

THE EFFECT OF ETHEPHON, NAA AND BA, USED SEPARATELY AND JOINTLY, ON THE EFFICIENCY OF THINNING IN APPLE TREES CULTIVARS JONAGOLD, GOLDEN DELICIOUS AND ELSTAR

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ABSTRACT

For illustration the effect of sequential thinning by use of different thinning agents the results of three experiments conducted in apple trees will be shown. The trials were conducted in 2002-2003 on cvs. Jonagold de Costa, Golden Deliciou and Elstar. The following substances were used for thinning: ethephon (in preparation Ethrel, 48% ethephon) at the beginning of bloom, NAA (as Pomonit Super 050 SL, 5% NAA in salt with triethanolamine) soon after bloom or on fruitlets of 10 mm, and BA (in Paturyl 10 WSC, 10%BA) at fruitlets 10-12 mm in diameter. They were used separately or sequentially for correction of thinning effect of preparation used in the same trees earlier. The effect on fruit set, yield, fruit size, red color and russeting as well as internal quality expressed by firmness and soluble solids of apple flesh at harvest, as well as on the subsequent blooming was evaluated.

INTRODUCTION

The thinning of fruitlets, despite being a procedure known for about a hundred years and carried out on a production scale in many orchards, still needs improvement. None of the thinning methods used to date has been ideal (Williams and Edgerton,1981;Wertheim,1998). Thus, there is a need to develop new methods which would eliminate or reduce all symptoms of adverse side-effects of fruitlet thinning . The main objective is to obtain results which are more repeatable, easier to predict and safe for the environment. Research such as that carried out by the European Group Working on Chemical Thinning, under the auspices of the European Research Institutes Network (EUFRIN), has served this purpose. Multiple application or mixtures of different thinning agents are sometimes used to adjust the fruit load when the additional rate used does not remove enough fruit (Dennis, 2000). Two or more thinner applications over thinning period is a good strategy since increasing the possibility of thinner application would coincide with favorable thinning weather. In Addition to that, multiple applications are safer because in this case less aggressive thinning treatments are generally used and the chance of over-thinning is reduced (Greene,2002, Stopar,2006). Numerous researchers have taken the trails to solve the thinning problem by subsequent use of preparations (Bound et al., 1993; Elfving and Cline, 1993; Greene and Authio, 1994; Webster and Spencer, 1999). The results of polish investigations on search of a safe and more efficient methods of thinning have been published earlier, too (Basak, 2000,2002,2004).

In this work the attempts have been made to sequential use the thinning agent available in Poland so that to increase their efficiency by the correction of thinning effect of preparation used in the same trees earlier, and to avoid over-thinning effects and to induce good blooming every year.

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MATERIALS AND METHODS

This paper contains the results of 3 experiments carried out in the Experimental Orchard of the Institute of Pomology and Floriculture in Skierniewice, Poland, in 2002-2003 in 6-year old 'Jonagold de Costa', 'Golden Delicious' and 7-year-old 'Elstar' trees grafted on M9 rootstocks. In 'Jonagold de Costa' and 'Golden Delicious' NAA at concentrations 10 and 20 mg/L or BA at concentrations 50 and 100 mg/L were used at fruitlets of 10 mm in diameter for correction of thinning by use of ethephon in dosis 200 mg/L at 20% opened

flowers. In trees of 'Elstar', belongs to more difficult for thinning of apple cultivar, the effect of extended program of subsequent thinning by use of ethephon, NAA and BA was evaluated. For correction the results of earlier thinning with ethephon the NAA alone, soon after bloom, BA at higher dosis (200 mg/L) alone or in mixture with NAA 10 mg/L were used at fruitlets of 10 mm in diameter. In 'Elstar' NAA was used soon after bloom (80% petals fallen plus 3 days). Moreover, the mixture of high dosis of BA (100 mg/L) with NAA 10 mg/L was used. The trees unthinned and hand thinned after June drop in the way as in commercial orchards were used for comparison.

Benzyladenine (BA) was used in the form of the Hungarian preparation Paturyl

10 WSC (10% a.i). Adjuvant Tween 20 was added to Paturyl. The source of ethephon was the preparation Ethrel (48% ethephon), made by Novartis in France. NAA (naphthylacetic acid) was used in the form of salt with triethanolamine in the preparation Pomonit Super 050 SL (5% a.i.), product of polish firm Agropak.

Each treatment method was tested on 6 trees (tree = replication) of similar height and bloom intensity. The trees were sprayed copiously with a lance up to run-off.

The effects of the treatments on the number and quality of fruit at harvest were evaluated according to the methods described by Basak (2000).

The results were statistically analyzed using analysis of variance and the significance of differences was assessed using Duncan *t* test at 95% probability level.

RESULTS AND DISCUSSION

High efficiency of subsequent use of different thinning agents in 'Jonagold de Costa' and 'Golden Delicious' trees was shown in presented here experiments. The subsequent use of thinning preparations allowed for more efficient regulation of fruit set, similarly as it was shown earlier by Basak (2004), Bregoli et al. (2006) and Webster and Spencer (2004).

Experiment 1. In 'Jonagold de Costa' trees none of the way of thinning caused significant reduction of fruit set (Table 1). However, subsequent use of NAA at both doses and BA at higher dose intensified a little fruitlets abscission in comparison to the use of ethephon, alone. The late use of NAA or BA at higher doses caused the significant decrease of total yield as compared with trees thinned by ethephon, only. Early use of ethephon caused only a little increase of fruit size. But additional spray of the same trees with NAA, especially at higher dose or with BA at higher dose caused significant increase of mean fruit weight to the same level as

in hand thinned trees. All thinning treatment improved size grading of the fruit, however, only subsequently treated with NAA and BA at higher doses showed the number of largest apples similar as in hand thinned trees. No distinct effect of thinning on red coloration of apples was found, however, the value of color index was higher in treated trees. The apples from hand thinned trees distinguished themselves in this respect. Thinning treatments caused a little reduction of russeting index, however, the apples treated with ethephon alone were russeted most intensively. Sequential use of ethephon with NAA, at both doses, and with BA at higher dose caused significant increase of firmness of apples at harvest as compared with trees treated with ethephon, only. However, only joint use of ethephon with higher dose of BA caused significant increase of soluble solids content as compared to control unthinned apples. Only apples from hand thinned trees showed the same amount of soluble solids. All thinning methods increased the number of flower clusters next spring. However, the trees after joint treatment with ethephon and BA at higher dose were blooming especially intensively.

Experiment 2. In experiment conducted in 'Golden Delicious' trees, it was found that: BA, independently of the dose, influenced much more the reduction of fruit set than NAA (Table 1). Also mean fruit weight was highest in case of joint use of ethephon with BA. Joint use of ethephon with NAA, but especially with BA improved index grading and caused significant increase of the number of largest apples, of diameter > 90 mm (Figure 2). Ethephon lightly reduced the number of apples with orange blush on > 50% but, opposite effect – significant reduction the number of green apples and increase in the number of apples with orange blush on > 50% was noticed after joint use of ethephon with higher dose of BA. Only ethephon used alone caused significant increase of the number of apples with russeting on less than 25% of surface. Joint use of preparations, but especially with BA at higher dose caused increase the height of apples, the effect of ethephon used alone was opposite. Most of treatments, with exception of ethephon jointly with higher dose of NAA, caused significant increase of firmness of 'Golden Delicious' apples. However, refraction value was highest for apples thinned by ethephon with highest dose of BA. All thinning treatments with chemicals significantly increased the intensity of flowering next spring, but especially intensive flowering was caused by sequential spray with ethephon and higher dose of BA.

In both cvs. joint treatment with ethephon and BA at higher dose distinguished from others. This treatment caused marked augmentation of apple size, the best colour and best 'internal' quality of fruits expressed by high firmness and refraction value. All thinning methods improved intensity of blooming the next spring, however, the trees of both cvs. were blooming most abundantly after joint treatment of ethephon and BA at a dose 100 mg/L. This way of thinning is willingly used in commercial orchards in Poland.

Experiment 3. In third experiment, conducted in 'Elstar' trees all chemicals used caused reduction of fruit set significantly as compared to unthinned trees. Only, subsequent use NAA and BA thinned at the same rate as hand thinning (Table 1). A little stronger thinning effect was found after use BA alone or as third treatment on trees sprayed earlier with ethephon and NAA and, after late use the mixture high dose BA with NAA. Subsequent use of high dose BA in trees sprayed earlier with ethephon caused overthinning. Most the ways of thinning caused significant increase of mean fruit weight (excluding effect of NAA used alone). The best effect was found after subsequent use NAA and BA, Ethephon + NAA + BA and mixture NAA with BA. Sequential use NAA with BA caused larger increase of fruit size than hand thinning, in spite the

same reduction of fruit set. All ways of thinning improved the distribution of apples in size groups (Figure 1). The best effect was found in treatments thinned sequentially. All thinning treatment caused significant increase the % of marketable apples (>70 mm in diameter). The worst results were found in consequence of use ethephon or NAA, alone. Significant reduction of total yield was found as the results of subsequent use ethephon and BA, after late use the mixture BA with NAA, and at less degree after use BA alone. The best effect was found after joint use NAA and BA.

The results of presented experiments have shown the high efficiency of subsequent use of different thinning agents in 'Jonagold de Costa' and 'Golden Delicious' apple trees. The subsequent use of preparations allowed for more efficient regulation of fruit set. In 'Jonagold de Costa' subsequent use of NAA caused more intensive reduction of fruit set in comparison to BA. However, in 'Golden Delicious' the effect of BA was more pronounced. The subsequent thinning caused distinct increase of mean fruit weight and improvement the distribution of apples in size groups. In both cvs. joint treatment with ethephon and BA at higher dose distinguished from others. This treatment caused largest increase of apple size, the best colour and best 'internal' quality expressed by high firmness and refraction value. All thinning methods improved intensity of blooming next spring. However, the trees of both cvs. were blooming most abundantly after joint treatment of ethephon and BA at dose 100 mg/L. In case of 'Elstar' trees the best thinning effect was found after subsequent use NAA (10 mg/L) and BA (200 mg/L) and, a little worse, if ethephon (200 mg/L) was followed by NAA (10 mg/L). The effect of BA alone at dose 200 mg/L was less pronounced.

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Table 1. The effect of thinning by use of ethephon, NAA and BA alone and subsequently or in the mixture

Treatment conc.mg/l	Fruit set (No. fruits/ 100 clusters)	Total yield (kg/tree)	Mean fruit weight (g)	Grading index ¹	Colour index ²	Russeting index ²	Shape of appes (Hight in mm)	Firmness at harvest (lb)	Soluble solids (%)	Blooming next year No.flower clusters/tree or in 5 ⁰ scale (1-no flowers) in 'Elstar'
JONAGOLD de COSTA/M9										
Control unthinned	65 a	25.6 ab	246 a	799	795	212	No. data	14.4 a	13.7 a	154 a
Hand thinned	69 a	28.6 ab	292 bc	861	880	178		15.3 bc	14.6 bc	238 a
Ethephon 200*	64 a	32.7 b	264 ab	823	848	189		14.7 ab	14.1 abc	280 a
Ethephon 200 + NAA 10***	49 a	26.6 ab	281 bc	844	841	197		15.5 cd	14.5 abc	325 a
Ethephon 200 + NAA 20	47 a	24.7 a	293 c	864	842	176		15.6 cd	14.1 abc	290 a
Ethephon 200 + BA 50***	65 a	31.6 ab	267 ab	862	822	180		15.2 bc	13.9 ab	276 a
Ethephon 200 + BA 100	55 a	24.5 a	302 c	851	816	181		16.2 d	14.9 c	489 b
GOLDEN DELICIOUS/M9										
Control unthinned	82 cd	36.5 c	193 a	633	187	276	74.3 abc	12.0 a	13.9 a	48 a
Hand thinned	84 cd	27.5 ab	216 bc	693	184	250	75.2 bc	12.4 ab	14.0 a	92 a
Ethephon 200*	71 bcd	34.0 bc	198 ab	634	168	263	73.3 a	13.1 bc	14.0 a	260 b
Ethephon 200 + NAA 10***	61 abc	28.4 abc	211 b	711	160	269	73.7 ab	13.3 c	13.7 a	270 b
Ethephon 200 + NAA 20	61 abc	30.3 abc	213 bc	706	182	283	75.3 bc	12.7 abc	14.5 a	334 bc
Ethephon 200 + BA 50***	50 ab	26.8 ab	231 cd	726	189	303	75.2 bc	13.0 bc	14.7 a	341 bc
Ethephon 200 + BA 100	44 a	22.7 a	237 d	745	190	264	75.6 c	13.5 c	15.5 b	474 c
ELSTAR /M9										
Control unthinned	68 d	36.9 e	126 a	368	554	No data	No data			1.25 a
Hand thinned	33 b	31.0 cde	149 b	538	655					1.42 a
Ethephon 200*	51 c	29.4 cde	142 ab	505	593					2.25 abc
NAA 10**	56 c	34.1 de	138 ab	497	652					1.67 ab
BA 200***	28 ab	24.7 abc	171 cd	593	635					2.67 abc
Ethephon 200* + NAA 10**	54 c	33.7 de	154 bc	551	594					1.58 ab
Ethephon 200* + BA 200***	22 a	18.1 a	187 d	635	562					2.92 abc
NAA 10** + BA 200***	35 b	29.4 cde	177 d	598	590					2.00 abc
Ethephon 200* + NAA 10** + BA200***	29 ab	25.9 bcd	176 d	592	576					3.67 bc
Mixture: BA 100 + NAA 10***	31 ab	21.3 ab	187 d	602	666					4.00 c

Explanation: Means in a given column marked with the same letters do not differ significantly, according to Duncan's test, P=0,05.

- *- preparation used at 20% opened flowers,
- ** - preparation used soon after bloom (80% petals fallen + 3 days)
- ***-preparations used when fruitlet diameter was 10 mm on old wood,

1-Grading index = [n1 x 1(<55) + n2 x 2(56-60) + n3 x 3(61-65) + n4 x 4(66-70) + ... + n10 x 10(96-100)]; n= fruit number at each class according to national standard in 5 mm weight classes;
2-Red colour/russeting index= [n1 x 1(class 1) + n2 x 3(class 2) + n3 x 5(class 3) + n4 x 7(class 4) + n5 x 9(class 5)]; n = fruit number in classes: 1=0%,2=<25%,3=26-50%,4=51-75%,5=>75% surface of red colour or russeted