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Disclaimer:

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Gary M. Saunders

Manager, Horticultural Services (Science)

Signature Date

Report authorised by:

Dr Christopher J. Atkinson

Deputy Chief Executive and Senior Science Programme Leader

A handwritten signature in black ink, appearing to read 'C. Atkinson', with a long horizontal flourish extending to the right.

28 September 2012

Signature Date

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GROWER SUMMARY

Headline

Exilis offers a viable alternative to hand thinning apples, but in this one year trial, did not result in increased returns compared to an un-thinned control.

Background and expected deliverables

Effective fruit thinning and increasing fruit size through the use of chemicals or mechanical methods, whilst reducing or removing the cost of hand-thinning, is seen as a high priority by UK top-fruit growers. In addition, the HDC Tree Fruit Panel considers this to be a high priority for research funding.

Apple trees often set excessive numbers of fruit in relation to tree size, resulting in the production of large numbers of small fruit. 'Thinning' or removing a proportion of the fruit enables the remaining apples to reach a larger size and these are easier and cheaper to pick. This enables growers to produce fruit in the desired size range for market requirements. In addition to increasing fruit size, thinning can also be used to increase fruit quality, for instance by removing damaged fruit from the tree. It can also prevent over cropping, which can lead to biennial bearing in some varieties.

There have been recent developments and changes in chemical and mechanical fruit thinning techniques. If effective, these proposed techniques could reduce or remove the cost of the hand thinning operation. This project investigated these alternative thinning techniques for the variety Gala and determined the cost benefit of each.

The treatments included in the investigation were:

1. Untreated
2. Hand thinning at 12-15 mm according to agronomists' recommendations
3. Exilis applied at 8-12 mm fruit size at 7.5 l/ha in a water volume of 500 l/ha, when temperature is forecast to be above 15°C for the two days following application
4. Ammonium thiosulphate (ATS) applied at open flower at a rate of 2% applied in 500 l/ha

5. ATS applied at open flower at a rate of 2% applied as 500 l/ha + Exilis applied at 8-12 mm fruit size at 7.5 l/ha in a water volume of 500 l/ha, when temperature is forecast to be above 15°C for the two days following application
6. Cerone (0.75 l/ha in a water volume of 500 l/ha) applied at petal fall
7. Cerone (0.75 l/ha in a water volume of 500 l/ha) applied at petal fall + Exilis applied at 8-12 mm fruit size at 7.5 l/ha in a water volume of 500 l/ha, when temperature is forecast to be above 15°C for the two days following application
8. Mechanical blossom thinning using the Fruit-tec Darwin thinner

Summary of the project and main conclusions

In this one year project, Exilis, when applied according to the manufacturer's recommendations, was shown to be a viable alternative method to hand thinning. The other methods evaluated were not effective at reducing crop load, but reports from commercial growers suggest that ATS and the Darwin mechanical blossom thinner are also potential candidates to replace hand thinning.

The use of Exilis in treatments 3, 5 and 7 resulted in a significant reduction in crop load, leading to an increase in fruit size. Greater returns were achieved for fruit in the larger size classes. However the reduction in fruit number outweighed this increase in return per apple, resulting in an overall reduction in income per tree. None of the treatments resulted in a break-even point where reduction in fruit number was offset by extra income from larger fruit.

Careful consideration therefore needs to be made by growers when deciding on the level of thinning required, taking into account the difference in return between the different size classes of fruit.

Return bloom was not affected by treatment, but it should be noted that winter pruning would have resulted in the removal of some of the fruiting wood.

Financial benefits

In this one year project on Gala apple, the treatment which provided the greatest degree of thinning (ATS & Exilis), provided the lowest return per tree (£12.33). In contrast the unthinned treatment returned £18.68 per tree. Any conclusions should be treated with caution, as these figures related to costs and income by size class specific to one farm (East Malling Research) and in one year(2011).

Action points for growers

- If thinning is required to increase crop size, Exilis can be used as an alternative to hand thinning.

SCIENCE SECTION

Introduction

Effective fruit thinning, and increasing fruit size through the use of chemicals or mechanical methods, whilst reducing or removing the cost of hand-thinning, is seen as a high research priority. Indeed at the HDC Tree Fruit Panel open meeting held on 3 March 2010 it was minuted that of current research priorities, fruit thinning and fruit size was the most important.

Two 6-BA products were given specific off label approval (SOLA) for use on apple in 2011. This project made use of 6-BA and hand thinning to develop commercially appropriate methods of thinning that potentially have an overall cost benefit to the crop.

The aim of the project was to determine the effectiveness and cost benefit of a range of thinning strategies for cultivar Gala apple and had the following specific objectives:

1. To apply eight treatments including an un-thinned control
2. To determine the time taken and cost for each treatment method
3. To determine yield in each size category at harvest for each treatment
4. To determine the cost benefit of each treatment

Materials and methods

The trial was conducted at East Malling Research, East Malling, Kent, in plot number EE191 on cv. Gala apple - 1.25ha plot of alternate rows of cvs. Mondial Gala and Queen Cox, both on M9 and planted in 1999. Weather data was collected during the trial from an on-site weather station.

The treatments applied were as follows:

1. Untreated
2. Hand thinning at 12-15 mm according to agronomists' recommendations
3. Exilis (6-BA) applied at 8-12 mm fruit size at 7.5 l/ha in a water volume of 500 l/ha

when the temperature is forecast to be above 15°C for the two days following application

4. Ammonium thiosulphate (ATS) applied at open flower at a rate of 2% applied at 500 l/ha
5. ATS applied at open flower at a rate of 2% applied at 500 l/ha + Exilis applied at 8-12 mm fruit size at 7.5 l/ha in a water volume of 500 l/ha when the temperature is forecast to be above 15°C for the two days following application
6. Cerone (0.75 l/ha in a water volume of 500 l/ha) applied at petal fall
7. Cerone (0.75 l/ha in a water volume of 500 l/ha) applied at petal fall + Exilis applied at 8-12 mm fruit size at 7.5 l/ha in a water volume of 500 l/ha when the temperature is forecast to be above 15°C for the two days following application
8. Mechanical blossom thinning using the Fruit-tec Darwin thinner

ATS was applied on 19/04/2011, Cerone on 29/04/2011 and Exilis on 05/05/2011. Thinning by the Darwin fruit thinner was carried out on 18/04/2011 and hand thinning to single fruit 12.5cm apart was carried out on 06/06/2011.

Treatments were replicated five times as plots of three trees, laid out in a randomised block design.

At pink bud flower clusters per tree were assessed and were again assessed the following season to determine if any of the treatments effected return bloom. Fruit number was determined prior to and post June-drop. At harvest fruit number and weight was determined for each size class for each tree.

Costs of chemicals used, time taken for application, time taken for hand thinning operations and for harvest were determined for each plot, along with commercially achieved price per fruit category to enable a simple cost benefit to be determined for each thinning strategy. This calculation consisted simply of income minus costs. Income was calculated on yield of each size class multiplied by return to the grower for each size class. Costs were calculated as the cost of the thinning operation plus the cost of harvest labour (based on time taken)

Results

Fruit number, fruit weight per tree and mean fruit weight

Total fruit number: treatments 2 (hand thin), 3 (Exilis), 5 (ATS + Exilis) and 7 (Cerone + Exilis) all showed a highly significant reduction compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$) with Exilis causing a reduction.

Total fruit weight: treatments 2 (hand thin) and 5 (ATS + Exilis) showed a significant reduction compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$) with Exilis causing a reduction overall.

Mean fruit weight: treatments 2, 3, 5 and 7 all showed a significant increase compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$), with Exilis causing an increase overall.

Table 1. Mean total fruit number and total fruit weight per tree

	Treatment	Total fruit number	Total fruit weight (kg)	Mean fruit weight (g)
1	Untreated	335.9	25.38	76.7
2	Hand thin	154.1	18.27	122.8
3	Exilis	174.3	20.24	117.5
4	ATS	323.5	26.45	82.8
5	ATS + Exilis	131.1	15.84	122.1
6	Cerone	294.0	24.29	83.4
7	Cerone + Exilis	174.1	19.82	118.2
8	Darwin	334.5	27.06	84.7
	F-prob	<0.001	0.011	<0.001
	SED (28 df)	35.44	3.243	6.60
	LSD	72.6	6.64	13.5

Fruit size distribution

Fruit number (<60mm): treatments 2, 3, 5 and 7 all showed a highly significant reduction compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$) with Exilis causing a reduction overall.

Fruit number (60-70mm): no evidence of any significant differences present.

Fruit number (>70mm): treatments 2, 3, 5 and 7 all showed a significant increase compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$) with Exilis causing an increase overall.

Table 2. Fruit number per tree by size class

	Treatment	Fruit number <60mm	Fruit number 60-70mm	Fruit number >70mm
1	Untreated	241.6	94.1	0.3
2	Hand thin	43.1	95.9	15.0
3	Exilis	53.2	100.1	21.0
4	ATS	241.6	80.9	0.9
5	ATS + Exilis	49.3	63.1	18.7
6	Cerone	219.3	68.8	5.9
7	Cerone + Exilis	61.1	96.9	16.1
8	Darwin	238.7	94.1	1.7
	F-prob	<0.001	0.517	<0.001
	SED (28 df)	28.07	20.96	4.51
	LSD	57.5	42.9	9.2

Fruit weight (<60mm): treatments 2, 3, 5 and 7 all showed a highly significant reduction compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$) with Exilis causing a reduction overall.

Fruit weight (60-70mm): no individual treatment showed a significant difference from the untreated control.

Fruit weight (>70mm): as for fruit number >70mm, treatments 2, 3, 5 and 7 all showed a significant increase compared to the control. In terms of +/-Exilis the effect is highly significant ($p<0.001$) with Exilis causing an increase overall.

Table 3. Weight of fruit per tree by size class

Treatment		Fruit weight (kg) <60mm	Fruit weight (kg) 60-70mm	Fruit weight (kg) >70mm
1	Untreated	16.20	9.14	0.03
2	Hand thin	3.71	12.22	2.33
3	Exilis	4.16	12.53	3.55
4	ATS	17.74	8.57	0.13
5	ATS + Exilis	4.63	8.14	3.07
6	Cerone	16.17	7.23	0.89
7	Cerone + Exilis	4.96	12.28	2.57
8	Darwin	17.54	9.24	0.28
F-prob		<0.001	0.177	<0.001
SED (28 df)		2.112	2.351	0.721
LSD		4.33	4.82	1.48

Cost benefit

The overall effect of Exilis ($p=0.001$), was a decrease in financial return. Thus, although numbers of large fruit were increased with thinning, this does not appear to be sufficient to offset the decreased numbers/weights. However, looking at individual treatments, only treatment 5 (ATS + Exilis) showed a statistically significant decrease compared to the untreated control.

Table 4. Average return per tree

Treatment		Return per tree (£)
1	Untreated	18.68
2	Hand thin	14.33
3	Exilis	15.92
4	ATS	19.39
5	ATS + Exilis	12.33
6	Cerone	17.85
8	Cerone + Exilis	15.46
8	Darwin	19.91
F-prob		0.055
SED (28 df)		2.483
LSD		5.08

Effect of treatment on return bloom

There was some variation in number of flower buds from 2011 to 2012 ranging from -3.8% to +6.4%. The effect of the treatments would however been somewhat masked by winter pruning.

Table 5. Percentage change in clusters of flower buds per tree from 2011 to 2012

Treatment		Change in clusters of flower buds 2011-2012 (%)
1	Untreated	-3.8
2	Hand thin	6.4
3	Exilis	5.9
4	ATS	-1.2
5	ATS + Exilis	6.2
6	Cerone	4.2
7	Cerone + Exilis	6.3
8	Darwin	2.1

Discussion

It must be remembered that the data presented in this report is from one year only and costs and income are specific for that year also. The Gala trees used cropped relatively well for that orchard, but initial crop load was estimated to be less than that of many commercial orchards. Seasonal variation is likely to affect the results in other years. For example, the use of Exilis as a thinning agent in the year of the trial was extremely effective, producing a yield profile similar to that of hand thinning. Exilis requires temperatures in excess of 15°C for two days following application and in 2011 weather conditions were favourable after application, but this might not be the case in subsequent years. ATS applied with Exilis produced an even greater thinning effect. ATS, Cerone and the Darwin machine failed to reduce crop load. ATS has been used successfully by industry to thin apple crops, as has the Darwin machine. Possible explanations for their lack of thinning effect may be timing, in that treatment applications may not have been made at the optimum times. It is known that there is a window of opportunity for successful application of both ATS and mechanical thinning by the Darwin machine.

Return bloom was not affected by treatment, but winter pruning would have had an effect of flower bud clusters as the pruning would have resulted in the removal of some of the fruiting wood.

Also shown, as expected, is that reducing crop load increases the size of the remaining fruit. Even though fruit size was increased by thinning, with associated higher prices for larger fruit, the overall reduction in fruit number outweighed the increase in income for the larger fruit resulting in a reduction in overall return for the ATS + Exilis treatment.

Conclusions

- Exilis can be used as an effective method of thinning reducing fruit number and increasing fruit size when compared to an un-thinned control.
- Thinning a crop and increasing fruit size may not result in an increased profit.
- Careful consideration is required when making decisions on thinning.

Knowledge and Technology Transfer

Presentation at HDC Agronomists day, 6 March 2012

Appendix

Weather Data

	Maximum (°C)	Minimum (°C)	Rainfall (mm)
01/04/2011	15.7	8.3	0.2
02/04/2011	19.3	3.1	0
03/04/2011	14.9	4.9	0
04/04/2011	13.1	8.4	1
05/04/2011	16.7	10.0	0
06/04/2011	21.4	4.7	0
07/04/2011	22.1	6.0	0
08/04/2011	20.5	3.7	0
09/04/2011	15.3	4.4	0.2
10/04/2011	17.5	3.3	0
11/04/2011	21.2	6.0	0.2
12/04/2011	14.0	-0.1	0
13/04/2011	12.8	6.2	0.2
14/04/2011	13.3	8.0	0
15/04/2011	15.3	6.9	0
16/04/2011	17.6	4.8	0
17/04/2011	18.3	4.9	0.2
18/04/2011	17.9	5.8	0
19/04/2011	23.2	7.0	0
20/04/2011	23.7	8.9	0.2
21/04/2011	24.5	6.0	0.2
22/04/2011	24.3	6.9	0
23/04/2011	25.7	7.4	0
24/04/2011	22.7	9.3	0
25/04/2011	20.6	8.2	0
26/04/2011	17.0	8.3	0
27/04/2011	15.6	5.9	0
28/04/2011	15.5	8.5	0
29/04/2011	17.6	10.7	0
30/04/2011	15.7	11.1	0

	Maximum (°C)	Minimum (°C)	Rainfall (mm)
01/05/2011	15.2	9.7	0
02/05/2011	14.1	5.7	0
03/05/2011	13.2	0.2	0
04/05/2011	15.7	2.7	0
05/05/2011	19.2	5.1	0
06/05/2011	23.4	13.0	2.8
07/05/2011	22.3	14.7	2
08/05/2011	19.6	7.1	0.2
09/05/2011	20.2	5.8	0
10/05/2011	20.6	6.9	0
11/05/2011	18.4	7.6	0.2
12/05/2011	18.2	3.8	0
13/05/2011	18.2	5.9	0
14/05/2011	16.9	8.1	0
15/05/2011	15.6	10.0	0
16/05/2011	20.8	10.3	0
17/05/2011	18.9	12.6	0
18/05/2011	17.3	9.9	0
19/05/2011	19.4	7.2	0
20/05/2011	19.9	4.8	0
21/05/2011	20.5	9.5	0.8
22/05/2011	19.1	7.9	0
23/05/2011	18.2	6.3	0
24/05/2011	19.1	2.4	0
25/05/2011	19.5	10.2	0
26/05/2011	16.8	10.2	5
27/05/2011	16.4	7.9	0
28/05/2011	17.6	12.5	0
29/05/2011	20.0	10.2	0
30/05/2011	20.8	8.0	1.4
31/05/2011	17.5	3.7	0