THE EFFECT OF FRUITLET THINNING ON FRUIT QUALITY PARAMETERS IN THE APPLE CULTIVAR 'GALA'

Alina Basak

Research Institute of Pomology and Floriculture
Pomologiczna 18, 96-100 Skierniewice, POLAND
e-mail: abasak@insad.pl

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A B S T R A C T

Fruitlet thinning is one of the most efficient and widely used methods of obtaining high quality apples. From 1996 to 2000, five experiments were conducted in Poland on thinning in 'Gala' apple trees. The trees were thinned chemically using: NAA (preparations: Pomonit R10, Pomonit Super 050 SL, Pommit Ekstra 110 SL); BA (preparations: Paturyl 100 SL, Accel, Exillis); endothalic acid (Endothal); ammonium thiosulphate (ATS); ethephon (Ethrel 480 SL, Agrostym 480 SL); ArmoThin (alkoxylated fatty alkylamine polymer); and PDJ (*n*-propyl dihydrojasmonate). The preparations were used separately or in sequence in order to correct the thinning effect of one preparation by using another. Data presented include the effects of different thinning methods on fruit size, size distribution, firmness, colour, refractive index and marketable yield.

Key word: fruitlet thinning, apple tree, fruit quality, cultivar 'Gala'

INTRODUCTION

'Gala' is one of the most important cultivars grown in Poland. It is also one of the most widely accepted apples on the European market, where it is being grown more and more in different countries. Nevertheless, 'Gala' trees need to be thinned because they tend to produce small fruits and bear biennially.

'Gala' responds very well to hand thinning of fruitlets, depending on the intensity of thinning and the date on which thinning is performed (Krzewińska et al., 1999). Intensive thinning during the blossoming period increased fruit

size the most, whereas the hand thinning after June drop "on the determined size" by the way currently used in commercial fruit orchards in Germany (Weber, 1996).did not give the expected results in 'Gala' in Polish experiments. Then, none of the methods of thinning evaluated during a four-year study was really effective (Krzewińska et al., 1999).

With 'Gala', hand thinning is costly because of the large number of small fruitlets. Therefore, 'Gala' trees should be first thinned chemically, and only then by hand if needed (Webster and Spencer, 1999).

The goal of this experiment was to elaborate a procedure for chemical thinning in 'Gala' using currently available agents in accordance with the manufacturer's recommendations.

This study was conducted within the framework of the European EUFRIN program.

MATERIAL AND METHODS

From 1996 to 2000, five experiments on chemical thinning were carried out at the Experimental Orchard at Dąbrowice, which belongs to the Research Institute of Pomology and Floriculture in Skierniewice, central Poland. The experiments were performed on apple trees of the cultivar 'Gala' grafted on M.26, which were twelve to sixteen years old.

Thinning was carried out in accordance with the procedures currently recommended by the EUFRIN working group.

Thinning was carried out using the following agents, either alone or in sequence:

- Ethephon (48% a.i.): Ethrel 480 SL (Novartis, France) and Agrostym 480 SL (Agropak, Poland), when blossoms were 80% open. Dose: 80 mg/L (Experiment 4);
- ammonium thiosulfate (98-100% a.i): ATS (CMF, Belgium), during full bloom on older wood. Doses: 0.5, 1.0 and 1.5% (Experiments 2, 3 and 4);
- endothal (5% a.i. endothalic acid): TD 2337-2 (Elf Atochem, USA), during full bloom on older wood. Doses: 0.05 and 0.1% (Experiment 1);
- NAA (10% a.i. potassium salt): Pomonit R10 immediately after blooming. Dose: 40 mg/l (Experiment 1);
- NAA (8% potassium salt with 1.5% urea): Pommit Ekstra 110 SL, immediately after blooming. Dose: 40 mg/l (Experiment 2);
- NAA (5% triethanolamine salt): Pomonit Super 050 SL, when fruitlets were 10 mm in diameter. Dose: 40 ml/100 ml (Experiment 4);
- BA (9.4% a.i.): Paturyl 100 SL, D4017 (Reanal, Hungary), when fruitlets were 10 mm in diameter. Doses: 50 and 100 mg/L (Experiments 1, 3 and 4);

- BA (8% with 0.13% GA_3): Accel (Abbott, USA), when fruitlets were 10 mm in diameter. Doses: 50 and 100 mg/L;
- BA (2%): Exillis (Fine Agrochemicals, UK), when fruitlets were 10 mm in diameter. Doses: 50 and 100 mg/L;
- alkoxylated fatty alkylamine polymer (10%): ArmoThin (AkzoNobel, Belgium), from the beginning of blossoming until ten days after full bloom. Dose: 0.5% (Experiments 3 and 4);
- BA (1.8% + 1.8% GA_{4+7}): Promalin, four times at one-week intervals. Used together with ArmoThin. Dose 25 ml/100 L Promalin and 0.5% ArmoThin; and
- PDJ (*n*-propyl dihydrojasmonate), 5 days after full bloom. Dose 500 mg/L (Experiment 3).

Moreover, BA and NAA or NAA and carbaryl (Sevin XLR, Rhone Poulenc, France) were applied consecutively as appropriate for each of these compounds or as the mixtures when the fruitlets were 10 mm in diameter. Two mixed preparations were also used: Bioprzerzedzacz 060 SC (BA 50 g + NAA 10 g) and Karbathin (carbaryl 400 g + NAA 4 g). They were used in the same way when the fruitlets were 10 mm in diameter. These preparations were compared in Experiments 1 and 5.

The control trees either were not thinned at all or were hand-thinned after the June-drop to one fruit per cluster. Each treatment was tested on six to eight trees, with one tree per replicate. Trees were randomly chosen from along the rows and were similar in terms of blossoming, fruiting and growth intensity. They were sprayed with hand gun up to the falling of droplets.

The effect of the treatments on the number and quality of fruit at harvest were evaluated as previously described (Basak, 2000).

Data were statistically elaborated by analysis of variance followed by Duncan's multiple-range t-test at $P \leq 0.05$.

RESULTS AND DISCUSSION

'Gala' trees need to be intensively thinned. Because they blossom over a long period, the fruitlets are at different stages of development at thinning time. The effectiveness of a particular thinning agent depends on the developmental stage of the fruitlets. Effectiveness also depended on weather conditions in each experiment (Williams, 1994; Wertheim, 1998).

Thinning is most effective when two or more preparations are used in sequence. The results on thinning 'Gala' trees with ethephon, NAA, BA and carbaryl were reported in an earlier study (Basak, 2000). The present study supported the additional information on how these agents affect fruit quality at harvest. Information on the effectiveness of other thinning methods is also presented (Tab. 1).

Table 1. Effect of thinning in 1999 on the some parameters of fruit quality in 'Gala' trees (Experiment 4)

Treatment	Mean fruit weight [g]	Fruits > 70 mm [%]	Grading index *	Colour index *	Russeting index *	Shape [height/ diameter]	Firmness [N]	Refractive index [%]
Control, not thinned	113.6 ab	21.5 a	380 b	587 a	135 a	0.89 a	18.5 ab	13.1 a-c
Hand thinned	131.9 bc	47.6 bd	444 c-e	705 b	132 a	0.94 bc	19.8 c	13.3 bc
Ethephon 150 mg/L at BB**	125.8 bc	38.1 abc	429 b-d	648 ab	123 a	0.92 a-c	18.9 a-c	12.2 a
Ethephon as above + BA 50 mg/L at 10 mm diam.	123.7 bc	35.5 abc	436 cd	651 ab	127 a	0.90 ab	19.0 a-c	12.7 a-c
Ethephon as above + NAA 10 mg/L at 10 mm diam.	128.5 bc	49.2 bcd	445 c-e	714 b	127 a	0.92 a-c	19.6 bc	13.2 a-c
ATS 1% at FB ow**	122.8 bc	26.0 a	393 a-c	642 ab	136 a	0.94 bc	18.9 a-c	13.0 a-c
ATS 0.5% at FB + BA 50 mg/L at 10 mm diam.	132.8 bc	48.1 b-d	443 c-e	573 a	132 a	0.93 bc	19.3 a-c	13.5 c
ATS 0.5% at FB + NAA at 10 mm diam.	128.7 bc	40.0 a-c	424 a-d	651 ab	132 a	0.94 bc	19.4 a-c	13.2 a-c
ArmoThin 0.5% at 5 dAFB**	97.0 a	20.4 a	375 a	597 a	135 a	0.91 a-c	18.7 a-c	12.4 ab
ArmoThin 0.5% as above + Promalin 25 mg/l 4 times	128.8 bc	32.2 ab	413 a-d	661 ab	127 a	0.95 c	18.3 a	12.6 a-c
NAA 10 mg/L at 10 mm diam	125.2 bc	33.5 a-c	413 a-d	717 b	145 a	0.93 bc	19.6 bc	12.9 a-c
NAA 10 mg/L + BA 50 mg/L at 10 mm diam.	141.2 c	62.2 d	487 e	659 ab	137 a	0.95 c	19.3 a-c	13.5 c
BA 100 mg/L at fruitlets 10 mm diam.	129.7 bc	40.9 a-c	429 b-d	721 b	124 a	0.92 a-c	19.4 a-c	13.1 a-c

Explanation: *grading index (according to national standard in 5 mm weight classes) = [n1 (< 55) x 1] + [n2 (55-60) x 3] + [n3 (60-65) x 5] + [n4 (65-70) x 7] + [n5 (70-75) x 9] + [n6 (> 75) x 11]; n = fruit number at each class, – red colour/russeting on: 1 = 0%, 2 = < 25%, 3 = 25-50%, 4 = 50-75%, 5 = > 75% surface class; index = [no.1 x 1 + no.2 x 3 + no.3 x 5 + no.4 x 7 + no.5 x 9]; no = number fruits at class e.g. 1 or 2…
**BB – beginning of bloom; FB ow – full bloom on old wood, dAFB – days after full bloom
Means with the same letter do not differ significantly at P=0.05 according toDuncan's t-test

Ethephon was applied when the blossoms were 80% open. The weather was cold and rainy. Ethephon did not visibly reduce the final fruit set. Nevertheless, ethephon accelerated natural fruitlet abscission, so that the remaining fruits were larger and more uniform. The marketable yield was also larger. Ethephon caused a slight flattening of the fruits.

When ethephon treatment was followed up by BA treatment after blossoming, the thinning rate did not increase. However, refractive index and firmness were higher than in fruits treated with ethephon alone.

Results were best when ethephon treatment was followed up by NAA treatment. Fruit size, size distribution and marketable yield were about the same as with hand thinning, but firmness and colour were better.

Ammonium thiosulphate (ATS) was applied at full bloom. ATS reduced fruit set, markedly increased fruit size, and increased the proportion of apples more than 70 mm in diameter. Colour, soluble solids content, firmness and starch content were about the same as with hand thinning. In other experiments ATS cut the initial fruit set by half, but did not affect the size of the final fruit set. Even though ATS markedly reduced the initial fruit set, but fruit size and elongation were only slightly better.

In another experiment, ATS was applied before blooming and Paturyl 100 SL (BA) was applied after blooming. Low doses of both agents were used. Fruit weight was about the same as with hand thinning, size distribution was better, firmness and refractive index were higher, and colour was less intense than with ATS treatment alone.

Applying ATS during blossoming and then NAA immediately after blossoming reduced fruit set by about the same amount, but did not increase fruit size as much as applying ATS and Paturyl, alone.

When **endothal** was applied during blossoming, thinning was less effective than with ATS, BA and hand-thinning. Endothal worked best when applied at full bloom and was followed up with low concentrations of NAA immediately after blooming. Further information about thinning with endothal in Poland is presented elsewhere (Basak and Krzewińska, 1998).

ArmoThin worked best when applied together with Promalin (BA) five days after full bloom (Basak and Faron, 2000).

ArmoThin alone reduced fruit set, but did not affect fruit size and colour. ArmoThin caused russeting when applied at the beginning of blossoming. No matter when they were treated, trees treated with ArmoThin always had malformed leaves, malformed fruits, lighter colored leaves and fruits with a rough, mat surface. These effects could be avoided by applying Promalin, which also prevents russeting and often causes fruitlet thinning as well (Basak et al., 1999). When Promalin was applied to trees sprayed with ArmoThin, fruitlet abscission was as high as with hand-thinning. Fruit size, size distribution, marketable yield and fruit elongation were also better, which agrees well with other studies (Laurens, 1989).

All of the preparations containing **NAA** markedly increased fruit weight and marketable yield when applied immediately after blossoming.

Pomonit R10 and Pommit Ekstra 110 SL, which contain the potassium salt of NAA, had little effect on colour and refractive index. Pommit Ekstra 110 SL, which also contains urea, reduced firmness and starch content and accelerated maturation as determined by the Streif's coefficient.

When Pomonit Super 050 SL , which contains the triethanolamine salt of NAA, was applied to fruitlets 10 mm in diameter, increased marketable yield, although not as much as hand-thinning. Colour was better, although russeting occurred even in spite of the low concentration used (10 mg/L).

In Experiment 3, **PDJ** was applied five days after full bloom at dose of 500 mg/L. Fruit set was reduced by 20%. However, colour was less intense, russeting was increased, and firmness and refractive index were lower. This agrees well with an earlier study on thinning with PDJ in Japan (Gemma, 2000).

BA applied as Paturyl 100 SL sometimes caused elongation, especially at low doses. BA had no significant effect on colour and russeting. Apples were less mature at harvest time, starch content was higher, and firmness and refractive index were the same.

All three preparations containing BA (Paturyl, Accel and Exillis) reduced fruit set about as much as hand thinning. Accel and Exillis improved fruit size, size distribution and marketable yield slightly more than Paturyl. All tree also increased the number of asymmetric fruits, especially Accel.

Fruit size was best with Pomonit R10 followed by Paturyl 100 SL, both in low concentrations. Colour was best with Paturyl 100 SL. More information on how BA affects fruit quality is given elsewhere (Basak, 2000; 2004).

Fruit quality was particularly good when BA was mixed with carbaryl or applied after NAA. In case of mixture of BA and carbaryl, yield and fruit size were better, but colour was worse. When BA was used with NAA, fruit colour was the same but refractive index was lower.

None of the preparations tested improved fruit quality as much as hand thinning in spite of the fact that hand thinning was carried out relatively late. Hand thinning improved over fruit quality, including size, colour, firmness, refractive index and starch content.

CONCLUSIONS

'Gala' needs to be intensively thinned because it tends to produce a large number of small fruits and tends to bear biennially. Choice of thinning method depends on weather conditions at treatment time and on the dynamics of blossoming. 'Gala' responds well to late thinning because it blossoms over a long period and can set fruit from lateral blossoms.

Applying ethephon during blossoming is not effective by itself, but is quite effective when followed up with BA (Paturyl 100 SL) or NAA (Pomonit Super 050 SL). Ethephon (Ethrel 480 SL) mixed with NAA (Pomonit Super

050 SL) gives good results when applied immediately after blooming (Jones et al., 1993).

ATS is effective only when the weather at full bloom is warm and dry. With 'Gala', the optimal concentration of ATS is 1%. ATS gives better results when followed up by applying BA (Paturyl 100 SL) after blossoming. 'Gala' is susceptible to the phytotoxic action of ATS.

Preparations containing NAA (Pomonit Super 050 SL, Pommit Ekstra 110 SL) are good thinning agents even if used late when the fruitlets are 10 mm in diameter. However, they can reduce firmness and refractive index and accelerate maturation. They are less effective if applied in cold, rainy weather because fruitlet growth is slow, then.

'Gala' responds well to thinning with BA (Paturyl 100 SL). BA not only stimulates fruit growth, but also improves other fruit quality parameters, especially refractive index. When BA is used at the optimal concentration (100 mg/L), fruit colour is not as intense. When used at lower concentrations, BA can adversely affect fruit shape and stimulate shoot growth.

The treatments which gave the best results with 'Gala'were:

- BA (Paturyl 100 SL) and NAA (Pomonit Super 050 SL) together, either mixed or in sequence.
- Late thinning with either a mixture of carbaryl (Sevin XLR) and BA (Paturyl 100 SL) or a mixture of carbaryl and NAA (Pomonit Super 050 SL).

The only treatments which eliminated biennial bearing were carbaryl used with BA, carbaryl and NAA, and ethephon (Ethrel 480 SL, Agrostym 480 SL) in mixture with NAA (Pomonit Super 050 SL).

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WPŁYW PRZERZEDZANIA ZAWIĄZKÓW NA CECHY JAKOŚCI OWOCÓW JABŁONI ODMIANY 'GALA'

Alina Basak

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

Przerzedzanie zawiązków owocowych jest jedną z najbardziej skutecznych i powszechnie stosowanych metod pozyskiwania owoców wysokiej jakości. W okresie od 1996 do 2000 roku wykonano w Polsce pięć doświadczeń nad przerzedzaniem zawiązków owocowych jabłoni odmiany 'Gala'. Drzewa były przerzedzane chemicznie z zastosowaniem: NAA (w preparatach: Pomonit R10, Pomonit Super 050 SL, Pommit Ekstra 110 SL); BA (w preparatach: Paturyl 100 SL, Accel, Exillis); kwasu endothalowego (w preparcie Endothal); tiosiarczanu amonu (ATS); etefonu (w preparacie Ethrel 480 SL, Agrostym 480 SL); preparatu ArmoThin (zawierającego polimer kwasów tłuszczowych) i PDJ (preparatu zawierającego pochodne kwasu jasmonowego). Preparaty stosowano osobno lub następczo w celu korekty efektów przerzedzania pod wpływem preparatu zastosowanego wcześniej. W pracy zamieszczono wyniki dotyczące wpływu różnych metod przerzedzania na wielkość owoców, ich dystrybucję w klasach wielkości, jędrność, kolor, wartość refrakcji i plon o wartości handlowej.

Słowa kluczowe: przerzedzanie zawiązków owocowych, jabłonie, jakość owoców, 'Gala'