velikosti plodičev 10 mm in 25 mm redčenje ni bilo statistično značilno. Pri sorti 'Zlati delišes' se je delež plodov večjih od > 65 mm sicer povečal pri vseh časovnih BA aplikacijah, vendar je bilo povečanje deleža letih statistično značilno le v primeru obravnavanja z ročnim redčenjem. Pri sorti 'Idared' je tretiranje z BA v različnem času povzročilo statistično značilno redčenje pri aplikaciji BA ob koncu cvetenja ter pri 10 mm premera plodičev. Povprečna masa plodov ob obiranju pri sorti 'Idared' pa se je statistično značilno povečala le pri tretiranju z BA pri 10 mm premera plodičev. Kljub temu, da se rezultati redčenja razlikujejo pri posameznih BA obravnavanjih med proučevanima sortama, je iz poskusa razvidno, da je BA učinkovito sredstvo za redčenje plodičev pri uporabi v širšem fenološkem intervalu, od konca cvetenja pa do 20 mm premera plodičev.

**Ključne besede:** jablana (*Malus x domestica* Borkh.), 6-benziladenin, redčenje cvetov, redčenje plodičev, premer plodičev

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## 1 INTRODUCTION

Thinning of flowers or fruitlets is the most important technique in apple growing practice to improve fruit quality, increase return bloom and reduce biennial cropping (Link, 2000). Chemicals and their concentrations, the timing of their application, the environmental factors encountered before, during and after application as well as tree factors, they all influence the ultimate thinning response (Greene, 2002). The cytokinin 6-benzyladenine (BA) has been suggested to be used as an effective thinning compound for apples (McLaughlin and Greene, 1984). BA increased the fruit weight as a result of reducing crop load (Elfving and Cline, 1993; Ferree, 1996), but it also increased the fruit weight additionally, beyond the effect attributable to chemical thinning (Greene, 1993; Greene, 2005). BA influenced larger fruit size or weight by increasing the number of cells per fruit through the stimulation of cell division (Wismer et al., 1995). It is also well documented in the literature that thinning with BA had a positive effect on increasing return bloom the following year (Greene et al., 1990; Bound et al., 1991; Elfving and Cline, 1993; Wismer et al., 1995).

The studies have shown that both, concentrations and timing of application, can influence the thinning effectiveness of BA (Greene et al., 1990). Although it

was reported that BA had a thinning response over a wider range of fruitlet diameter (Elfving and Cline, 1993), it was mostly demonstrated that BA was the most effective when applied at about 10 mm of fruitlet diameter (Greene, 1993; Basak, 1996; Stopar and Lokar, 2003). However, the variable thinning response of BA may be attributed, partly, to the differences in environmental conditions at the time of application. Bound et al. (1997) indicated that BA thinning efficacy is dependent on temperature at the time of application, with the lower levels of thinning achieved when the temperature was low. Furthermore, when the average temperature during 10 days after treatments was higher than before the treatment, good thinning results were recorded compared to the results obtained when temperature decreased during the 10 days after treatments (Bubán and Lakatos, 2000).

The aim of this study was to evaluate the thinning efficacy of BA sprayed on two apple cultivars at various phenological stages, i.e. applied at different time of blooming period and over a wider range of fruitlet diameter.

## 2 MATERIAL AND METHODS

The experiments were conducted in the experimental orchard of Agricultural Institute of Slovenia on mature, 2.5 m high and 1.0 m wide apple trees of cv. 'Golden Delicious' / M.9 and cv. 'Idared' / M.9. The trees were planted at a density of 3300 trees per hectare and trained to a slender spindle form. Standard commercial practices for fertilization and pest control were performed during the experiments. The trees selected for the experiment were of similar growth vigor and bloom density, approximately 190-220 flower clusters per tree for cv. 'Golden Delicious' and 95-120 flower clusters per tree for cv. 'Idared'. The experiments were designed as a complete randomized block with six and eight replications for cv. 'Golden Delicious' and cv. 'Idared', respectively and a single tree as the experimental unit per treatment. Non thinned and hand thinned trees were compared with trees in which BA was applied at full bloom and at the end of the blooming period as well as at different fruitlet diameters (6 mm, 10 mm, 15 mm, 20 mm, 25 mm).

The treatments were sprayed at a BA concentration rate of 100 mg l<sup>-1</sup> for cv. 'Golden Delicious' and 50 mg l<sup>-1</sup> for cv. 'Idared' with the product Exilis (2% 6-benzyladenine, Fine Agrochemicals, Whittington, Great Britain). Spraying was performed to the drip point with a hand sprayer to whole tree. About half a liter of water per tree was used to fully wet the crown. Hand thinned treatment was done at the end of June drop. Fruits were collected at harvest, counted, weighed and graded by diameter into two size classes (<65 mm, >65 mm). The return bloom was estimated the following year at full bloom time with the scale 1 – 10 (1 = no flowers, 10 = snow ball). Data were statistically evaluated using analysis of variance (ANOVA) followed by means separation using Duncan's multiple range test at P= 0.05. All calculations were performed using the statistical program Statgraphics 5.0 (STSC, Rockville, USA).

## 3 RESULTS AND DISCUSSION

### 3.1 Cv. 'Golden Delicious'

Hand thinning performed at the end of June drop period reduced the final fruit number from 254 fruits (control) to 142 fruits per tree, i.e. for about 44 % (Table 1). The consequence was a significant increase in the mean fruit

weight for about 38 % and also the number of bigger sized fruits (fruits > 65mm) increased significantly compared to the control, non thinned trees.

Spraying of BA 100 mg l<sup>-1</sup> caused significant thinning of cv. 'Golden Delicious' (Table 1 – fruit no./tree) if BA

was applied at the end of blooming period or if applied when fruitlet diameters were 6 mm, 15 mm or 20 mm. If final fruit number per 100 flower clusters was taken into consideration there was a significant reduction as well as when BA was applied at the end of bloom or at 15 mm fruit diameter. The thinning response was not significant if BA was applied at full bloom or at 10 mm or 25 mm fruitlet diameter. The results obtained in this experiment with BA sprayed at 10 mm did not support the findings of many reports saying that the best application time coincides with about 10 mm stage of fruit development (Greene, 1993; Basak, 1996; Bubán and Lakatos, 1997). It is known that different factors like weather conditions, especially temperature, may influence the thinning efficiency (Williams, 1994; Green, 2002) and that BA needs high temperature for a good effect (Bound et al., 1997). This cannot be confirmed by our experiment, since high morning temperature (20°C) recorded at the time of 10 mm BA application and prolonged sunny weather on the day when the treatment was done did not induce appropriate thinning of cv. 'Golden Delicious'. However, it can be seen from our results that BA can be effective as a thinner, if applied at a very wide phenological interval, since significant thinning was obtained if BA was used at the end of bloom time and later at 6 mm fruit diameter as well as at greater fruitlet diameters (15 mm and 20 mm), which could be very interesting for the practice.

BA applications did not have any significant influence on the total yield per tree or on the mean fruit weight at all application time treatments performed when compared to the non thinned trees (Table 1). Only hand thinning resulted in significantly greater mean fruit weight and enhanced the share of bigger fruits. The mean fruit weight of BA treated apple trees of cv. 'Golden Delicious' did not increase significantly irrespective of the time of BA application, even at the treatments in which BA significantly reduced the final fruit retention. According to the literature this is quite unusual since BA has been shown to increase the fruit size even in the absence of fruit thinning (Greene, 1993; Wismer et al., 1995; Basak, 1996). A possible reason for such small mean fruit weight could be found in dry weather conditions present in the studied year. However, the share of bigger size fruits (> 65mm) was enhanced on BA applied trees, but not significantly.

Return bloom estimated the following spring showed very low bloom density for cv. 'Golden Delicious' even

for the treatments, in which significant thinning occurred the previous year, with the exception of the treatment applied at 6 mm fruitlet diameter, the return bloom of which was slightly but significantly better compared to the control (Table 1). However, very high crop load, likely too high in some thinned trees, could be the reason for unsuccessful flower bud formation on experimental trees.

### 3.2 Cv. 'Idared'

BA thinning experiment on cv. 'Idared' showed an even weaker thinning response than that on cv. 'Golden Delicious'. Hand thinning of cv. 'Idared' was done according to the needs, the final fruit number was reduced almost to the half and the mean fruit weight was increased (Table 1). There was a significant reduction of the total yield as well.

BA treatments applied on cv. 'Idared' at different time of blooming period and at different size of fruitlet development at the concentration of 50 mg l<sup>-1</sup> caused significant thinning response only if treated at the end of the bloom or at 10 mm fruitlet diameter (Table 1 – fruit no./tree) while there was no significant thinning for the remaining BA time application treatments. Although there was a weak increase of cv. 'Idared' mean fruit weight at different time of BA application treatments compared to the control, it was not significant, except for the application performed at 10 mm fruitlet diameter. Anyhow, the mean fruit weight was still insufficient and does not satisfy the commercial demand. The total yield as well as the yield of bigger fruits (> 65mm) of all BA treatments did not differ significantly compared to the control trees (Table 1).

In comparison with cv. 'Golden Delicious' better return bloom was estimated for cv. 'Idared', although only the treatment, in which BA was applied at the end of the bloom showed significantly better return bloom compared to the control (Table 1). Considering that the size of the trees of both cultivars was approximately the same, the trees of cv. 'Idared' had only a half of flower clusters per tree when starting the experiment and also the final fruit retention was about half of that compared to the trees of cv. 'Golden Delicious'. This could be the reason for much better return bloom observed on the trees of cv. 'Idared'.

## 4 CONCLUSIONS

It was observed in the experiments performed that inadequate thinning occurred for both cultivars and that

it may result in insufficient mean fruit weight as well. This could be influenced by the dry weather conditions

present at the studied year. Also, BA applied at fruit size of 10 mm showed inconsistent thinning results for the two investigated cultivars, since thinning was poor at 10 mm application for cv. 'Golden Delicious', but it was significant for cv. 'Idared'. However, it was demonstrated that BA can be active as a thinner in a

wider period of phenological stages, from the end of bloom up to 20 mm of fruit diameter and not mainly around the 10 mm stage of fruit development as indicated by many reports.

**Table 1:** The number of flower clusters per tree when starting the experiment, the final fruit retention, yield and fruit quality parameters at harvest and return bloom in cv. 'Golden Delicious'/ M.9 and cv. 'Idared'/ M.9 thinning experiments

Cultivar / Treatment *	No. flower clusters/tree	Fruit (final)		Yield (kg/tree)	Mean fruit weight (g)	Fruit number > 65mm	Return bloom (1-10)
		no./tree	no./100 clusters				
<b>'Golden Delic.'</b>							
No thinning	218 a	254 d	121 c	18.7 ab	74 ab	10 a	1.0 a
Hand thin	190 a	142 a	75 a	14.5 ab	102 c	59 b	1.2 ab
BA full bloom	218 a	255 d	116 bc	19.4 b	74 ab	38 ab	1.0 a
BA end of bloom	217 a	190 abc	89 ab	16.0 ab	88 bc	38 ab	1.3 ab
BA Ø = 6 mm	197 a	185 abc	94 abc	15.2 ab	83 ab	38 ab	2.3 b
BA Ø = 10 mm	203 a	213 bcd	108 bc	15.7 ab	73 ab	23 ab	1.7 ab
BA Ø = 15 mm	207 a	174 ab	89 ab	13.9 ab	80 ab	22 a	2.0 ab
BA Ø = 20 mm	203 a	195 abc	98 abc	13.5 a	70 a	12 a	1.3 ab
BA Ø = 25 mm	202 a	243 cd	120 c	19.2 b	78 ab	44 ab	1.5 ab
<b>'Idared'</b>							
No thinning	103 ab	119 c	120 b	11.3 b	96 ab	54 ab	3.5 abc
Hand thin	110 ab	68 a	64 a	8.3 a	124 d	47 a	2.9 ab
BA full bloom	120 b	126 c	107 b	11.7 b	93 a	53 ab	2.7 ab
BA end of bloom	100 ab	89 ab	95 b	9.5 ab	110 bcd	52 ab	5.6 d
BA Ø = 6 mm	106 ab	109 bc	107 b	11.9 b	110 bcd	63 ab	4.9 cd
BA Ø = 10 mm	97 a	89 ab	92 b	10.0 ab	115 cd	61 ab	4.9 cd
BA Ø = 15 mm	111 ab	109 bc	102 b	11.5 b	106 abc	59 ab	2.4 a
BA Ø = 20 mm	103 ab	120 c	120 b	12.3 b	102 abc	69 b	4.1 bcd
BA Ø = 25 mm	110 ab	116 c	106 b	12.1 b	104 abc	69 b	2.8 ab

\* Mean separation within column by Duncan's multiple range test, P = 0.05

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