

THE EFFECT OF ETHEPHON, NAA, BA AND THEIR COMBINATIONS ON THINNING INTENSITY OF 'SUMMERRED' APPLES

UČINEK ETEFONA, NAA, BA IN NJIHOVIH KOMBINACIJ NA REDČENJE PLODIČEV JABLANE SORTE SUMMERRED

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ABSTRACT

The chemical thinning of 'Summerred'/M.9 was investigated on three years old apple trees. The application of ethephon 200 ppm was done at the start of flowering time, 6-benzyladenine (BA) 100 ppm and 1-naphthaleneacetic acid (NAA) 10 ppm was applied at 10 mm fruitlet diameter and the combination spraying of these thinners was done as a multiple (ethephon + BA, ethephon + NAA) or tank mix (BA + NAA) application. The alone application of ethephon or NAA reduced the final fruit number but did not enhance the mean fruit weight, similar as the consecutive (multiple) application of ethephon and NAA. On the contrary, when BA was applied (alone or in combination with ethephon) a nice fruit growth happened after the thinning of fruitlets. The tank mix spraying of BA + NAA reduced the fruit number adequately and the fruit growth was enhanced. The strongest thinning (overthinning) occurred when ethephon spraying was followed by the mixture of BA and NAA three weeks later. Significantly better return bloom was observed in the case of BA and NAA alone application, ethephon + BA, BA + NAA and ethephon + BA + NAA treatments.

KEY WORDS: apple thinning, 6-benzyladenine, 1-naphthaleneacetic acid, ethephon

INTRODUCTION

Chemical thinning of apple fruitlets increases the percentage of the first class fruit and promotes the annual cropping. 1-naphthaleneacetic acid (NAA) and ethephon have been widely used chemicals for apple thinning purpose for many years [19]. Both, NAA and ethephon were not the best thinning agents due to a negative effect on fruit growth as it was observed in certain reports [10]. Some authors reported that the growth of fruit after NAA application was not enhanced enough if the thinning intensity in crown was considered [2, 17]. Thinning with NAA could cause severe fruit growth inhibition known as 'pygmy' fruit on Red 'Delicious' [7] or 'Fuji' apples [11]. This effect was greater on lateral fruits, and on fruits with intraspor fruit competition [3]. Bound [4] indicated that at higher concentration or later application timings both NAA and ethephon were likely to depress the fruit size.

Recently, a synthetic cytokinin 6-benzyladenine (BA) was found as a good apple thinning agent [8, 20]. In addition to that and independently of its thinning action, BA enhances the growth of apple fruit [9]. The higher concentration of BA was used (from 50 to 200 ppm) the higher was the 'Golden Delicious' fruit weight [15].

The combination spraying of fruit thinning agents mostly resulted in a strong thinning response [18]. Multiple application or mixtures are sometimes used to adjust the fruit load when the initial rate does not remove enough fruit [5]. Overthinning might occur if 'Jonagold' was thinned with the highest level of NAA (10 ppm) followed by ethephon (50 ppm) while the same applications thinned 'Pink Lady' much lighter [12]. The tank mix application of BA and NAA at 10 mm fruitlet diameter could cause overthinning or the inhibition of apple fruit growth [1]. BA and NAA produced independent and additive thinning response when tank mix was used for spraying 'Empire' apples [6].

The aim of the experiment was to observe the thinning intensity of apple cultivar Summerred after the application of ethephon, NAA and BA thinning agents in the common rate and time. The single application of these agents was compared with the consecutive application of ethephon (sprayed at bloom time) followed by NAA or BA at 10 mm fruitlet diameter. The experiment was conducted in the frame of EUFRIN (European Fruit Research Institute Network).

MATERIAL AND METHODS

Three years old 'Summerred'/M.9 trees were selected according to high bloom density and homogeneous growth vigor. In the field trial a standard randomized block design with eight replications and a single tree per plot were used. The treatments were as follows:

- 1) Non thinned
- 2) Hand thinned (done at June drop time)
- 3) Ethephon 200 ppm (4.2 mL Ethrel / 10 L water - Chromos, Zagreb, Croatia)
- 4) BA 100 ppm (56 mL VBC 30001 / 10 L water - Valent Biosciences Corp., IL, USA)
- 5) NAA 10 ppm (2.5 mL Nokad / 10 L water - Isagro, Mozanica Italy)
- 6) Ethephon 200 ppm + BA 100 ppm
- 7) Ethephon 200 ppm + NAA 10 ppm
- 8) BA 100 ppm + NAA 10 ppm (*tank mix*)
- 9) Ethephon 200 ppm + BA 100 ppm + NAA 10 ppm

The times of chemical application were: a) 20 % flowering (the king flower was opening) for ethephon applications and b) the stage of 10 mm fruitlet diameter for NAA and BA applications. The spraying was done with a hand sprayer to the point of drip. No surfactant was used. When ethephon was combined with NAA or BA spraying, first, ethephon was applied at 20 % of full flowering and later, after the fruitlets enlarged to 10 mm mean size, NAA or BA was applied. At maturity time the fruit was harvested, counted, weighed and graded into two size classes, < 68 mm and > 68 mm of fruit diameter. Fruit russeting was estimated visually; 1= no russet on the skin; 9 = near all the fruit is covered by russet. The return bloom was estimated visually next spring at bloom time using the scale 1-9 (1 = no flower clusters present on the trees; 9 = abundant flowering / snow ball). During the experiment the trees received standard pest and disease management program. Data were subjected to analysis of variance (ANOVA) using the statistical program Statgraphics 5.0 (STSC, Rockville, USA). ANOVA was calculated as randomised complete block design and means were separated using Duncan's multiple range test at P= 0.05.

RESULTS AND DISCUSSION

The control (non-thinned) trees were overloaded so the mean fruit weight was low and just 1/3 of the

apples were bigger than 68 mm fruit diameter (Table 2). Hand thinning reduced the yield and consequently the mean fruit weight was enlarged significantly (Table 2). The alone spraying of ethephon 200 ppm applied when the king flower was opened, reduced the final fruit number per tree while the fruit weight was not enhanced significantly. Similarly, in a three years thinning experiment with ethephon (300 ppm) on 'Jonagold', 'Elstar' and 'Golden Delicious' the fruit growth did not follow the thinning effect adequately [13]. When 'Gala' trees were sprayed with ethephon 150 ppm at petal fall time, the mean fruit weight was even smaller comparing to the non thinned control [14]. Our thinning experiment proved the statement that ethephon is not a very good thinner.

A strong thinning effect comparable to hand thinning treatment occurred in the case of BA 100 ppm alone or NAA 10 ppm alone spraying (both at 10 mm

fruitlet diameter) and in the case of successive spraying of ethephon 200 ppm followed by BA 100 ppm application (Table 1). In the case of BA treatments (when BA was sprayed alone or in combination with ethephon) a very nice fruit growth happened after the thinning of fruitlets (Table 2). A strong influence of BA on apple fruit growth was reported from many other experiments [9, 20]. On the contrary, when NAA 10 ppm was sprayed alone the fruitlets were thinned, but this does not enhance the growth of the remaining fruit significantly. Consequently, the yield was reduced to the half. The inhibition of fruit growth after the application of NAA was proved by other researchers [2, 3, 17]. Similarly, when ethephon 200 ppm was followed by NAA 10 ppm, thinning occurred (on the border of significance) while the fruit growth did not follow this thinning effect.

Table 1: Bloom density at starting the experiment and final fruit number of Summerred / M.9 apple trees after the application of thinning agents

Preglednica 1: Gostota cvetenja dreves ob nastavitvi poskusa ter končno število plodov sorte Summerred / M.9 po nanosu sredstev za redčenje plodičev jabolane

Treatment ^x Obravnavanje ^x	<i>Flower clusters</i> Število socvetij		Fruit (final) <i>ob obiranju</i>		<i>Plodovi</i>
	no./tree <i>št./drevo</i>	no./cm ² <i>št./cm²</i>	no./tree <i>št./drevo</i>	no./100 clust. <i>št./100</i>	no./cm ² <i>št./cm²</i>
1) No thinning (brez redčenja)	119 a	29,0 a	61 d	56 c	14,8 e
2) Hand thin (ročno redčeno)	108 a	28,4 a	36 abc	36 ab	9,8 abcd
3) Ethephon 200 ppm	110 a	27,1 a	47 c	45 bc	11,6 cd
4) BA 100 ppm	97 a	28,2 a	29 ab	31 ab	8,0 ab
5) NAA 10 ppm	102 a	29,4 a	32 ab	35 ab	8,9 abc
6) Ethephon 200 + BA 100	104 a	28,7 a	36 abc	36 ab	9,5 abc
7) Ethephon 200 + NAA 10	107 a	28,9 a	46 c	46 bc	12,7 de
8) BA 100 + NAA 10	114 a	29,2 a	42 bc	39 ab	10,6 bcd
9) Ethephon + BA + NAA	107 a	31,8 a	25 a	24 a	7,1 a

^x Mean separation within column by Duncan's multiple range test, P = 0.05.

^x Statistična razvrstitev poprečij obravnavanj z Duncanovim razvrstitvenim testom, P = 0.05

Table 2: Total yield, mean fruit weight, yield of bigger size fruit, russetting and the return bloom estimation of Summerred/M.9 apple trees.

Preglednica 2: Pridelek drevesa, poprečna teža plodov, pridelek velikih plodov, rjavost in ocena povratnega cvetenja sorte Summerred/M.9.

Treatment ^x <i>Obravnavanje^x</i>	Yield (kg / tree) <i>Pridelek (kg/drevo)</i>	Mean weight <i>Poprečna plodov (g)</i>	fruit Fruit > (g) (kg / tree) <i>Plodovi > 68 mm drevo)</i>	Russetting <i>Rjavost (kg / plodov (1 - 9)^y</i>	Return bloom <i>Povratno cvetenje (1 - 9)^z</i>
1) No thinning (<i>brez redčenja</i>)	6,6 c	110 a	2,8 ab	2,1 a	3,5 a
2) Hand thin (<i>ročno redčenje</i>)	4,7 ab	133 bc	3,3 ab	2,0 a	2,9 a
3) Ethephon 200 ppm	5,5 abc	119 ab	2,9 ab	2,4 a	5,0 ab
4) BA 100 ppm	4,5 ab	164 e	3,8 abc	2,7 ab	7,6 c
5) NAA 10 ppm	3,8 a	122 ab	2,2 a	2,8 ab	7,0 bc
6) Ethephon 200 + BA 100	5,7 bc	159 de	5,0 c	3,1 b	7,5 c
7) Ethephon 200 + NAA 10	5,5 abc	123 ab	3,3 ab	2,3 a	5,0 ab
8) BA 100 + NAA 10	5,9 bc	142 cd	4,3 bc	3,3 b	8,2 c
9) Ethephon + BA + NAA	3,8 a	159 de	3,2 ab	3,4 b	7,9 c

^x Mean separation within column by Duncan's multiple range test, P = 0.05.^x Statistična razvrstitev poprečij obravnavanj z Duncanovim razvrstitvenim testom, P = 0.05^y 1 = no russetting present; 9 = more than 90 % of fruit is covered by russet^y 1 = ni rjavosti; 9 = več kot 90 % površine plodu je rjava^z 1 = no flowering; 9 = abundant flowering^z 1 = brez cvetenja; 9 = izredno obilno cvetenje

The combination of NAA 10 ppm + BA 100 ppm sprayed at 10 mm fruitlet diameter was known as a really strong thinning procedure. This tank mix combination could cause a severe fruitlet abscission on 'Empire' or result in the highest percentage of small fruits and the lowest percentage of large fruits of Redchief 'Delicious' [1]. The lower rate tank mix application of both agents (NAA 5 ppm and BA 50 ppm) on 'Gala' or 'Golden Delicious' expressed no overthinning [15]. In our experiment, tank mix spraying of NAA 10 ppm + BA 100 ppm reduced the final fruit number suitably. Lower bearing trees were distinguished by better fruit growth so the total yield/tree was not diminished (Table 1, 2). No overthinning or 'pigmy' fruit was observed at harvest. The strongest thinning (overthinning) was observed after the sequence application of ethephon 200 ppm followed by the mixture of BA 100 ppm and NAA 10

ppm three weeks later. Consequently, the fruit growth was enhanced but the total yield/tree was still reduced. In like manner Stover et al. [16] indicated that multi-step application of thinning agents reduced the crop load and increased the fruit size significantly stronger compared to single applications.

Russetting of fruit was estimated at harvest. A significant but not much stronger russetting was noticed in the case of ethephon + BA, BA + NAA, and ethephon + BA + NAA treatments (Table 2).

Return bloom estimated next spring showed low bloom density for the control and hand thinned trees (Table 2). Better return bloom was seen on all chemically treated trees, while significantly better flowering was estimated on stronger thinned trees: BA and NAA alone, ethephon + BA, BA + NAA, ethephon + BA + NAA.

REFERENCES

- [1] Bukovac, M.J., Black, B.L., Hull, J., Stopar, M. 1994. Interaction between NAA and BA on cropping and fruit size in 'Delicious' and 'Empire' apples. *HortScience* 29: 472
- [2] Black, B.L., Bukovac, M.J., Hull, J. 1995. Effect of spray volume and time of NAA application on fruit size and cropping of Redchief 'Delicious' apple. *Scientia Horticulturae* 64: 253-264
- [3] Black, B.L., Bukovac, M.J., Stopar, M. 2000. Intraspur fruit competition and position influence fruit size at harvest and response to chemical thinning agents in spur-type 'Delicious' apple. *Acta Horticulturae* 527: 119-125
- [4] Bound, S.A. 2001. Managing crop load. In: *Crop management and postharvest handling of horticultural products, Volume I*, by Dris, R./ Niskanen, R./ Jain, S.M.; Inc. Plymoth, UK, Science Publisher, p. 89-109
- [5] Dennis, F.G. 2000. The history of fruit thinning. *Plant Growth Regulation* 31: 1-16
- [6] Elfving, D.C./ Cline, R.A. 1993. Benzyladenine and other chemicals for thinning 'Empire' apple trees. *J. Amer. Soc. Hort. Sci.* 118 (5): 593-598
- [7] Greene, L. 1943. Growth regulators and fruit set with Starking apples. *Proc. Amer. Soc. Hort. Sci.* 42: 149-150
- [8] Greene, D.W. Autio, W.R., Miller, P. 1990. Thinning activity of benzyladenine on several apple cultivars. *J. Amer. Soc. Hort. Sci.* 115 (3): 394-400
- [9] Greene, D.W. 1993. A review of the use of benzyladenine (BA) as a chemical thinner for apples. *Acta Horticulturae* 329: 231-236
- [10] Link, H. 2001. Significance of flower and fruit thinning on fruit quality. *Plant Growth Regulation* 31: 17-26
- [11] Jones, K.M., Koen, T.B., Bound, S.A., Oakford, M.J. 1991. Some reservation on thinning of Fuji apples with naphthaleneacetic acid (NAA) and ethephon. *New Zealand Journal of Crop and Horticultural Science* 19 (3): 225-228
- [12] Jones, K.M., Bound, S.A., Summer, C.R., Oakford, M.J. 1997. Preliminary examination of thinning strategies on young 'Jonagold' and 'Pink Lady' apples. *Australian Journal of Experimental Agriculture* 37 (3): 377-382
- [13] Stopar, M. 2000. Comparison of the most frequently used thinning compounds for the thinning of 'Jonagold', 'Elstar' and 'Golden Delicious' apples. *Res. Rep. Biot. fac. UL - Agriculture* 75-1:89-94
- [14] Stopar, M., Zadavec, P. 2001. New apple thinning agents and their combination evaluated on cultivar Gala. *Sodobno kmetijstvo* 34 (4): 154-158
- [15] Stopar, M. 2002. Thinning of 'Gala' and 'Golden Delicious' apples with BA, NAA and their combinations. *Journal of Central European Agriculture* 3 : 1-6
- [16] Stover, E., Fargione, M., Risio, R. Yang, X. 2002. Crop load reduction and fruit size following multi step thinning of 'Empire' apple. *HortScience* 37 (1): 130-133
- [17] Thomann, N., Botzner, B. 1996. Sind Spritzungen mit NAA für die Wachstumsregulierung geeignet ? *Obstbau Weinbau*, 33 (11): 304-306
- [18] Wertheim, S.J. 1998. Chemical thinning of deciduous fruit trees. *Acta Horticulturae*, 463, p. 445-462
- [19] Wertheim, S.J. 2000. Developments in the chemical thinning of apple and pear. *Plant Growth Regulation* 31: 85-100
- [20] Wismer, P.T., Proctor, J.T.A., Elfving, D.C. 1995. Benzyladenine affect cell division and cell size during apple fruit thinning. *J. Amer. Soc. Hort. Sci.* 120 (5): 802-807

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