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INFLUENCE OF AUXIN NAA AND ETHEPHON ON YIELD QUALITY OF APPLE (*Malus domestica* Borkh.) 'ŠAMPION' CV.

WPŁYW AUKSYNY NAA ORAZ ETEFONU NA JAKOŚĆ PLONU JABŁONI (*Malus domestica* Borkh.) ODMIANY 'ŠAMPION'

Abstract: The experiment was carried at the Experimental Station of Garlica Murowana near Krakow in 2006 and 2008. In 2007 the experiment was not conducted due to frost damages. The objects of the experiment were fourteen-year-old apple trees 'Šampion' cv. on MM.106 rootstock. The aim of the experiment was to evaluate the influence of ethephon (2-chloroethylphosphonic acid) and auxin NAA (naphthalene acetic acid) used in two terms and concentrations on the yield and fruit quality. First treatment was carried out at the end of flowering (80 % the falling petals), second when fruitlets' diameter was 12 mm. Two concentrations: 20 and 60 mg NAA · dm^{-3}, and 200 and 600 mg ethephon · dm^{-3} were used each time. Controlled trees were not sprayed. After fruit harvest total yield with division into five classes: apple blush, flesh firmness, extract content, acidity and pH were estimated.

Experiments showed that used preparations increased the number of fruit with more than 12 cm diameter and decreased the amount of small fruit in total yield. All used combinations increased pH of fruit juice in comparison with control. Used compounds did not show clear influence on fruit juice's extract contents. Used compounds did not have influence on fruit storage ability assessed.

Keywords: auxin, NAA, ethephon

Thinning of fruitlets is an essential treatment in modern apple orchards, which can guarantee high annual yield of good quality fruit. Commonly used preparations for thinning fruitlets are ethephon (*2-chloroethylphosphonic acid*) and auxin NAA (*naphthalene acetic acid*).

The aim of the experiment was to assess the effectiveness of these preparations, depending on the applied concentration and time.

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Material and methods

The experiment was carried out in the Experimental Station of Garlica Murowana near Krakow in 2006 and 2008. In 2007 the experiment was not conducted due to frost damages. The objects of the experiment were fourteen-year-old apple trees, 'Šampion' cv., on MM.106 rootstock. The study was conducted in six replications (one replication equals one tree).

The aim of the experiment was to evaluate the influence of ethephon (2-chloroethylphosphonic acid) and auxin NAA used in two terms and concentrations on the yield and fruit quality. First treatment was applied at the end of flowering (80 % the falling petals), and second when fruitlets' diameter was 12 mm. Two concentrations: 20 and 60 mg NAA · dm^{-3}, and 200 and 600 mg ethephon · dm^{-3} were used each time. Trees of control treatments were not sprayed.

During harvest the yield of each tree was sorted into four classes of grandiosity: 5–6, 6–7, 7–8 and above 8 cm in diameter. Fruit color was estimated visually by the percentage of fruit surface covered with blush. 25 fruit from class with diameter of 6–7, and 7–8 from each tree were evaluated. Firmness was measured on side color core blushing fruit. Total acidity of fruit juice (expressed as malic acid) and juice pH were measured in 25 fruit randomly selected from each combination. For statistical calculations the average for the whole fruit value was used. Fruit were stored in an ordinary cold for 4 months and after this period firmness, extracts content, pH and acidity of the juice were measured once again.

Results

Studies showed that there was no relation between the date of treatment and the effectiveness of preparations (Table 1).

Table 1

Percentage of incorporation of the fruit [%] depended on the date of the treatment as well as type and concentration of preparation

Specification	2006	2008
Term of treatments I	12.2 a*	5.3 a
Term of treatment II	13.9 a	5.9 a
Treatments		
Control	24.1 a	6.7 a
NAA 20 mg · dm^{-3}	14.3 b	6.1 a
NAA 60 mg · dm^{-3}	11.0 c	5.3 a
Ethefon 200 mg · dm^{-3}	14.3 b	5.7 a
Ethefon 600 mg · dm^{-3}	12.8 bc	3.6 b

Explanations: I – first treatment at the ending of flowering (80 % the falling petals), II – second treatment at 12 mm fruitlets; * Values marked with same letter do not differ significantly at $\alpha = 0.05$.

The effectiveness of treatment in the first and second term was at the same level. Both preparations showed similar effectiveness, and slight differences resulted only from applied concentration. In 2006 ethephon thinned most effectively when was used in higher concentration (600 mg dm^{-3}), however the same concentration of ethephon used in the second year of the experiment caused excessive thinning. Both products used in low concentrations showed similar efficacy. Studies showed that ethephon and auxin NAA applied in both terms increased the participation of fruit with diameter larger than 7 cm and decreased the share of fruit with diameter smaller than 7 cm in total yield (Fig. 1).

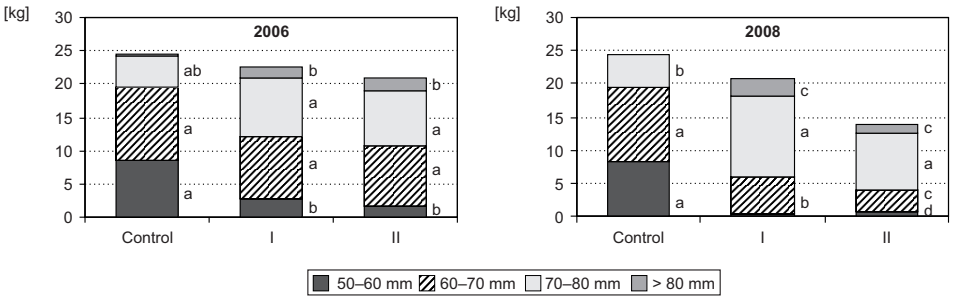

Fig. 1. Class of grandiosity in the yield of fruit in general, depending on the date of preparations application

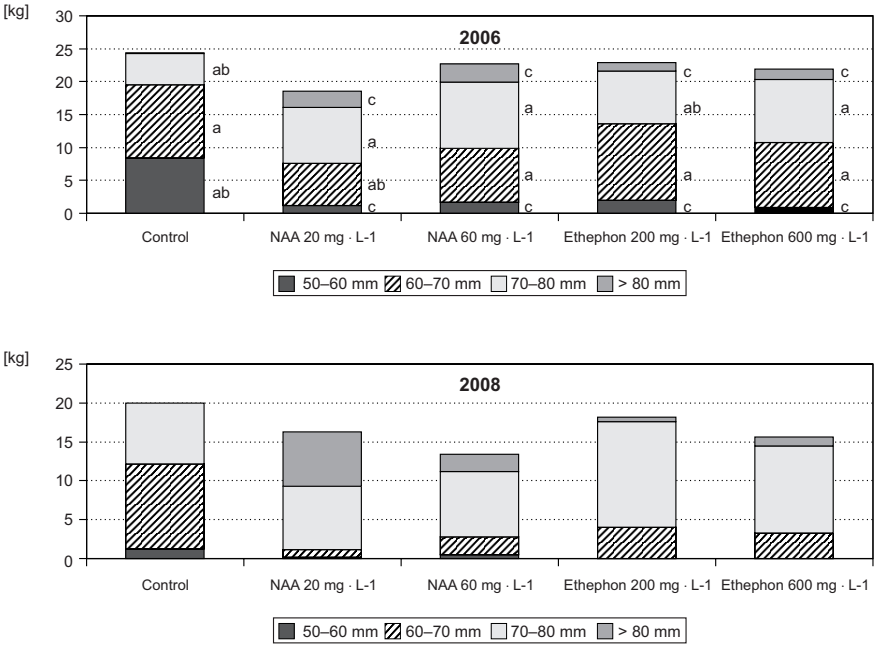

Fig. 2. Class of grandiosity in the yield of fruit in general, depending on type and concentration of applied preparation

Analyzing the effectiveness of treatments for type of preparation and concentration, there was no apparent difference between them. Both applied preparations influenced on reducing the proportion of fruit with a diameter of less than 7 cm and increasing the number of fruit over 7 cm in diameter (Fig. 2).

High concentrations of applied preparations did not cause the decrease in yield and did not affect the degree of fruit colouring. The term of treatment nor the type or concentration of used preparations did not affect the percentage of skin surface covered with apple bloom (Table 2).

Table 2

Fruit colour [%] depending on the date of the treatment as well as type and concentration of preparation

Specification	2006	2008
Term of treatment I	53.4 a*	45.9 a
Term of treatment II	52.1 a	44.9 a
Treatments		
Control	50.5 a	42.5 a
NAA 20 mg · dm^{-3}	55.0 a	42.9 a
NAA 60 mg · dm^{-3}	54.1 a	44.4 a
Ethefon 200 mg · dm^{-3}	51.4 a	49.0 a
Ethefon 600 mg · dm^{-3}	52.7 a	48.5 a

Explanations: see Table 1.

No influence of treatments was shown on the fruit firmness. Regardless of the date of treatment, type of preparation and concentration obtained results were not different from control objects (Table 3).

Table 3

Firmness of the fruit [kG] depending on the date of the treatment as well as type and concentration of preparation

Specification	2006				2008			
Term of estimation	At harvest		After storage		At harvest		After storage	
Diameter of fruit	6–7 cm	7–8 cm	6–7 cm	7–8 cm	6–7 cm	7–8 cm	6–7 cm	7–8 cm
Term of treatment I	6.7 a	6.6 a	4.7 a	4.5 a	5.8 a	5.6 a	4.5 a	4.3 a
Term of treatment II	6.7 a	6.6 a	4.4 a	4.3 a	5.8 a	5.4 a	4.4 a	4.3 a
Treatment								
Control	6.6 a	6.3 a	4.3 a	4.3 a	5.4 a	5.3 a	4.3 a	4.2 a
NAA 20 mg · dm^{-3}	6.7 a	6.4 a	4.4 a	4.3 a	5.9 a	5.8 a	4.5 a	4.3 a
NAA 60 mg · dm^{-3}	6.8 a	6.5 a	4.6 a	4.4 a	5.9 a	5.6 a	4.3 a	4.2 a
Ethefon 200 mg · dm^{-3}	6.8 a	6.4 a	4.8 a	4.5 a	5.8 a	5.6 a	4.4 a	4.4 a
Ethefon 600 mg · dm^{-3}	6.8 a	6.7 a	4.5 a	4.3 a	5.9 a	5.6 a	4.6 a	4.3 a

Explanations: see Table 1.

Studies carried out after storage showed that treatment did not affect fruit firmness, content of juice extract (Table 4) and pH of fruit juice (Table 5).

Table 4

Extract juice of fruit [%] at harvest and after storage

Treatment	2006		2008	
	At harvest	After storage	At harvest	After storage
Control	*12.6 a*	12.5 a	11.8 a	12.2 a
NAA 20 mg · dm^{-3}	12.3 a	12.3 a	11.7 a	11.9 a
NAA 60 mg · dm^{-3}	13.1 a	13.1 a	11.6 a	11.8 a
Ethefon 200 mg · dm^{-3}	12.5 a	12.4 a	12.0 a	12.1 a
Ethefon 600 mg · dm^{-3}	13.2 a	12.9 a	11.8 a	12.2 a

* Values marked with same letter do not differ at $\alpha = 0.05$.

Table 5

pH of fruit juice

Treatment	2006		2008	
	At harvest	After storage	At harvest	After storage
Control	3.8 a*	3.9 a	3.7 a	3.8 a
NAA 20 mg · dm^{-3}	3.8 a	3.9 a	3.7 a	3.8 a
NAA 60 mg · dm^{-3}	3.8 a	3.9 a	3.7 a	3.8 a
Ethefon 200 mg · dm^{-3}	3.8 a	3.9 a	3.7 a	3.8 a
Ethefon 600 mg · dm^{-3}	3.8 a	3.9 a	3.7 a	3.8 a

* Values marked with same letter do not differ at $\alpha = 0.05$.

No differences were found after harvest and after storage in comparison with the control treatment. Both applied preparations caused an increase of the total acidity of fruit juice, which was observed also after storage (Table 6).

Table 6

Total acidity of fruit juice [g · 100 g^{-1}] (expressed as malic acid)

Treatment	2006		2008	
	At harvest	After storage	At harvest	After storage
Control	0.24 d*	0.17 d	0.33 c	0.24 d
NAA 20 mg · dm^{-3}	0.29 c	0.20 c	0.41 b	0.32 a
NAA 60 mg · dm^{-3}	0.33 a	0.23 b	0.43 a	0.28 c
Ethefon 200 mg · dm^{-3}	0.31 b	0.23 b	0.43 a	0.32 a
Ethefon 600 mg · dm^{-3}	0.33 a	0.26 a	0.41 b	0.30 b

*Values marked with same letter do not differ at $\alpha = 0.05$.

No differences were found after harvest and after storage in comparison with the control treatment. All preparations caused an increase the total acidity of fruit juice, what was observed also after storage (Table 6).

Discussion

As reported by Dennis [1] auxin NAA was recommended for thinning mainly during flowering. However, subsequent studies have shown that NAA is well-thinner for fruitlets. In presented experiment it was found that auxin NAA is suitable both thinning at the end of flowering and about two weeks later also. Very similar to the NAA thinning effect was observed in case of ethephon. Its effectiveness did not depend on the date of application.

The results do not confirm the opinion according to which sensitivity to ethephon is starting to decrease after petals fall [2, 3]. The preparations applied in 3 times higher concentrations only slightly decreased fruit setting which was also observed in experiment conducted by Jones et al [4]. All treatments increased the average mass of fruit. Decreasing proportion of small fruit and increasing share of large fruits in whole yield was also observed. The treatment in the first term led to increase the average mass of fruit. Positive effect on fruit size, despite of poor thinning was also observed by other authors [5, 6].

In the experiment, no differences between the type of preparation and participation of each class of grandiosity of fruits in total yield were showed. Both used preparations in similar way affected the yield and fruit size. No significant differences were observed between NNA at concentration 20 and 60 mg · dm^{-3} as well as between ethephon in concentration at 200 and 600 mg · dm^{-3}. No effect of the term treatment, the type of used preparation or concentration on fruit color intensity was observed. Similar results obtained Michalski et al [6] and Pietranek et al [7]. In presented experiment slight impact of treatments on the decreasing of fruit flesh firmness was obtained, but the differences were not confirmed statistically. Similar results were obtained by Guaka et al [8] and Mcartney and Wells [9]. There was no effect of the treatment term on fruit firmness after harvest and after storage. In presented experiment applied thinning preparations did not influence the extract and pH of fruit juice. No impact on the tested parameters was also noted by Pietranek et al [7] and Basak [10]. In conducted experiment an increase of fruit juice acidity in all studied combinations were noted. Link [11] also reported the positive impact of this treatment on the acidity of the fruit juice.

Conclusions

1. Auxin NAA and ethephon showed similar effectiveness in thinning of flowers and fruitlets of apple trees.
2. The effect of using higher concentrations of the preparations did not differ significantly from the lower ones.

3. All treatments regardless of the preparation, concentration and term of application improved fruit quality.

4. There was no negative impact of treatments on the quality of fruits and the ability of fruit to storage.

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WPŁYW AUKSYNY NAA ORAZ ETEFONU NA JAKOŚĆ PLONU JABŁONI (*Malus domestica* Borkh.) ODMIANY 'ŠAMPION'

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Abstrakt: Doświadczenie przeprowadzono w sadzie doświadczalnym w Garlicy Murowanej koło Krakowa w latach 2006 i 2008. W 2007 r. ze względu na uszkodzenia przymrozkowe nie prowadzono badań. Obiektem badań były intensywnie plonujące czternastoletnie drzewa jabłoni odmiany 'Šampion' na podkładce 'MM.106'. Celem doświadczenia była ocena wpływu etefonu oraz auksyny NAA na ilość i jakość plonu. Każdy z preparatów zastosowano w dwóch stężeniach: 200 i 600 mg etefonu · dm^{-3} oraz 20 i 60 mg NAA · dm^{-3}. Zabiegi wykonano w dwóch terminach: gdy opadło 80 % płatków korony oraz gdy zawiązek z kwiatu królewskiego osiągnął 12 mm średnicy. Drzewa kontrolne nie były opryskiwane. Podczas zbioru oceniano: plon ogólny z podziałem na klasy wielkościowe, powierzchnię jabłek pokrytych rumieńcem, jędrność miąższu, ekstrakt, ogólną kwasowość soku oraz pH.

Wszystkie zastosowane zabiegi spowodowały zwiększenie udziału jabłek o średnicy powyżej 7 cm oraz zmniejszenie ilość owoców drobnych w ogólnym plonie. Stwierdzono również dodatni wpływ zastosowanych zabiegów na wzrost kwasowości soku owoców. W doświadczeniu nie stwierdzono wpływu zabiegów na stopień wybarwienia owoców oraz jędrność miąższu, pH oraz ogólną kwasowość ekstraktu soku. Zastosowane preparaty nie miały wpływu na zdolność przechowalniczą owoców.

Słowa kluczowe: auksyna, NAA, etefon