EFFECT OF PLANT GROWTH REGULATORS ON APPLE FRUIT PREHARVEST DROP AND QUALITY

Nomeda Kvikliene, Darius Kviklys
and Audrius Sasnauskas

Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry,
Kauno str. 30, LT-4335 Babtai, Kaunas distr., Lithuania
e-mail: n.kvikliene@lsdi.lt

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A B S T R A C T

The effect of preharvest treatment with Pomonit Super 050SL (5% triethanolamine salt of NAA) alone, and in a mixture with Agrostym 480 SL (48% of ethephon) on 'Auksis' apple fruit abscission and quality was investigated. Trials were conducted on full bearing apple trees grafted on M.9 rootstock at the Lithuanian Institute of Horticulture in 2008-2009. Chemical treatments were applied one week before the predictable optimum harvest date. Fruit drop was measured four times at weekly intervals. Cumulative preharvest drop was assessed by summing the number of fruits shed at each harvest date. The fruit weight, blush colour, flesh firmness, soluble solids content, starch pattern index, and Streif index were monitored during the investigation period. It was found that Pomonit Super 050 SL reduced fruit drop by 67% in comparison with the untreated control. The effectiveness of Pomonit Super 050 SL applied in a mixture with Agrostym 480 SL for managing fruit drop was lower. Nevertheless, fruits in this treatment had more intensive blush but significantly lower firmness and starch content. The mixture of Pomonit Super 050 SL and Agrostym 480 SL determined more intensive fruit ripening processes.

Key words: *Malus* x *domestica*, fruit drop, fruit quality, preharvest spray

INTRODUCTION

'Auksis' is one of the most popular and commercially important apple cultivars in Lithuania where it makes up about 15% of the national crop. It is a particularly tasty and attractive variety, and is also quite winter hardy. 'Auksis' is picked at the beginning of September, and can be stored until February. Unfortunately, 'Auksis' is prone to fruit drop and to softening during storage. Due to early harvest time, 'Auksis' fruits lack blush since day

and night temperatures do not contrast at this time. Growth regulators are widely used in different countries for improving coloration and reducing fruit abscission (Marini et al., 1993; Masia et al., 1998; Dal Cin et al., 2008; Stern and Ben-Arie, 2008). Ethephon can be used to improve fruit colour and advance fruit maturation when used just before optimal harvest time. But it does significantly shorten fruit storage time and shelf life, and can cause excessive fruit drop if fruits are not harvested within 10 days after application (Omafra, 2007; Singh and Shafiq, 2008). Naphthaleneacetic acid (NAA) is an auxin-type growth regulator that primarily is used to reduce preharvest drop. NAA does not strengthen up the fruit attachment, but only prevents further loosening from the fruit stem. When it is used to reduce drop, it does not delay ripening. The result may be overripe fruit that have a shorter storage life if harvest is delayed (Curry, 2006). Aminoethoxyvinylglycine (AVG), an ethylene biosynthesis inhibitor, has been used to control preharvest apple drop for over the past decade. An application 2 to 3 weeks before the anticipated start of harvest is most effective in retarding preharvest drop during the normal harvest period, and for a period of time afterwards (Greene, 2006; Rath et al., 2006; Robinson et al., 2006).

The aim of this study was to assess the effects of Pomonit Super 050 SL (NAA) and Agrostym 480SL (48% of ethephon) used during the ripening period, on fruit abscission and fruit quality.

MATERIAL AND METHODS

Field trials were conducted at the Lithuanian Institute of Horticulture (Central Lithuania 55˚ 60' N, 23˚ 48' E) in 2008-2009 on full bearing 'Auksis' apple trees grafted on M.9 rootstock. The experiment was set up in a randomized block design, with four replications and four trees per replicate. Treatments were performed one week before the predicted harvest date. The trial scheme was following:

1. the untreated control;
2. Pomonit Super 050 SL 0.04%;
3. Pomonit Super 050 SL 0.04% + Agrostym 480 SL 0.12%;
4. Pomonit Super 050 SL 0.04% + Agrostym 480 SL 0.12% followed with Pomonit Super 0.04% after 5 days.

Fruit drop was evaluated 4 times, at weekly intervals. Cumulative drop was expressed as percentage of total fruit yield.

Fruit quality was assessed in the 2nd and 3rd week after the treatment. Fruit blush (surface red colour) was estimated by visual evaluation and expressed as percentage of skin covered with red blush. Firmness was measured with a penetrometer (FT-327) with 11 mm diameter probe and expressed in Newtons (N). Soluble solids content was measured with a refractometer and expressed as percentage of fresh weight. The starch index was determined using a 0.1N iodine and potassium iodine solution (scale 1-10). Streif index was calculated as follows: Firmness/(soluble solids content x starch).

Variance analysis of the main quality traits was done using Fischer least significant difference test at $p \leq 0.05$.

RESULTS

All the treatments showed a significant effect on cumulative preharvest drop (Tab. 1). The greatest effect was obtained when Pomonit Super 050 SL was applied one week before optimal harvest time. In this treatment, cumulative fruit drop was 33%. A mixture of Pomonit Super 050 SL and Agrostym 480 SL was less effective, the same as application of mixture followed by additional spray with Pomonit Super 050 SL. Fruit drop in these treatments was 50.5% and 44%, respectively. The dynamics of fruit drop during the observation period was affected by different treatments. One week after application, fruit drop in all treatments was nonsubstantial. In the untreated control, fruit drop reached 5.26%.

After two weeks, the fruit drop in the control increased up to 18.1%, whereas there was only 3.48% of dropped fruits in the Pomonit Super 050 SL treatment. Effectiveness of the Pomonit Super 050 SL and Agrostym 480 SL mixture was lower. Nevertheless, fruit drop in these treatments was lower by 32-41% than in the untreated control. Three weeks after treatment, significantly lower fruit drop was observed when Pomonit Super 050 SL was used separately or when Pomonit Super 050 SL was used repeatedly after the treatment with the Pomonit Super 050 SL and Agrostym 480 SL mixture. Four weeks later, none of the treatments had a significant effect on fruit drop.

All fruit quality indices responded to the preharvest spray of apple trees (Tab. 2). Significant changes of fruit blush were observed already after one week. An especially strong increase in blush was recorded when Pomonit Super 050 SL was applied in a mixture with Agrostym 480 SL. Pomonit Super 050 SL used separately was less effective and changes in fruit blush were not consistent. Three weeks after treatment, significant changes in fruit blush were observed in all treatments. The highest effectiveness was obtained when a second spray of Pomonit Super 050 SL was used 5 days after the Pomonit Super 050 SL and Agrostym 480 SL mixture.

Fruit flesh softening was more pronounced when Agrostym was used in a mixture with Pomonit Super 050 SL. Significant reduction of fruit firmness was already obtained after one week. At the same time, Pomonit Super 050 SL used separately had no negative effect on flesh firmness. However, three weeks after treatment, softening of fruit flesh was recorded in all treatments. Apple fruits picked from treated trees were 13-23% softer in comparison with the untreated control.

Content of soluble solids did not respond to growth regulators until the 3rd week.

All spray treatments induced fruit ripening. Fruits from treated trees were more mature than untreated fruits.

Table 1. Influence of Pomonit Super 050SL and Agrostym 480SL on preharvest fruit drop (mean of 2008 and 2009)

Treatment*	Fruit drop [%]				
	after 1 week	after 2 weeks	after 3 weeks	after 4 weeks	total
1.The Control	5.3	18.1	27.3	25,2	75.8
2	0.4	3.48	13.4	15.5	32.7
3	0.5	12.4	15.0	22.7	50.5
4	0.3	10.7	11.5	21.7	44.2
LSD_{05}	5.94	13.44	13.56	13.95	22.41

*Treatments are indicated in Material and methods section

Table 2. Influence of Pomonit Super and Agrostym 480SL on fruit quality (mean of 2008 and 2009)

Treatment	Blush [%]		Firmness [N]		TSS [%]		Streif's index	
	after 1 week	after 3 weeks	after 1 week	after 3 weeks	after 1 week	after 3 weeks	after 1 week	after 3 weeks
1	22.4	39.7	87.1	65.7	12.8	12.8	0.16	0.07
2	33.5	60.0	83.4	57.1	12.9	13.3	0.13	0.06
3	46.5	56.0	69.6	51.7	13.0	13.7	0.08	0.05
4	46.5	70.5	64.2	50.3	13.2	13.0	0.06	0.05
LSD_{05}	10.32	11.81	9.02	5.15	0.93	0.51	0.061	0.011

*Treatments are indicated in Material and methods section

One week after treatment a significantly lower Streif's index was found for fruits treated with mixture of Pomonit Super 050 SL and Agrostym 480 SL. Slight decrease of Streif's index was recorded in fruits treated by Pomonit Super 050 SL alone, but differences were not significant. Three weeks later, differences between treatments were less pronounced, though fruits treated with Pomonit Super 050 SL mixed with and Agrostym 480 SL had significantly lower Streif's index.

DISCUSSION

The problem of preharvest fruit drop has been reported to be severe in early ripening cultivars and ranges from 40 to 60% of crop load. Preharvest drop can be successfully checked with the application of NAA (Basak and Krokocka, 2000; Curry, 2006). It's use is especially important with apple cultivars like 'Auksis' which are prone to heavy preharvest fruit drop, and according to our results fruit losses can reach up to 23% in two weeks. Earlier harvest of cv. 'Auksis' is not recommended since at that time the apples lack blush. In our trial, effect of NAA on fruit drop was significant and the harvest window of cv. 'Auksis' could be prolonged more than two weeks. Needless to say it is not only the amount of fruit drop that is a decisive factor. Fruit quality changes must also be monitored during the harvest period. As demonstrated in our experiment,

all fruit quality parameters changed according to the harvest time and chemical applied. Flesh firmness is one of the main quality parameters determining fruit storage. After one week in NAA treatment, changes of fruit firmness were inconsequential. However, after three weeks, fruit softening was significant. A higher rate of fruit softening was established when using the ethephon treatment, where significant differences appeared already one week after application.

Ethephon usually is used for fruit colour improvement (Whale et al., 2008). Our trial results confirmed the significantly better colour development of apples when using the ethephon treatment and when using the NAA treatments, too. However, ethephon stimulates ripening as was confirmed by changes in the Streif's index. Usually cv. 'Auksis' fruits should be picked when the Streif's index reaches 0.16-0.13 (Kvikliene, 2006), while the Streif's index of apples treated by ethephon was only 0.08-0.06. Such changes must be taken into account if apples are intended for long-term storage. In order to reduce the negative effect of ethephon, repeated NAA treatment is recommended (Byers, 1998; Singh and Shafiq, 2008). However these findings were not confirmed in our trial. Ripening processes were not delayed by an additional application of NAA.

In conclusion, the agrotechnology of cv. 'Auksis' could be improved by application of growth regulators.

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WPŁYW REGULATORÓW WZROSTU ROŚLIN NA PRZEDZBIORCZE OPADANIE OWOCÓW I ICH JAKOŚĆ

Nomeda Kvikliene, Darius Kviklys
and Audrius Sasnauskas

S T R E S Z C Z E N I E

W Litewskim Instytucie Ogrodnictwa w latach 2008-2009 badano wpływ środka Pomonit Super 050 SL (5% kwas 1-naftylooctowy w postaci soli z trójetanoloaminą) zastosowanego samodzielnie oraz w połączeniu ze środkiem Agrostym 480 SL (48% etefon) na przedzbiorcze opadanie owoców jabłoni oraz ich jakość. Badanie przeprowadzono na w pełni owocujących drzewach jabłoni 'Auksis' szczepionych na M.9. Środki zastosowano tydzień przed przewidywanym zbiorem owoców. Opadanie owoców było mierzone czterokrotnie w odstępach tygodniowych. Zsumowano liczbę owoców, które opadły w każdym dniu zbioru. Suma ta stanowiła łączne przedzbiorcze opadanie owoców. Oceniano masę owoców, ich wybarwienie, jędrność miąższu, zawartość ekstraktu, wzór indeksu skrobiowego oraz wskaźnik Streifa. Wyniki wykazały, że Pomonit Super 050 SL zredukował przedwczesne opadanie owoców o 67% w porównaniu z kontrolą, w której nie zastosowano środków. Mieszanina środków Pomonit Super 050 SL oraz Agrostym 480 SL jeszcze bardziej spowodowała zredukowanie opadania owoców oraz wpłynęła pozytywnie na ich intensywność dojrzewania. Owoce były bardziej wybarwione, ale mniej jędrne i zawierały mniej skrobi.

Słowa kluczowe: jabłoń domowa (*Malus x domestica*), opadanie owoców, jakość owoców, przedzbiorczy oprysk