EFFICIENCY OF FRUITLET THINNING IN APPLE 'GALA MUST' BY USE OF METAMITRON AND ARTIFICIAL SHADING

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A B S T R A C T

The use of the photosynthesis inhibitor metamitron, and the use of temporary artificial shading as two methods of fruitlet thinning, were evaluated in 2006 and 2008 in apple trees 'Gala Must'. The use of these 2 methods used separately, were expected to induce a temporary decrease in photosynthetic intensity which would strengthen the competition between the fruitlets. This process would then lead to the abscission of the weaker ones. For this purpose, metamitron (preparation Goltix 700SC) was used. A dose of 350 mg/l was sprayed on the trees either one time (when fruitlets were 6-8 mm in diameter), or twice (the second spraying was repeated 6 days later on fruitlets 10-14 mm in diameter). Another group of trees was covered for 5 to 14 days with polipropylene material causing about a 70% reduction of light. In 2006, only the double metamitron treatment caused significant reduction of fruit set (comparable to hand thinning). This resulted in an increase in the fruit size and yield of marketable (> 70 mm) apples without negative effect on the total yield, 'internal quality' and red colour of the apples. In 2008, the good effect of thinning was noticed after one spray with metamitron, while a double treatment caused over-thinning. The single treatment with metamitron positively influenced fruit size, the distribution of apples in size classes, and yield of apples with diameters of > 70 mm. Comparable thinning was recorded in trees artificially shaded for 10 days; fruitlets were 6 to 14 mm in diameter. The uniform distribution of fruits, which were homogenous in size in the canopy of the trees, proved that both methods of thinning have high selectivity.

Key words: fruitlet thinning, metamitron, artificial shading, reduction of photosynthesis, yield, fruit quality, apple

INTRODUCTION

Fruit thinning is relevant management practice to produce apples with high quality fruit size, red coloration, "internal quality" and other fruit quality parameters. Thinning is also relevant to overcome biennial bearing in several apple cultivars thereby securing regular harvests. Therefore, thinning by use of specific chemicals or by hand, was common in commercial orchards. Recently, owing to the growing tendency to use pro-ecological methods in fruit production, decreasing the number of chemicals used for thinning, and growing cost of labour for hand thinning, the search of alternative methods of this practice have been intensified. Recently, thinning resulting from temporary photosynthetic inhibition, by shading, or spraying the trees with photosynthetic inhibitors has been tested. Such methods introduced new possibilities for fruit set regulation (Widmer, 2007; Kelderer et al., 2008).

Several studies have proven a positive thinning effect with short-term shading of fruit trees in the post bloom period or by spraying the trees with photosynthetic inhibitors (Byers et al., 1985, 1990; Corelli-Grapadelli, 1994; Bertshinger, 1997; Lafer, 2007). Shading the fruitlets causes modification of the carbohydrate metabolism (Gifford and Evans, 1981; Zibordi et al., 2009). This can decrease the soluble carbohydrate reserves in the tree and worsen its supply to young fruits in the period of their intensive growth (Byers et al., 1991; Corelli-Grapadelli et al., 1994; Prantl et al., 2004; Zibordi et al., 2008). This strengthens the competition between different sinks and induces abscission of weaker fruits (Byers et al., 1985, 1990, 1991). This concerns their natural drop and also fruit drop induced by thinning compounds, e.g. NAA or ethephon (Byers et al., 1985). Moreover, two compounds, terbacil and metamitron, known as photosynthesis inhibitors, were used with success for thinning apple and peach (Byers et al., 1990; Köpcke, 2005; Clever, 2007; Dorigoni and Lezzer, 2007).

The objective of the experiments presented in this paper was the thinning of apple fruitlets by spraying with metamitron, and shading the trees.

MATERIAL AND METHODS

Experiment 1 was set up in 2006, on 10 year old apple trees of 'Gala Must" grafted on M.9 rootstocks. Trees which were homogenous in respect of no. of flower clusters/tree and growth vigour were selected in two neighbouring rows (8 trees for every treatment). The experimental trees were planted at a distance of 3.5 m between rows and 1.5 m in a row. Total yield of the control trees was on average, 35 kg/tree. Thus, 60 tons of apples could be expected from a 1 ha area. The trees showed moderate growth vigour and canopy size suitable for spraying with the use of a motor knapsack sprayer. On average, 0.8 l of liquid was used for a uniform spraying of the canopy till run off. The treatments (1, 2, 3, 4, 7, 8) of these trials were repeated with the same group of trees in 2008, for experiment 2.

Two methods of thinning were evaluated in the experiments. For spraying some trees, metamitron in the form of the preparation Goltix 700 SC was used. Metamitron was either used once at one dose 350 mg/l when fruitlets were at a 6-8 mm diameter (as in treatment 3), or twice; 6 days later on fruitlets with a diameter of 10-14 mm (treatment 4). Tween 20 as an adjuvant was added to each spray.

Another group of trees were covered with polypropylene material for artificial shading of the canopy. The shading caused about a 70% light intensity reduction in the canopy. Four combinations of artificial shading were evaluated: the trees were shaded for 5 to 14 days, and the trees were shaded when fruitlets were at different sizes.

The following treatments were evaluated in experiment 1:

1. The control – unthinned.
2. Hand thinning.
3. Metamitron 350 mg/l one treatment, when fruitlets were 6-8 mm in diameter + Tween 20.
4. Metamitron 350 mg/l two treatments: first – when fruitlets were 6-8 mm in diameter + Tween 20, second – when fruitlets were 10-16 mm in diameter + Tween 20.
5. Artificial shading when fruitlets were 6-9 mm in diameter (for 5 days).
6. Artificial shading when fruitlets were 9-14 mm in diameter (for 7 days).
7. Artificial shading when fruitlets were 6-14 mm in diameter (for 10 days).
8. Artificial shading when fruitlets were 14- 26 mm in diameter (for 14 days).

In the second experiment treatments 1, 2, 3, and 7 as above, were applied.

The effects on the fruit set, the yield, fruit quality at harvest and subsequent blooming were recorded and evaluated according to the following measurements: (1) the number of inflorescences and the number of fruitlets on each tree; (2) the fruit yield produced by each tree, and, for 1 crate of apples from each tree, which contained fruits from the same part of the tree crown as in all the other trees; (3) weight of 1 apple; (4) the share of fruits (in kg or number) in size classes based on their diameter, from 50 mm to > 80 mm, with the intervals of 5 mm; (5) marketable yield (apples > 70 mm in diameter) in kg/tree and number/tree; (6) the extent of colour development on a 5° point scale (1 – no blush, 2 – blush on 1-25%, 3 – 26-50%, 4 – 51-75%, 5 – > 75% of surface area); (7) the extent of russeting on a 5° scale, for colour development; (8) refraction (%) and firmness (lb) and starch index in 10° scale at harvest; (9) the bloom intensity next season on a 5° scale (1 – no flowers, 5 – very abundant blooming).

Each treatment was tested on 6 trees (1 tree = replication) of similar height and blooming intensity, randomly distributed along the row.

The results were statistically analyzed using an analysis of variance and Duncan's t-test at $p = 0.05$ level for significance.

RESULTS

Experiment 1 was conducted in 2006, when the trees were blooming very abundantly. The weather conditions were sunny and warm. It was found that only two sprayings of trees with metamitron, or the artificial shading for 10 days starting from fruitlet which were at a stage of 6 mm in diameter, caused reduction of fruit set similar to that obtained with hand thinning. No thinning effect was noticed in trees treated with metamitron for one term, only. The most intensive thinning, shown by the reduction of fruit set (by half in comparison to the control untreated trees), was noticed with the use of artificial shading for 14 days. The intensive thinning effect was achieved when shading was started when fruitlets were 14 mm in diameter. This treatment caused a very even distribution of single fruits per cluster, throughout the tree canopy. The two methods of shading, for 5 days when fruitlets were 6 to 9 mm in diameter, and for 7 days when fruitlets were 9 to 14 mm in diameter, did not induce fruitlet abscission. The large number of clusters with two fruits, in trees treated with metamitron (once or twice) and late shading for 7 days, suggest the lower selectivity of thinning in the case of these treatments, in comparison to others (Tab. 1).

There was a good effect of metamitron on mean fruit weight, especially after two applications. Substantial increase in fruit size was found after artificial shading for 10 and 14 days. A shorter 5-7 day shading time had no effect on fruit size. A lot of pigmy fruits were noticed in 'Gala Must' in 2006. However, all thinning treatments reduced the number of pigmy fruits in comparison to the untreated control trees. The lowest number of pigmy fruits was observed in the trees which had been shaded early and for a short period.

The improved distribution of apples in size groups, and consequently, the increase of their grading index value were observed. These improvements were especially true, when metamitron was used twice or artificial shading was used for 10-14 days. The significant effect of two applications of metamitron, or of long shading, on the yield of marketable apples was noticed. The yield of apples > 70 mm in diameter in kg/tree was higher compared to the untreated control trees. In this respect the effect of hand thinning was the best. The low increase in total yield was noticed in trees treated twice with metamitron. Only a 14 day artificial late shading, caused reduction of total yield by 20% (insignificant in comparison with the control).

No distinct effect of treatments tested on red colour of apples was found. The only exclusion was for the 14 day shading which resulted in a significant increase of red colour index value.

No significant effect of treatments tested in 2006 on internal quality of apples 'Gala Must' at harvest, expressed by firmness, refraction value and starch index, was noticed.

Table 1. Effect of treatments in 2006 on fruit set, yield and mean fruit size, and quality of apples 'Gala Must'

Treatment	% fruit set (No. fruit/100 flower clusters)	Average fruit weight [g]	Total yield [kg/tree]	Yield >70mm [kg/tree]	Yield >70mm (% of total)	Pigmy fruits No./tree	Firmness [lb]	Refrac-tion [%]	Starch index in 10° scale	Subsequent blooming in 2007 5° scale (5-very abundant)
Control untreated	50.8 b*	134.3 a	36.0 ab	18.5 ab	51.4 a	76.0 b	15.3 ab	11.5 a	9.1 a	1.4 a
Hand thinning	38.5 ab	159.3 bc	36.2 ab	28.3 b	78.3 bc	00.0 a	15.5 ab	11.6 a	8.7 a	1.7 a
Metamitron 350 mg/l once	53.3 b	145.8 ab	38.6 b	24.3 ab	63.0 ab	53.8 b	15.5 ab	11.4 a	8.9 a	1.2 a
Metamitron 350 mg/l twice	40.6 ab	155.0 bc	35.5 ab	27.2 ab	76.5 bc	51.7 b	15.1 ab	11.6 a	9.3 a	1.5 a
Shading, fruitlets – 6 to 9 mm Ø for 5 days	48.5 b	134.3 a	36.6 ab	20.5 ab	52.1 a	38.5 b	15.6 ab	11.5 a	8.6 a	1.7 a
Shading, fruitlets – 9 to 14 mm Ø for 7 days	52.1 b	135.8 a	34.1 ab	17.5 a	53.6 a	65.2 b	14.7 a	11.1 a	9.6 a	1.9 a
Shading, fruitlets – 6 to 14 mm Ø for 10 days	35.1 ab	166.0 c	31.2 ab	26.0 ab	83.4 c	43.5 b	14.7 a	10.7 a	8.9 a	2.6 b
Shading, fruitlets – 14 to 26 mm Ø for 14 days	25.0 a	171.7 c	26.8 a	23.7 ab	88.1 c	54.9 b	15.7 b	11.7 a	8.8 a	3.3 b

*Mean followed by the same letter do not differ at p = 0.05 according to Duncan's multiple range t-test

In experiment 1, only long shading (10 and 14 days) significantly improved subsequent blooming. The other trees, including those treated with metamitron, bloomed poorly and bloomed similarly to the untreated control.

In **Experiment 2.** conducted in cloudy or less sunny weather after blooming as compared to season 2006, the two applications with metamitron caused overthinning. The best effect of thinning was observed in trees sprayed only once with metamitron, and in trees shaded late for 10 days. The use of metamitron, and shading (used separately on different trees) significantly reduced the number of spurs with 2 and more fruits per one cluster.

All methods of thinning caused an increase in mean fruit weight but only the effect of metamitron was significant. A more distinct and significant effect of all the thinning methods was observed on the distribution of apples in size classes, and consequently on the value of the size grading index, and on the yield of apples with a diameter of more than 70 mm (Fig. 1). However, shading, and the application of metamitron, (both treatments done on separate trees), gave the best results only once.

In experiment 2, Shading, and the use of metamitron (used separately on different trees) caused a distinct, but not significant, reduction in the red colour of apples (Fig. 2.). This methods of thinning increased the number of apples without red colour, more than two times. Treatment with metamitron especially diminished the number of apples with red colour on 25-75% of the fruit area. Consequently, the value of the colour index expressed the homogeneity of apples, and the average intensity of their red colour was reduced.

The "internal" quality of apples, expressed by their firmness and refraction value at harvest was slightly improved, especially when metamitron was applied.

In the experiment conducted in 2008, both treatments with metamitron or a 10 day late shading used on different trees than the metamitron sprayed trees, induced very abundant subsequent blooming in 'Gala Must' trees (Tab. 2).

DISCUSSION

The results of our experiments have shown that the limitation of photosynthates which happens with the use of shading or spraying the trees with photosynthetic inhibitors might be an alternative to chemicals commonly used for thinning on apple trees, confirming the opinion of other researchers (Byers et al., 1991; McArtney et al., 2004; Widmer, 2007). It was shown that the duration of shading, and the period of treatment had a decisive influence on the thinning effect. However, different cultivars respond differently to shading. In our experiments the best effect of thinning was noticed in the case of long shading, which lasts 10 days, starting at the moment when the diameter of the fruitlets was 6 mm up to fruit size of 14 mm in diameter. This method of thinning

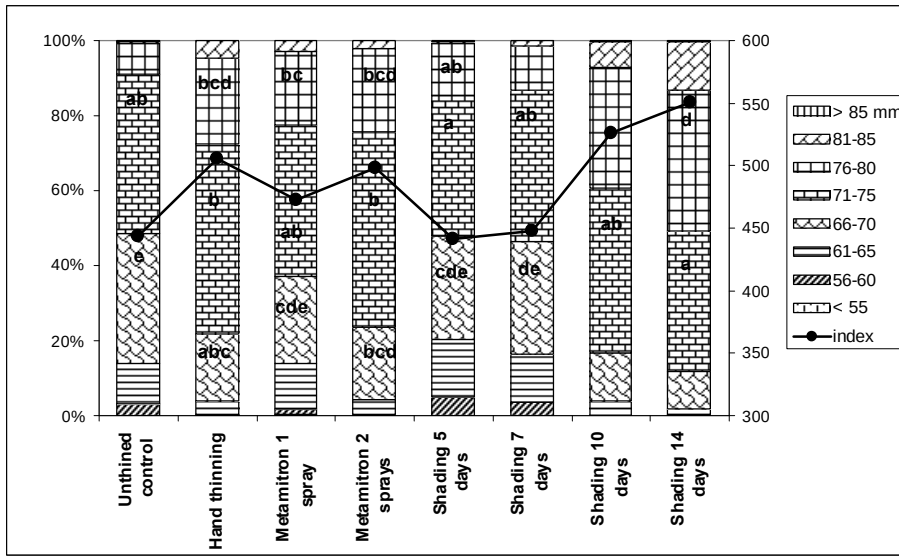

Figure 1. Apple distribution in size classes – 'Gala Must' 2006

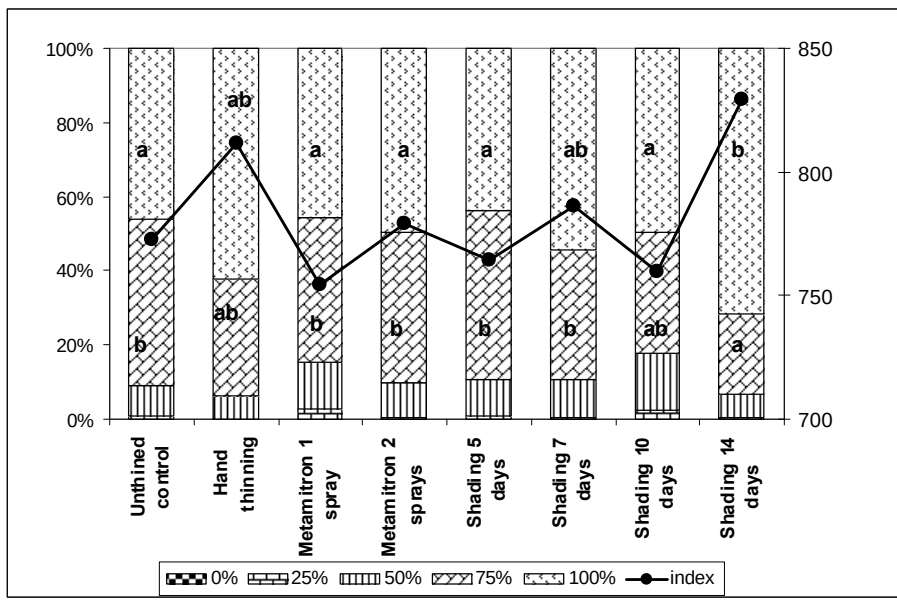

Figure 2. Apple distribution in colour classes – 'Gala Must' 2006

Table 2. Effect of treatments in 2008 on fruit set, yield and mean fruit size, and quality of apples 'Gala Must'

Treatment	Fruit set [%[		Average fruit weight [g]	Size grading index[1]	Total yield [kg/tree]	Fruits > 70mm % of total		Effect on red colour		Firmness (lb)	Refraction [%]	Subsequent blooming in 2009 5° scale
	No. fruit/100 flower clusters	Spurs with >2 fruits % total				[kg/tree]	(No. /tree)	colour grad-ing index [2]	% apples with red colour on 25-75% surface			
Control untreated	56 c*	18 b	143 a	470 a	47 c	60 a	61 a	674 ns	28 c	13.4 a	12.3 a	3.2 a
Hand thinning	57 c	17 ab	159 ab	533 b	45 c	83 b	85 b	629	19 bc	13.2 a	12.4 b	3.3 a
Metamitron 350 mg/l once	23 ab	9 a	179 bc	609 cd	24 b	89 bc	90 bc	546	11 ab	13.7 ab	12.9 ab	4.8 de
Metamitron 350 mg/l twice	8 a	3 a	202 c	645 d	14 a	93 c	96 c	563	4 a	14.2 b	13.1 ab	5.0 e
Shading starting at fruitlets 10 mm Ø for 10 days	25 b	4 a	170 ab	593 c	30 b	91 bc	91 bc	484	16 bc	13.5 ab	12.5 a	4.5 cde

*Explanation, see Table 1

[1]Size 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 = number of fruits in each class according to the national standard in 5 mm weigh classes

[2]Red colour 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 = number of fruits in classes: 1+ 05, 2 = < 25%, 3 = 26-50%, 4 = 51-75%, 5 = > 75% surface with red colour

caused a marked increase in fruit size and a greater marketable yield. This method also caused subsequent blooming without a distinct effect on the red colour of apples and their internal quality. The shorter and earlier version of the shading was not effective in the case of apple of 'Gala Must' distinguished with its abundant set of fruits but differentiated phenologicaly owing to extended blooming. In experiments conducted in Switzerland, starting with shading 25 days after full bloom, in 'Golden Delicious' the best thinning effect was noticed after 3 days of shading but 'Topaz' required 7 days for comparable results (Widmer et al., 2008). In the experiments conducted at the Laimburg Research Station in Italy on 'Golden Delicious' grafted on M.9, the best thinning effect was achieved after shading when fruitlets were 15 mm in diameter (Kelderer et al., 2008). Noteworthy thinning effects could not be achieved below 60% light reduction. The effects of the thinning methods in different years (with different meteorological conditions) seem to be surprisingly low in the experiments by Widmer et al. (2008). In our experiments, long shading gave a good thinning effect in both experiments, in spite of different weather in both seasons.

The effect of thinning by shading when blossoming in the following year, was mostly unsatisfactory in experiments of Widmer et al. (2008). In our experiments, conducted in Poland, the long shading in 'Gala Must' trees, improved subsequent blooming significantly. Maybe, the abundant fruit set of these trees during the year of thinning, and heavy abscission of fruits after shading, favoured the abundant flower bud set for the following year.

The different weather conditions in 2006 and 2008 modified the efficiency of metamitron used for thinning in 'Gala Must' apple trees. In 2006, with sunny weather, a good thinning effect was noticed in trees treated twice with metamitron, but in 2008, the weather was worse and only one spray with metamitron gave a good effect, while the repeated application caused overthinning. Applying metamitron twice in 2006, and once in 2008 caused a substantial increase in fruit size and the yield of marketable fruits. Good effect of metamitron applied in 2008 on subsequent blooming in 'Gala Must' was found. However, in the trials of other authors (Clever, 2007), thinning by metamitron sometimes diminished subsequent blooming in apple. In German experiments, a single metamitron application gave good results in younger orchards with a range of cultivars. The second treatment would cause excessive reduction of the yield. In older trees, the second metamitron application, at 10-14 days after the first one, gave an enhanced thinning effect.

According to the opinion of researchers (Widmer et al., 2008), shading presents the only possibility to selectively promote fruitlet drop and thereby achieve thinning. If thinning has been done by hand, shading seems to be an interesting alternative. However, thinning due to shading is

no alternative to chemical thinning because thinning by shading is too expensive (Kockerols et al., 2008). Therefore, in some circumstances the metamitron – photosynthetic inhibitor, could be used because it shows great potential for crop load control.

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SKUTECZNOŚĆ METAMITRONU I ZACIENIANIA W PRZERZEDZANIU ZAWIĄZKÓW OWOCOWYCH JABŁONI ‘GALA MUST’

Alina Basak

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

W latach 2006 i 2008 oceniono dwie metody przerzedzania zawiązków z zastosowaniem inhibitora fotosyntezy – metamitronu oraz czasowego zacieniania jabłoni odmiany ‘Gala Must’. Oczekiwano, że zastosowanie tych metod spowoduje czasowe ograniczenie intensywności fotosyntezy, co powinno nasilić współzawodnictwo pomiędzy zawiązkami i doprowadzić do opadnięcia słabszych z nich. W tym celu wykorzystano metamitron (preparat Goltix 700 SC) w stężeniu 350 mg/l, opryskując drzewa jednokrotnie (na zawiązki o średnicy 6-8 mm), lub dwukrotnie (drugi oprysk 6 dni później, na zawiązki o średnicy 10-14 mm). Inną grupę drzew przykryto na 5 do 14 dni polipropylenową tkaniną, powodując ograniczenie ilości światła docierającego do drzew o około 70%. W 2006 roku tylko podwójny oprysk metamitronem spowodował istotną redukcję zawiązania owoców w porównaniu z ręcznym przerzedzaniem. Konsekwencją tego zabiegu był wzrost wielkości owoców oraz plonu handlowego jabłek (o średnicy > 70 mm) bez negatywnego wpływu na plon całkowity, jakość wewnętrzną owoców i ich wybarwienie. W innych doświadczeniach (w roku 2008) dobry efekt przerzedzający obserwowano po jednokrotnym oprysku metamitronem, oprysk dwukrotny spowodował nadmierne przerzedzenie. Jednokrotne zastosowanie metamitronu wpłynęło korzystnie na wielkość owoców, dystrybucję jabłek w klasach wielkości oraz plon handlowy (średnica owoców > 70 mm). Porównywalną skutecz-

ność odnotowano na drzewach cieniowanych przez 10 dni, kiedy zawiązki miały 6-14 mm średnicy. Jednakowe rozmieszczenie owoców, równomiernie w całej koronie drzew, dowodzi, że obydwie metody przerzedzania charakteryzują się wysoką selektywnością.

Słowa kluczowe: przerzedzanie zawiązków, metamitron, zacienianie, redukcja fotosyntezy, plon, jakość owoców, jabłko