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Grower summary

TF 148

Thinning of apple flowers using chemicals sensitive to the environment

Final report 2005

CONTENTS

Grower summary

Science Section

EAST MALLING RESEARCH

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Authentication

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

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D S Johnson

Date ……………………………......................................

Grower Summary

Headline

Sodium chloride (common salt) is an effective alternative to ammonium thiosulphate for thinning apple flowers and may be more acceptable in organic and integrated fruit production systems.

Background and expected deliverables

The overall objective of this three-year project is to provide the UK apple industry with technologies for reducing fruit set that are suitable for organic and integrated fruit production systems. The development of safe and effective measures for achieving the desired level of fruit set is critical in achieving the size of fruit demanded by retailers and consumers. The profitability of fruit growers is highly dependent on achieving sufficient volumes of Class 1 fruit of greater than 63mm diameter (dessert cultivars). To achieve the correct crop loading by hand thinning alone is prohibitively expensive. The ability to thin apple crops reliably at a time that provides the greatest potential size, i.e. full bloom, would be a major benefit to the UK industry, particularly if achieved using chemicals deemed to present no hazard to farm operatives or consumers.

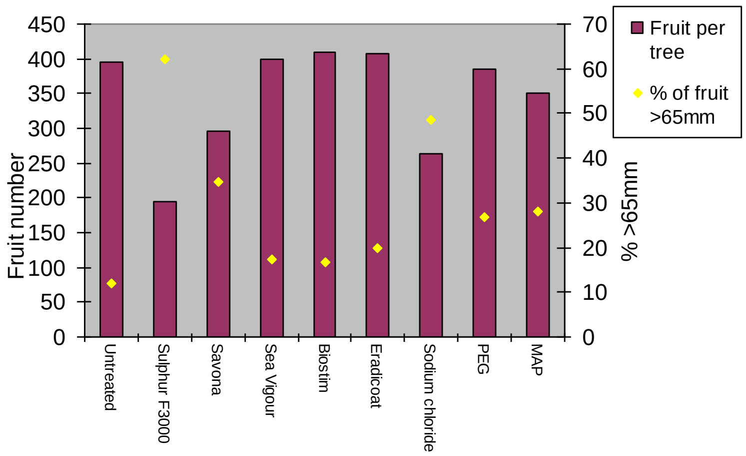
Summary of the project and main conclusion

Screening trials were carried out on Royal Gala in 2003 to evaluate the effectiveness of a number of chemicals in thinning apple flowers in comparison with the use of ammonium thiosulphate (‘Sulphur F3000’) and hand thinning of fruitlets. These included ‘Savona’, ‘Sea Vigour’, ‘Biostim’, ‘Eradicoat’, common salt (sodium chloride), ‘PEG 100’ (polyethylene glycol) and mono-ammonium phosphate (MAP).

Application of ‘Sulphur F3000’ proved to be the most effective thinning treatment and supports the recommendation provided in the Best Practice Guide for UK Apple Production (Defra) (Figure 1). The two other chemicals which were consistently effective at thinning the crop and improving fruit size were sodium chloride (common salt) and to a lesser extent

'Savona'. However, 'Savona' caused a significant increase in russetting that appears to rule out this material as a potential chemical thinning treatment for apples. Polyethylene glycol (PEG) and mono ammonium phosphate (MAP) provided consistent trends in the results that merited their inclusion in the second year of the project. There was insufficient indication of any potential benefits of 'Sea Vigour', 'Biostim' or 'Eradicoat' to justify their inclusion in further work.

Fig. 1. Blossom thinning in 2003



In 2004, two replicated experiments were carried out in a Royal Gala orchard at East Malling Research. In the first experiment, three chemicals that showed promise as thinning agents in screening trials done in 2003 were evaluated further. These chemicals, sodium chloride (common salt), polyethylene glycol and mono-ammonium phosphate, were applied at two rates and on one or two occasions and their effects on cropping were compared with those achieved using 'Sulphur F3000' or hand thinning of fruitlets. In the second (screening) experiment three other chemicals ('Codacide', kaolin and vinegar) were evaluated for their effectiveness in reducing fruit set and improving fruit size at harvest.

Application of 'Sulphur F3000' on two occasions (as recommended in 'The Best Practice Guide for UK Apple Production') resulted in a lower fruit set than achieved with hand thinning and the yield of fruit was reduced significantly to 19.2 kg per tree (31 tonnes per hectare). This compares with 29.1 kg tree or 48 tonnes per hectare for the hand-thinned trees.

In response to the lower numbers of fruit on trees treated with ‘Sulphur F3000’ the percentage of fruit above 65 and 70 mm diameter was higher than for hand thinned trees. Although the actual (saleable) weight of fruit above 65 mm diameter was higher for hand-thinned as opposed to chemically-thinned (‘Sulphur F3000’) trees, the cost implications of hand and chemical thinning and other costs such as picking, storage and packing etc. need to be considered when calculating the most financially viable thinning treatment.

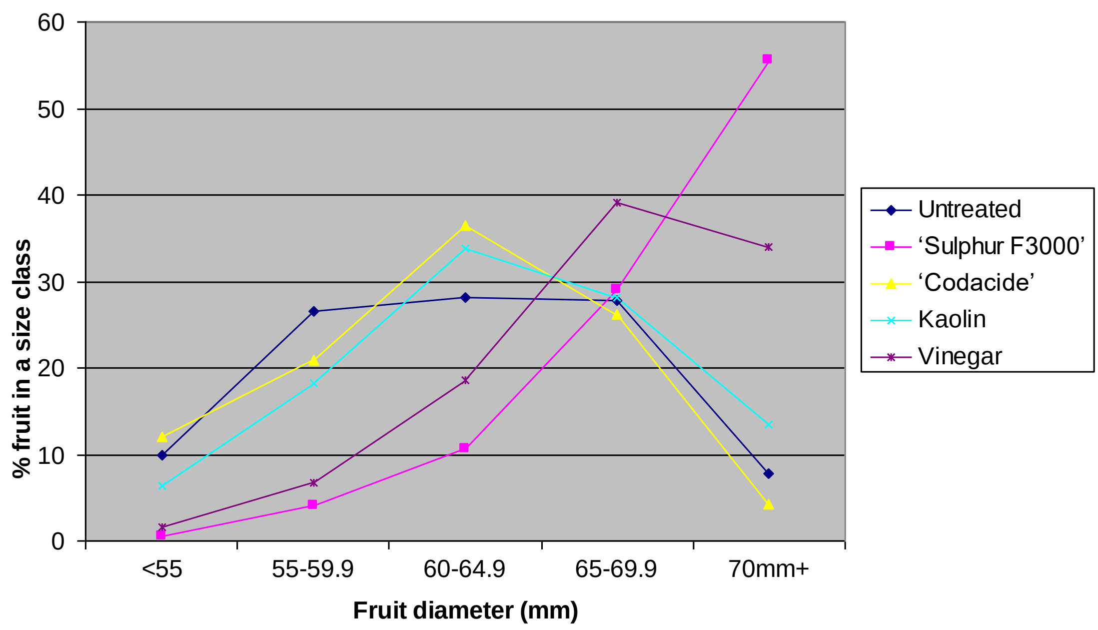
Thinning effects of ‘Sulphur F3000’ applied on one occasion were small in comparison with those achieved by two applications. This result was expected in view of the opportunity to thin the flowers on both two-year old wood and on one-year old wood provided by two applications.

In a comparison of treatments applied on two occasions, common salt reduced fruit number and yield to a similar extent as ‘Sulphur F3000’ and there was no effect of dose rate. Two applications of ‘PEG’ or ‘MAP’ reduced fruit numbers although the effect just failed to reach significance and there was no significant reduction in yield. Although ‘PEG’ and ‘MAP’ increased the percentage of fruit above 65 mm the effects on grade-out were small in comparison with those of ‘Sulphur F3000’ and common salt. Doubling the dose of ‘PEG’ did not increase thinning efficiency, although the effectiveness of ‘MAP’ was improved significantly with a 16% increase in the percentage of fruit above 65 mm diameter.

It is considered that the most successful thinning treatment is that which provides the highest actual (saleable) yield of fruit above 65 mm diameter. Consequently thinning protocols that result in over-thinning, i.e. yield reduction, may not prove to be the most cost effective option. In this trial ‘Sulphur F3000’ and common salt (high rate) proved to be the most effective thinning agents when applied on two occasions when performance was assessed on percentage size grade out. However, the saleable weight of fruit of greater than 65 mm was highest for hand thinning (34.8 tonnes per hectare) followed by high rate common salt (32.9 tonnes per hectare), low rate common salt (28.3 tonnes per hectare), ‘Sulphur F3000’ (27.3 tonnes per hectare) and ‘MAP’ (23.3 tonnes per hectare). This method of assessing thinning efficiency assumes that it was possible to pick only fruit of greater than 65 mm so that no costs were incurred by picking and then subsequently grading out smaller fruit. It would appear that common salt compares well with ‘Sulphur F3000’ for effective thinning of apple flowers and may prove more acceptable for use in organic orchards.

In Experiment 2, none of the chemicals tested reduced yield of fruit at harvest. Only 'Sulphur F3000' and vinegar significantly reduced the number of fruits at harvest in proportion to the initial number of flower buds. 'Sulphur F3000' tended to be more effective than vinegar but the difference between the two treatments was not statistically significant. 'Codacide' and kaolin did not reduce fruit numbers at harvest and consequently had no effect on fruit yield or grade-out (Figure 2).

Fig. 2. Blossom thinning in 2004



In 2005, replicated experiments were carried out in Royal Gala, Queen Cox and Bramley's Seedling orchards at East Malling Research. Specific objectives in 2005 were:

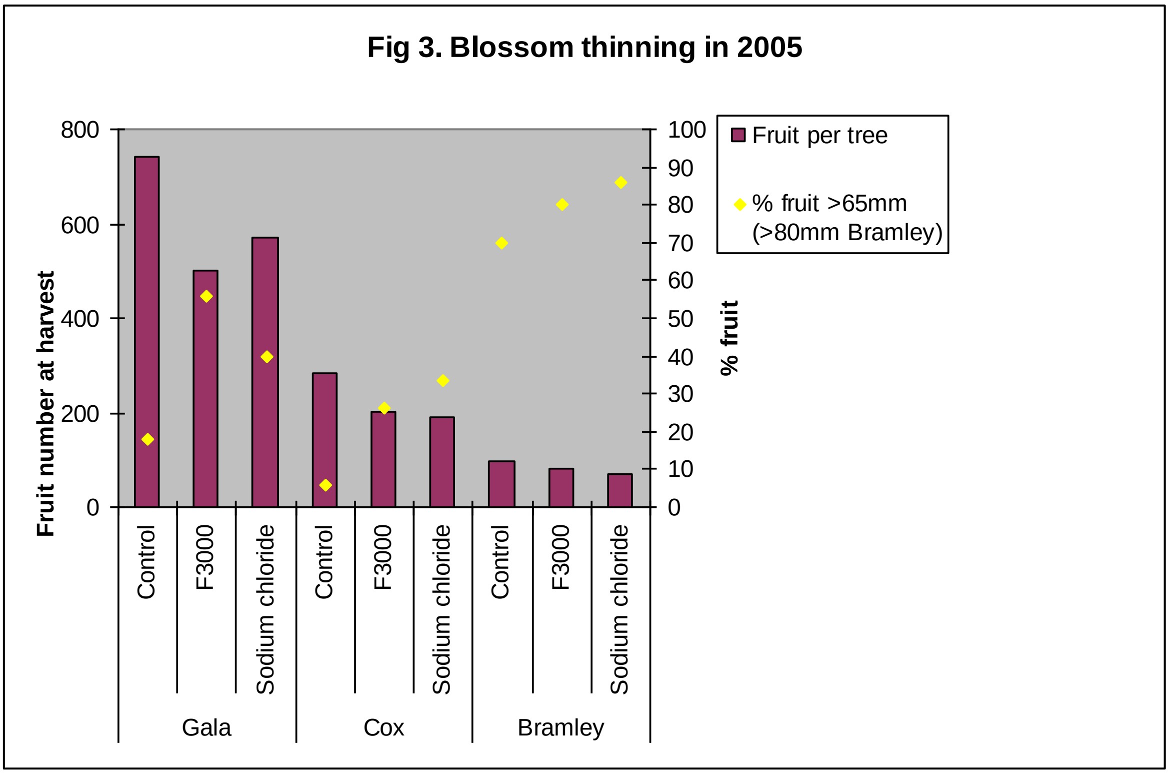
- to investigate the effect of dose on the thinning effect of vinegar
- to evaluate the thinning potential of 'Azolon' fluid (Methylene-urea-N)
- to compare the effectiveness of common salt and 'Sulphur F3000' as chemical flower thinning agents on Royal Gala, Queen Cox and Bramley's Seedling.

As in the previous year, there were serious adverse consequences of not thinning Gala trees in 2005. Although yield from un-thinned trees was high at 26 kg per tree (43 tonnes per hectare) the mean fruit weight was only 57.2 g and none of the fruit was above 65 mm diameter, which is the critical size threshold for the cultivar.

Hand thinning of trees to leave two fruits per cluster reduced the number of fruit on the tree at harvest and increased mean fruit weight and improved grade-out by reducing the percentage of fruit in the <55mm category and increasing the % in the 55-59.9mm category. However, only 2.5% of fruit from hand-thinned trees were above 65mm diameter which contrasts markedly with the previous year where hand thinning transformed the potential financial return from the orchard by increasing the percentage of fruit above 65 mm from 10% to 73% (by weight). Hand thinning resulted in a 46% reduction in fruit number per tree in 2004 but only a 22% reduction in 2005. Clearly further thinning of clusters was required in 2005 to achieve a level of crop that could achieve sufficient size.

'Sulphur F3000' and common salt were the most effective chemical thinning agents on Royal Gala and were equivalent in their affects on crop load and grade-out. They were also far more effective than hand thinning but clearly further hand thinning subsequent to chemical thinning was required to improve the size-grade out and to make the crop viable commercially. Vinegar was as effective as hand thinning in reducing fruit number per tree and improving fruit size but much less effective than either 'Sulphur F3000' or common salt. Diluting vinegar by 50% markedly reduced its efficacy although there was an improvement in size grade-out compared with the untreated controls. There were no significant effects of 'Azolon' fluid on any of the measured parameters although number of fruits per tree and the percentage of small fruits (<55mm) tended to be reduced.

Both 'Sulphur F3000' and common salt proved to be effective thinning agents on the three cultivars tested with neither chemical being consistently more effective (Figure 3). On Royal Gala 'Sulphur F3000'was generally more effective than salt, but the reverse was true on Bramley's Seedling. Both chemicals produced a similar response on Queen Cox. Clearly on the dessert cultivars subsequent hand thinning was required to improve the size grade-out to commercially acceptable levels. There is an expectation that growers would need to follow up chemical thinning with hand-thinning and it is important that application of flower thinning agents does not result in over-thinning. Clearly reducing the time to hand thin by pre-thinning with chemicals has major implications on the cost of achieving the correct crop load and on the profitability of apple production.



Conclusions

Most-effective thinning agents were: 'Sulphur F3000' (ammonium thiosulphate or ATS), common salt (sodium chloride), 'Savona' and vinegar although the latter two chemicals increased skin russet.

Partially effective thinning agents were: 'PEG 100' (polyethylene glycol) and mono ammonium phosphate.

Ineffective thinning agents were: 'Sea Vigour', 'Biostim', 'Eradicoat', 'Codacide', Kaolin and 'Azolon'.

- ATS in the form of 'Sulphur F3000' was confirmed as an effective agent for thinning apple flowers and more effective than any of the other prospective chemical thinners tested on Gala in 2003.

- In 2004, sodium chloride (common salt) was generally as effective as ATS as a thinning agent for Royal Gala.

- In 2005, on Royal Gala 'Sulphur F3000' was generally more effective than sodium chloride (common salt), but the reverse was true on Bramley's Seedling. Both chemicals produced a similar response on Queen Cox.

- Hand thinning subsequent to chemical thinning was often required to improve the size grade-out to commercially acceptable levels.

Financial benefits

The work done in 2004 provides a good example of what can be achieved by effective chemical flower thinning of Royal Gala trees. Clearly, the ability to produce 27.3 ('Sulphur F3000') or 32.9 (sodium chloride) tonnes per hectare of fruit above 65 mm diameter has a massive effect on profitability, particularly where this is achieved without the expense of hand thinning of fruitlets. In the 2004 experiments un-thinned trees produced only 5.7 tonnes per hectare of fruits above 65 mm diameter whereas hand thinning to leave 2 fruits per cluster provided 34.8 tonnes per hectare. Several factors would have to be considered when determining the most cost effective thinning treatments. The ideal size distribution of fruit on the tree and actual amount in any size category has implications for the cost of picking, storage, grading and packing and is influenced markedly by the market demand for apples of particular sizes. Clearly chemical thinning has a major part to play in determining both the proportion and amount of fruit in the more profitable size bands and is relatively inexpensive compared with the cost of hand thinning.

Action points for growers

- Growers may be interested in applying common salt to **small areas** of orchard at a time when they would normally apply ATS (see the Defra *'Best Practice Guide for UK Apple Production'* for advice on the use of chemicals for thinning of flowers).

- It is advisable to apply 12 g of common salt per litre of water applied at high volume.

- Although 16 g per litre of water is likely to be more effective in view of the evidence from abroad that this may result in over-thinning, interested growers may like to compare the effects of the two rates in **small areas** of orchard.

Science Section

Introduction

Achieving the optimum crop load in apple orchards is critical for profitable production. Large fruits typically have twice the value of small fruits and are easier and cheaper to pick and cheaper to grade. Whilst hand thinning of fruitlets is the best way to achieve the correct crop load, it is too costly to carry out without prior reduction in the number of flowers or fruitlets by the use of chemical thinning agents. There are currently no chemical fruitlet thinners approved for use in the UK although trials with products containing benzyladenine (BA) appear promising (see HDC News, April 2003). Currently, the UK fruit industry is reliant on the use of the foliar nutrient ammonium thiosulphate (ATS) to thin apple flowers even though ATS is not approved for this purpose. Commonly blossom thinning with ATS is supplemented by hand thinning at the 12mm fruitlet diameter stage. Effective blossom thinning using ATS is dependent on spray concentration and timing, weather conditions and cultivar. UK experience of using ATS as a thinning agent for apples is outlined in the 'The Defra Best Practice Guide for UK Apple Production'.

It is clear from reports on APRC project SP137 'Current developments in the use of plant growth regulants in apple and pear production' and from discussions with the author, Dr Tony Webster (2002 a & b), that considerable research is being done world-wide to develop new thinning options for organic production. These new options would include environmentally sensitive sprays suitable for conventional and organic orchards. This project recognises the need to evaluate on UK cultivars coatings, pollenicides and other chemicals that have shown promise as blossom thinners in trials done elsewhere and to perform experiments to optimise their application under UK conditions.

Aims of the project

The overall objective is to provide the UK apple industry with suitable technology for reducing fruit set that is suitable for organic and integrated fruit production systems. The development of safe and effective measures for achieving the desired level of fruit set is critical in achieving the size of fruit demanded by retailers and consumers. The profitability of fruit growers is highly dependent on achieving sufficient volumes of Class 1 fruit of greater than 63mm diameter (dessert cultivars). To achieve the correct crop loading by hand thinning alone is prohibitively expensive. The ability to thin apple crops reliably at a time that provides the greatest potential size, i.e. full bloom, would be a major benefit to the UK industry particularly if achieved using chemicals deemed to present no hazard to farm operatives or consumers.

Outline of results from year 1

Screening trials were carried out in 2003 to evaluate the effectiveness of a number of chemicals in thinning apple flowers in comparison with the use of ATS and hand thinning of fruitlets.

Chemical thinning treatments (Table 1) were applied at high volume (approximately 0.6 litres/tree) to 13 year-old trees of Royal Gala on M9 rootstock on the Home Farm site of East Malling Research (EMR). Sprays were applied on 29 April 2003 when the majority of trees were at full bloom. Hand thinning to two fruits per cluster was carried out on the 29 and 30 May 2003 when fruitlet size was approximately 10-12mm.

Table 1. Treatments evaluated in the thinning experiment in 2003

Treatment	Active ingredient	Concentration ml/l
Unthinned control	-	-
Hand thinned	-	-
'Sulphur F3000'	Sulphur and ammonia	18.5
'Savona'	Potassium salts of fatty acids	40
'Sea Vigour'	Fish solids	10
'Biostim'	Glycoprotein extract	30
'Eradicoat'	Natural plant extracts	25
Common salt	Sodium chloride	12 g
'PEG 100'	Polyethylene glycol	20 g
MAP	Mono ammonium phosphate	15

Damage to petals, flowers and leaves was assessed 24 hours after applying the treatments. The entire crop of fruit from each tree was harvested on 16 September 2003 and stored in air at 0-0.5^{o}C until early December. On removal from store the crop from each tree was graded for size. A sub-sample of 20 fruit was taken (random selection) from the crop from each tree and inspected for the presence of rots and an assessment was made of red colour (area not intensity) and amount of russet. Firmness measurements were made on the opposite sides of each of 10 fruit and each fruit was examined internally for the presence of disorders.

Damage to petals, flowers and foliage in order of severity was as follows:

1. 'SulphurF3000'. Severe petal and flower necrosis. Marginal necrosis on a few very young spur leaves.

2. 'Savona'. Severe petal and flower necrosis similar to 'Sulphur F3000' though no damage to young spur leaves.

3. MAP. Minimal necrosis to petals only. No damage to flowers or leaves.

4. Sodium chloride. Marginal necrosis to petals. No damage to flowers or leaves

5. 'Eradicoat'. Marginal necrosis to petals. Not as severe as sodium chloride. No damage to flowers or leaves

6. PEG 1000. Marginal necrosis to petals. Not as severe as 'Eradicoat'. No damage to flowers or leaves

7. 'Biostim'. Slight necrosis observed on only a few petals. No damage to flowers or leaves

8. 'Sea Vigour'. No damage to petals flowers or leaves.

Only 'Sulphur F3000', sodium chloride and 'Savona' reduced the number of fruits at harvest in proportion to the initial number of flower buds (Table 2). These treatments increased mean fruit weight and the percentage (expressed by number or weight) of fruit above 65 mm diameter. The greatest thinning effect was achieved by the use of 'Sulphur F3000' followed by sodium chloride and lastly by 'Savona'. The 'Sulphur F3000' treatment resulted in a reduced yield of fruit per tree.

Table 2. The effects of chemical thinning sprays applied to open flowers and hand thinning of fruitlets (10-12mm diameter) of Royal Gala. Effects on fruit number and yield (kg) per tree, percentage of flower buds that set fruits, mean fruit weight, the percentage of fruit with a diameter of 65mm or greater and severity of skin russet.

	Yield per tree (kg)	Fruit number at harvest per 100 flower buds	Mean fruit weight (g)	The percentage of fruit of diameter 65mm or greater		Skin russet index (max 100)
				By weight	By number	
Untreated	29.27	146.9	76.1	11.9	9.2	10.25
Hand thinned	29.96	133.9	89.2	26.9	22.6	8.62
Sulphur F3000	22.55	72.4	119.0	62.0	54.0	9.12
Savona	26.85	107.6	96.7	34.6	29.6	19.88
Sea Vigour	33.35	143.2	85.8	17.2	13.6	9.88
Biostim	34.02	156.8	85.4	16.8	12.8	10.62
Eradicoat	32.85	143.8	83.9	19.9	15.8	9.88
Sodium chloride	26.29	97.7	103.1	48.6	41.1	11.38
PEG	30.35	141.1	85.9	26.7	20.3	11.62
MAP	29.05	132.7	84.6	28.0	25.9	9.62
SED (70 d.f.)	3.478	11.26	9.03	11.14	10.36	2.416

Application of ‘Sulphur F3000’ proved to be the most effective thinning treatment and supports the recommendation provided in the Best Practice Guide for UK Apple Production (Defra). The two other chemicals which were consistently effective at thinning the crop and improving fruit size were sodium chloride (common salt) and to a lesser extent ‘Savona’. However, ‘Savona’ caused a significant increase in russetting that appears to rule out this material as a potential chemical thinning treatment for apples. Polyethylene glycol (PEG) and mono ammonium phosphate (MAP) provided consistent trends in the results that merited their inclusion in the second year of the project. There was insufficient indication of any potential benefits of ‘Sea Vigour’, ‘Biostim’ or ‘Eradicoat’ to justify their inclusion in further work.

Outline of results from year 2

The specific objectives in 2004 were:

1. To optimise the effectiveness of potential thinning agents that had shown promise in screening trials carried out in 2003 and to compare their effectiveness with the use of ammonium thiosulphate (‘Sulphur F3000’) and with hand thinning of fruitlets. Chemicals to be included were sodium chloride (common salt), polyethylene glycol (PEG) and mono-ammonium phosphate (MAP).

2. To evaluate new potential thinning agents (‘Codacide’, kaolin and vinegar) and to compare their effectiveness with that of ‘Sulphur F3000’.

Chemical thinning treatments were applied at high volume (approximately 0.6 litres/tree) to 6 year-old trees of Royal Gala on M9 rootstock in an orchard (EE190) on the Home Farm site of East Malling Research.

Experiment 1 - Optimising the effectiveness of potentially effective thinning agents

Sprays containing sodium chloride, PEG or MAP were applied on one (full bloom on spur buds) or two occasions (full bloom on spur buds and again at full bloom on axillary buds) and at two dose rates with the aim of maximising their ability to thin (Table 3). Sprays containing ‘Sulphur F3000’ were applied at a single rate (18.5 mL L^{-1}) on one or two occasions. The effects of chemical treatments were compared with those of hand thinning of fruitlets to two per cluster on 2 and 5 June 2004. Unthinned trees acted as controls.

Table 3. Treatments evaluated in the thinning Experiment 1 in 2004

Treat No.	Active	Product	Concentration	No. sprays
1	-	Untreated	-	
2	-	Hand thinned	-	
3	Sulphur & ammonia	‘Sulphur F3000’	18.5 mL L^{-1}	1
4	Sodium chloride	Common salt	12 g L^{-1}	1
5	Polyethylene glycol	‘PEG 100’	14 mL L^{-1}	1
6	Mono ammonium phosphate	‘MAP’	15 g L^{-1}	1
7	Sulphur & ammonia	‘Sulphur F3000’	18.5 mL L^{-1}	2
8	Sodium chloride	Common salt	12 g L^{-1}	2
9	Polyethylene glycol	‘PEG 100’	14 mL L^{-1}	2
10	Mono ammonium phosphate	‘MAP’	15 g L^{-1}	2
11	Sodium chloride	Common salt	16 g L^{-1}	1
12	Polyethylene glycol	‘PEG 100’	28 mL L^{-1}	1
13	Mono ammonium phosphate	‘MAP’	30 g L^{-1}	1
14	Sodium chloride	Common salt	16 g L^{-1}	2
15	Polyethylene glycol	‘PEG 100’	28 mL L^{-1}	2
16	Mono ammonium phosphate	‘MAP’	30 g L^{-1}	2

Experiment 2 - screening of potentially effective products

Each spray treatment comprised one application of each thinning product made on 7 May 2004 when the majority of trees were judged to be at full bloom on spur buds (Table 4). Subsequently all axillary flowers were removed.

Table 4. Treatments evaluated in the thinning Experiment 2 in 2004

Treatment No.	Active	Product	Concentration
1	-	Untreated	-
3	Sulphur and ammonia	'Sulphur F3000'	18.5 mL^{-1}
3	Rape seed oils	'Codacide'	5 mL L^{-1}
4	Clay	Kaolin	50 g L^{-1}
5	Acetic acid	Vinegar	Undiluted

Damage to petals, flowers and leaves was assessed 24 hours after applying the treatments. The entire crop of fruit from each tree was harvested on 20 September (Experiment 1) and 21 September 2004 (Experiment 2). Fruit from Experiment 1 was graded immediately for size using sizing rings and the number and weight of fruit in each size grade was recorded. Fruit from Experiment 2 was stored in air at 0-0.5^{o}C until the middle of December. On removal from store the crop from each tree was size graded for size. A sub-sample of 20 fruit was taken (random selection) from the crop from each tree and inspected for the presence of rots and an assessment was made of red colour (area, not intensity) and amount of russet. Firmness measurements were made on the opposite sides of each of 10 fruit and each fruit was examined internally for the presence of disorders.

Damage to petals and leaves

Petal and leaf necrosis was evident on some of the sprayed trees 24 hours after applying the treatments.

Damage to petals and foliage in order of severity was as follows:

1. 'SulphurF3000'
   Low rate. Necrosis to petals. Marginal necrosis to leaves.
   High rate. Severe necrosis to petals. Marginal necrosis to leaves.

2. Common Salt.
   Low rate. Necrosis to petals
   High rate. Necrosis to petals – more severe than the low rate of common salt but not as severe as high rate of 'Sulphur F3000'.

3. Vinegar

   Necrosis to petals. Marginal necrosis to leaves

4. PEG

   Low rate.   No petal or leaf damage noted

   High rate. Minimal amount of necrosis to petals and leaves

5. MAP

   Low rate. Minimal necrosis to petals. No damage to leaves

   High rate. Excessive necrosis to petals. No damage to leaves

6. 'Codacide'

   No damage to petals or leaves

7. Kaolin

   No damage to petals or leaves

In Experiment 1 there were serious adverse consequences of not thinning Gala trees in 2004. Although yield from un-thinned trees was high at 35 kg per tree (57 tonnes per hectare) the mean fruit weight was only 86.6 g and only 10% of the crop (by weight) was above 65 mm diameter, which is the critical size threshold for the cultivar (Table 5).

Table 5. Experiment 1. The effects of chemical thinning sprays applied to open flowers and hand thinning of fruitlets (10-12mm diameter) of Royal Gala in 2004. Effects on fruit number and yield (kg) per tree, percentage of flower buds that set fruits, mean fruit weight and percentage of fruit of 65 mm diameter or greater.

	Dose rate (L^{-1})	**No. sprays**	**Yield per tree (kg)**	**Fruit number at harvest per 100 flower buds**	**Mean fruit weight (g)**	**% fruit of diameter 65mm or greater (by wt)**
Untreated			35.05	139	86.6	10.0
Hand thinned			29.12	77	131.2	73.2
'Sulphur F3000'	18.5 mL	1	29.70	97	108.2	40.4
Common salt	12 g	1	30.18	110	97.0	30.1
'PEG 100'	14 mL	1	33.20	127	89.3	18.0
'MAP'	15 g	1	27.53	103	95.1	21.0
'Sulphur F3000'	18.5 mL	2	19.17	47	143.5	87.3
Common salt	12 g	2	25.92	76	120.8	66.9
'PEG 100'	14 mL	2	31.78	113	98.5	25.9
'MAP'	15 g	2	35.15	127	95.7	28.5
Common salt	16 g	1	26.87	95	97.6	28.8
'PEG 100'	28 mL	1	32.08	127	91.0	19.2
'MAP'	30 g	1	27.12	121	91.6	24.8
Common salt	16 g	2	24.23	65	129.1	83.1
'PEG 100'	28 mL	2	31.10	119	95.3	26.5
'MAP'	30 g	2	33.87	116	105.4	42.2
SED (79 d.f.)			4.123	15.1	5.78	7.37

Hand thinning of trees to leave two fruits per cluster transformed the potential financial return from the orchard by increasing mean fruit weight to 131.2 g and increasing the percentage of fruit above 65 mm to 73% (by weight). This was achieved with no significant reduction in yield.

Application of 'Sulphur F3000' on two occasions (as recommended in 'The Best Practice Guide for UK Apple Production') resulted in a lower fruit set than achieved with hand thinning and the yield of fruit was reduced significantly to 19.2 kg per tree (31 tonnes per hectare). This compares with 29.1 kg tree or 48 tonnes per hectare for the hand-thinned trees. In response to the lower numbers of fruit on trees treated with 'Sulphur F3000' the percentage of fruit above 65 and 70 mm diameter was higher than for hand thinned trees. Although the actual (saleable) weight of fruit above 65 mm diameter was higher for hand-thinned as opposed to chemically-thinned ('Sulphur F3000') trees, the cost implications of hand and chemical thinning and other costs such as picking, storage and packing, etc., need to be considered when calculating the most financially viable thinning treatment.

Although 'Sulphur F3000' applied on one occasion resulted in a significant reduction in the number of fruits per tree and an increase in the percentage of fruit above 65 and 70 mm diameter, the effects were small in comparison with those achieved by two applications. This result was expected in view of the opportunity to thin the flowers on both 2-year-old wood and on 1-year-old wood provided by two applications.

When assessing treatments applied as single applications it was clear that PEG was ineffective as a chemical thinner irrespective of dose rate. Common salt and 'MAP' reduced fruit numbers to a similar extent as 'Sulphur F3000' but unlike common salt the 'MAP' sprays did not significantly increase the percentage of fruit above 65 mm diameter. There were no significant effects on fruit numbers at harvest resulting from an increase in the dose rate of common salt or 'MAP'. Common salt application resulted in a thinning response similar to 'Sulphur F3000' with little enhancement of effects by increasing the dose rate from 12 to 16 g per litre.

In a comparison of treatments applied on two occasions, common salt reduced fruit number and yield to a similar extent as 'Sulphur F3000' and there was no effect of dose rate. Two applications of 'PEG' or 'MAP' reduced fruit numbers although the effect just failed to reach significance and there was no significant reduction in yield. Although 'PEG' and 'MAP' increased the percentage of fruit above 65 mm diameter (by number and weight) the effects on grade-out were small in comparison with those of 'Sulphur F3000' and common salt. Doubling the dose of PEG did not increase thinning efficiency, although the effectiveness of 'MAP' was improved significantly with a 16% increase in the percentage of fruit above 65 mm diameter.

It is considered that the most successful thinning treatment is that which provides the highest actual (saleable) yield of fruit above 65 mm diameter. Consequently thinning protocols that result in over-thinning i.e. yield reduction may not prove to be the most cost effective option. In this trial 'Sulphur F3000' and common salt (high rate) proved to be the most effective thinning agents when applied on two occasions when performance was assessed on percentage size grade out. However the saleable weight of fruit of greater than 65 mm was highest for hand thinning (34.8 tonnes per hectare) followed by high rate common salt (32.9 tonnes per hectare), low rate common salt (28.3 tonnes per hectare), 'Sulphur F3000' (27.3 tonnes per hectare) and 'MAP' (23.3 tonnes per hectare). This method of assessing thinning efficiency assumes that it was possible to pick only fruit of greater than 65 mm so that no costs were incurred by picking and then subsequently grading out smaller fruit. It would appear that common salt compares well with 'Sulphur F3000' for effective thinning of apple flowers and may prove more acceptable for use in organic orchards.

In Experiment 2, none of the chemicals tested reduced yield of fruit at harvest (Table 6). Only 'Sulphur F3000' and vinegar reduced significantly the number of fruits at harvest in proportion to the initial number of flower buds. 'Sulphur F3000' tended to be more effective than vinegar but the difference between the two treatments was not statistically significant. 'Codacide' and kaolin did not reduce fruit numbers at harvest and consequently had no effect on fruit yield or grade-out.

Table 6. Experiment 2. The effects of chemical thinning sprays applied to open flowers of Royal Gala in 2004. Effects on fruit number and yield (kg) per tree, percentage of flower buds that set fruits, mean fruit weight and the percentage of fruit with a diameter of 65mm or greater and severity of skin russet

	Yield per tree (kg)	**Fruit number at harvest per 100 flower buds**	**Mean fruit weight (g)**	**The percentage of fruit of diameter 65mm or greater**		**Skin russet index (max 100)**
				By weight	**By number**	
Untreated	24.3	237.1	101.3	35.4	30.7	3.33
'Sulphur F3000'	20.5	136.3	140.1	84.7	78.6	4.00
'Codacide'	26.1	251.4	96.3	30.5	23.8	4.67
Kaolin	26.2	245.1	104.0	41.6	35.1	2.67
Vinegar	23.1	176.0	126.4	73.0	65.6	7.00
SED (25 d.f.)	3.62	22.35	7.24	11.02	10.12	1.189

Vinegar tended to be less effective than 'F3000' at reducing fruit numbers at harvest but not significantly so. Both treatments increased mean fruit weight and the percentage of fruits above 65 mm diameter (by weight and number). They also reduced the percentage of fruit in the lower size categories (<55 and 55-60 mm diameter) and increased the percentage of fruit above 70 mm diameter.

None of the treatments affected the amount of red colour, incidence of stalk-end russet or fruit firmness. However, vinegar increased the incidence and severity of skin russet compared to the untreated control fruit.

Targets for year 3

The specific objectives in 2005 were:

- To investigate the effect of dose on the thinning effect of vinegar.
- To evaluate the thinning potential of ‘Azolon’ fluid (Methylene-urea-N).
- To compare the effectiveness of common salt and ‘Sulphur F3000’ as chemical flower thinning agents on Royal Gala, Queen Cox and Bramley’s Seedling.

Materials and Methods

Experiment 1 – Thinning effects of common salt, ‘Sulphur F3000’, vinegar and ‘Azolon’ fluid

The experiment was carried out in 2005 on 7-year-old trees of Royal Gala on M9 rootstock in an orchard (EE190) on the Home Farm site of East Malling Research. The trees were planted in 1998 at an in-row spacing of 1.75 metres and 3.5 metres between rows (1632 trees per hectare). Sprays containing ‘Sulphur F3000’, sodium chloride or malt vinegar were applied on two occasions (late full bloom on spur wood and again at 10% petal fall on axillary (one-year) wood) with the aim of maximising their ability to thin (Table 7). The effect of ‘Azolon’ fluid (controlled release nitrogen fertiliser) on cropping was also investigated following reports from abroad of crop reduction and fruit size improvement (Handschack and Alexander, 2002). Sprays containing ‘Azolon’ were applied at a single rate (5 mL L^{-1}) on four occasions, i.e. at 5% open flower and late full bloom on spur wood and at 5% and 10% petal fall on axillary wood. The effects of chemical treatments were compared with those of hand thinning of fruitlets to two per cluster when fruits had reached 9-12 mm diameter. Unthinned trees acted as controls.

Table 7. Treatments evaluated in the thinning Experiment 1 in 2005

Treat No.	Active	Product	Concentration	No. sprays
1	-	Untreated	-	-
2	-	Hand thinned	-	-
3	Sulphur & ammonia	'Sulphur F3000'	15 mL L^{-1}	2
4	Sodium chloride	Common salt	12 g L^{-1}	2
5	Acetic acid	Vinegar (5% a.i.)	Undiluted	2
6	Acetic acid	Vinegar (5% a.i.)	500 mL L^{-1}	2
7	Methylene-urea-N	'Azolon'	5 mL L^{-1}	4

Experiment 2 – thinning effects of 'Sulphur F3000' and common salt on different cultivars

The experiments were carried out in 2005 on Queen Cox, Royal Gala and Bramley's Seedling apples. All orchards were on the Home Farm site of East Malling Research. The Queen Cox trees (orchard EE190) were on M9 rootstock planted in 1998 at an in-row spacing of 1.75 metres and 3.5 metres between rows (1632 trees per hectare). The Royal Gala trees (pollinators in orchard DM169) were planted in 1996 at an in-row spacing of 3 metres and 5 metres between rows (667 trees per hectare). The Bramley's Seedling trees (orchard EE193) were originally Jonaprinz on M9 rootstock planted in 2000 at an in-row spacing of 2 metres and 4 metres between rows (1250 trees per hectare) that were grafted over in March 2003.

Sprays containing 'Sulphur F3000' or common salt were applied on two occasions (late full bloom on spur wood and again at 80% full bloom on axillary (one-year) wood) with the aim of maximising their ability to thin (Table 8). Unthinned trees acted as controls.

Table 8. Treatments evaluated in the thinning Experiment 2 in 2005

Treatment No.	Active	Product	Concentration	No. sprays
1	-	Untreated	-	-
2	Sulphur and ammonia	'Sulphur F3000'	15 mL L^{-1}	2
3	Sodium chloride	Common salt	12 g L^{-1}	2

Spray Application

Treatments were applied at high volume (approximately 1000 litres/ha) with a hand-held pressurised mist sprayer. Trees were sprayed to ensure good coverage without incurring runoff. Spray treatments applied on 3 and 9 May to Royal Gala and 4 May to Queen Cox were affected by rain (see below):

<u>3 May - Royal Gala</u>

Vinegar (50% dilution). Rain followed at completion of spraying

Vinegar. Rain followed ½ - 1 hour after spraying

'Sulphur F3000'. Rain followed 1½ hours after spraying

Common salt. Rain followed 2 hours after spraying

'Azolon'. Rain followed 2½ hours after spraying

<u>9 May – Royal Gala</u>

Vinegar (50% dilution). Rain followed 2¾ hours after spraying

Vinegar. Rain followed 3 ½ hours after spraying

'Sulphur F3000'. Rain followed 4 hours after spraying

Common salt. Rain followed 4 ½ hours after spraying

'Azolon'. Rain followed 5 hours after spraying

<u>4 May – Queen Cox</u>

Common salt. Rained during applying spray

'Sulphur F3000'. Rain followed ½ hour later

Damage to petals and leaves

Petal and leaf necrosis was evident on some of the sprayed trees inspected after the final application of spray treatments. In general, necrosis of flower parts is an indication that the treatments are likely to be effective in preventing pollination or fertilisation and a consequent reduction in fruit set can be expected. Clearly, any damage to the young leaves should be avoided where possible.

Experiment 1

Damage to petals and foliage was as follows:

	Damage to leaves	**Damage to petals**
'Sulphur F3000'	None	Brown and shrivelled
Common salt	None	Brown and shrivelled
Vinegar	Slight	Brown and shrivelled
Vinegar (50% dilution)	None	Brown and shrivelled
'Azolon'	None	None

Experiment 2

Damage to petals was as follows:

		Damage to petals
Royal Gala	'Sulphur F3000'	Very slight
	Common salt	Slight
Queen Cox	'Sulphur F3000'	None
	Common salt	None
Bramley's Seedling	'Sulphur F3000'	Not recorded
	Common salt	Not recorded

The occurrence of rain after application of the treatments is likely to have reduced the effectiveness of the treatments as indicated by the general lack of damage to the flowers following application of 'Sulphur F3000' or common salt.

Experimental design and layout

Ninety-six trees were selected for the two experiments and the numbers of floral buds (spur, terminal and axillary) on each tree were counted. There were six replicate trees per treatment that were selected to ensure that the range in bud numbers was similar for all treatments. Previous experience has shown that greater sensitivity can be achieved in thinning trials by allocating treatments to trees on the basis of bud count rather than arbitrarily randomising treatments in blocks.

Meteorological records

Temperature at the start of spraying at 0900 h on 28 April 2005 was 15.6^{o}C and relative humidity was 64%.

Temperature at the start of spraying at 0900 h on 3 May 2005 was 17.3ºC and relative humidity was 72%.

Temperature at the start of spraying at 0900 h on 4 May 2005 was 13.3ºC and relative humidity was 83%.

Temperature at the start of spraying at 0900 h on 5 May 2005 was 17.7ºC and relative humidity was 50%.

Temperature at the start of spraying at 0900 h on 6 May 2005 was 16.5ºC and relative humidity was 49%.

Temperature at the start of spraying at 0900 h on 9 May 2005 was 13.4ºC and relative humidity was 52%.

Temperature at the start of spraying at 0900 h on 12 May 2005 was 12.8ºC and relative humidity was 60%.

Assessments

At harvest, the entire crop of fruit from each tree was harvested. Harvest dates for Bramley's Seedling, Queen Cox and Royal Gala were 2, 6 and 13 September 2005 respectively. Fruit was transported to the Crop Handling Centre and the crop from each tree was graded for size using sizing rings and the number and weight of fruit in each size grade was recorded. The percentage of fruit (by weight and number) in each size category was calculated in each experiment.

Statistical analyses

All data were subjected to an analysis of variance (ANOVA). ANOVA was also carried out on percentage data that were transformed to angles prior to analysis. This technique is often applied to percentage data to help stabilise variances. Transforming the data made little difference to statistical significance of the treatment effects and did not alter the conclusions of the experiment. Consequently means based on the original data are presented in the tables of results in preference to the transformed means. The overall effects of chemical treatments can be compared using the standard errors of the difference between means (s.e.d.) and degrees of freedom (d.f.) given in the tables.

Results and Discussion

Experiment 1 (Tables 9-12)

As in the previous year, there were serious adverse consequences of not thinning Gala trees in 2005. Although yield from un-thinned trees was high at 26 kg per tree (43 tonnes per hectare) the mean fruit weight was only 57.2 g and none of the fruit was above 65 mm diameter, which is the critical size threshold for the cultivar.

Hand thinning of trees to leave two fruits per cluster reduced the number of fruit on the tree at harvest, increased mean fruit weight and improved grade-out by reducing the % of fruit in the <55mm category and increasing the % in the 55-59.9mm category. However, only 2.5% of fruit from hand-thinned trees were above 65mm diameter, which contrasts markedly with the previous year where hand thinning transformed the potential financial return from the orchard by increasing the percentage of fruit above 65 mm from 10% to 73% (by weight). Hand thinning resulted in a 46% reduction in fruit number per tree in 2004 but only a 22% reduction in 2005. Clearly a more severe hand thinning strategy was required in 2005 to achieve a level of crop that could achieve sufficient size.

‘Sulphur F3000’ and common salt were the most effective chemical thinning agents and were equivalent in their affects on crop load and grade-out. They were also far more effective than hand thinning but clearly further hand thinning subsequent to chemical thinning was required to improve upon the size-grade out and to make the crop viable commercially.

Vinegar was as effective as hand thinning in reducing fruit number per tree and improving fruit size but much less effective than either ‘Sulphur F3000’ or common salt. Diluting vinegar by 50% markedly reduced its efficacy although there was an improvement in size grade-out compared with the untreated controls.

There were no significant effects of 'Azolon' fluid on any of the measured parameters although number of fruits per tree and the percentage of small fruits (<55mm) tended to be reduced. These results are consistent with reports from Russian research that 'Azolon' has a weak thinning effect compared with that of ammonium thiosulphate (Handschack and Alexander, 2002). However, these authors reported increases in fruit size that were greater than those achieved with the most effective hormone thinning agents (Amid-Thin + Ethephon). Major effects of 'Azolon' on fruit size were not observed in this trial but more work would be required to evaluate fully this material as a foliar fertilizer for size improvement.

Table 9. Experiment 1.The effects of chemical thinning sprays applied to open flowers and hand thinning of fruitlets (9-12mm diameter) of Royal Gala in 2005. Effects on fruit number and yield (kg) per tree, percentage of flower buds that set fruits and mean fruit weight

	Dose rate (L^{-1})	**No. sprays**	**Yield per tree (kg)**	**Number of fruit per tree**	**Fruit number at harvest per 100 flower buds**	**Mean fruit weight (g)**
Untreated			26.35	463	194.2	57.2
Hand thinned			25.33	361	158.0	72.7
'Sulphur F3000'	15 mL	2	21.23	213	88.7	99.4
Common salt	12 g	2	23.77	279	123.1	85.8
Malt vinegar	Undiluted	2	25.60	352	151.1	72.6
Malt vinegar	500 mL	2	28.30	430	181.5	67.1
'Azolon'	5 mL	4	24.32	381	165.6	63.8
SED (d.f.)			2.929	41.6	20.51	6.00

Table 10. Experiment 1. The effect of chemical thinning sprays applied in 2005 to open flowers and hand thinning of fruitlets (9-12mm diameter) on the percentage of the crop (by weight) of Royal Gala apples graded into different size bands

	Dose rate (L^{-1})	**No. sprays**	**The percentage of fruit (by weight) in different size categories**				
			<55mm	**55-59.9mm**	**60-64.9mm**	**65-69.9mm**	**70mm or more**
Untreated			81.2	18.6	0.2	0.0	0.0
Hand thinned			35.7	57.4	4.4	2.5	0.0
'Sulphur F3000'	15 mL	2	5.0	40.5	28.4	25.2	1.0
Common salt	12 g	2	7.5	53.1	16.5	21.7	1.1
Malt vinegar	undiluted	2	19.7	64.5	11.1	4.4	0.3
Malt vinegar	500 mL	2	42.8	54.8	1.9	0.5	0.0
'Azolon'	5 mL	4	59.4	39.7	0.8	0.1	0.0
SED (d.f.)			13.60	13.74	4.28	5.04	0.61

Table 11. Experiment 1. The effect of chemical thinning sprays applied in 2005 to open flowers and hand thinning of fruitlets (9-12mm diameter) on the percentage of the crop (by number) of Royal Gala apples graded into different size bands

	Dose rate (L^{-1})	No. sprays	The percentage of fruit (by number) in different size categories				
			<55mm	55-59.9mm	60-64.9mm	65-69.9mm	70mm or more
Untreated			84.1	15.8	0.1	0.0	0.0
Hand thinned			41.3	53.4	3.4	1.8	0.0
'Sulphur F3000'	15 mL	2	8.2	43.1	26.6	21.4	0.7
Common salt	12 g	2	11.5	55.5	15.2	17.1	0.8
Malt vinegar	undiluted	2	25.6	62.3	8.8	3.1	0.1
Malt vinegar	500 mL	2	47.4	50.8	1.4	0.3	0.0
'Azolon'	5 mL	4	64.3	35.0	0.7	0.0	0.0

Table 12. Experiment 1. The effects of chemical thinning sprays applied in 2005 to open flowers and hand thinning of fruitlets (9-12mm diameter) of Royal Gala on the percentage of fruit with a diameter of 65mm or greater

	Dose rate (L^{-1})	No. sprays	The percentage of fruit of diameter 65mm or greater	
			By weight	By number
Untreated			0.0	0.0
Hand thinned			2.5	1.8
'Sulphur F3000'	15 mL	2	26.1	22.1
Common salt	12 g	2	22.9	17.8
Malt vinegar	undiluted	2	4.7	3.3
Malt vinegar	500 mL	2	0.5	0.3
'Azolon'	5 mL	4	0.1	0.0
SED (d.f.)			5.55	4.92

Experiment 2 (Tables 13-21)

Both 'Sulphur F3000' and common salt proved to be effective thinning agents on the three cultivars tested with neither chemical being consistently more effective. On Royal Gala 'Sulphur F3000' was generally more effective than salt but the reverse was true on Bramley's Seedling. Both chemicals produced a similar response on Queen Cox. Clearly on the dessert cultivars subsequent hand thinning was required to improve the size grade-out to commercially acceptable levels. There is an expectation that growers would need to follow up chemical thinning with hand-thinning and it is important that application of flower thinning agents does not result in over-thinning. Clearly, reducing the time to hand thin by pre-thinning with chemicals has major implications on the cost of achieving the correct crop load and on the profitability of apple production.

Table 13. Experiment 2 - Gala. The effects of chemical thinning sprays applied to open flowers of Royal Gala in 2005 on fruit number and yield (kg) per tree, percentage of flower buds that set fruits, mean fruit weight and the percentage of fruit with a diameter of 65mm or greater

	Yield per tree (kg)	**Number of fruit per tree**	**Fruit number at harvest per 100 flower buds**	**Mean fruit weight (g)**	**The percentage of fruit of diameter 65mm or greater**	
					By weight	**By number**
Untreated	61.9	743	227	84.0	17.8	13.6
'Sulphur F3000'	54.2	502	152	112.8	56.0	47.3
Common salt	52.4	572	180	93.5	39.8	33.2
SED (d.f.)	3.94	64.2	32.4	11.12	9.48	8.99

Table 14. Experiment 2 - Gala. The effect of chemical thinning sprays applied in 2005 to open flowers on the percentage of the crop (by weight) of Royal Gala apples graded into different size bands

	The percentage of fruit (by weight) in different size categories				
	<55mm	**55-59.9mm**	**60-64.9mm**	**65-69.9mm**	**70mm or more**
Untreated	9.4	50.4	22.4	17.6	0.2
'Sulphur F3000'	2.1	18.4	23.5	45.7	10.3
Common salt	5.7	32.3	22.3	36.6	3.2
SED (d.f.)	3.74	6.93	5.83	7.59	3.13

Table 15. Experiment 2 - Gala. The effect of chemical thinning sprays applied in 2005 to open flowers on the percentage of the crop (by number) of Royal Gala apples graded into different size bands.

	The percentage of fruit (by number) in different size categories				
	<55mm	**55-59.9mm**	**60-64.9mm**	**65-69.9mm**	**70mm or more**
Untreated	14.8	53.0	18.6	13.4	0.1
'Sulphur F3000'	3.6	23.5	25.6	37.9	9.3
Common salt	9.4	36.2	21.2	30.9	2.3
SED (d.f.)	5.92	7.81	5.12	7.25	3.39

Table 16. Experiment 2 - Cox. The effects of chemical thinning sprays applied to open flowers of self-fertile Queen Cox in 2005. Effects on fruit number and yield (kg) per tree, percentage of flower buds that set fruits, mean fruit weight and the percentage of fruit with a diameter of 65mm or greater.

	Yield per tree (kg)	**Number of fruit per tree**	**Fruit number at harvest per 100 flower buds**	**Mean fruit weight (g)**	**The percentage of fruit of diameter 65mm or greater**	
					By weight	**By number**
Untreated	20.73	283	213	74.7	5.8	4.7
'Sulphur F3000'	17.05	203	159	84.8	26.4	21.7
Common salt	16.90	192	152	91.8	33.3	29.1
SED (d.f.)	2.198	31.0	34.5	10.88	14.35	13.24

Table 17. Experiment 2 - Cox. The effect of chemical thinning sprays applied in 2005 to open flowers on the percentage of the crop (by weight) of self-fertile Queen Cox apples graded into different size bands

	The percentage of fruit (by weight) in different size categories				
	<55mm	**55-59.9mm**	**60-64.9mm**	**65-69.9mm**	**70mm or more**
Untreated	40.2	30.8	23.2	5.8	0.0
'Sulphur F3000'	10.7	35.3	27.6	22.4	4.0
Common salt	14.9	29.3	22.5	22.3	11.0
SED (d.f.)	9.65	10.08	8.78	9.85	5.90

Table 18. Experiment 2 - Cox. The effect of chemical thinning sprays applied in 2005 to open flowers on the percentage of the crop (by number) of self-fertile Queen Cox apples graded into different size bands

	The percentage of fruit (by number) in different size categories				
	<55mm	**55-59.9mm**	**60-64.9mm**	**65-69.9mm**	**70mm or more**
Untreated	40.1	34.8	20.4	4.7	0.0
'Sulphur F3000'	13.0	40.4	24.8	18.8	2.9
Common salt	19.7	30.3	21.0	20.0	9.0
SED (d.f.)	11.10	9.68	8.94	9.40	4.93

Table 19. Experiment 2 - Bramley. The effects of chemical thinning sprays applied to open flowers of Bramley's Seedling in 2005 on fruit number and yield (kg) per tree, percentage of flower buds that set fruits, mean fruit weight and the percentage of fruit with a diameter of 65mm or greater

	Yield per tree (kg)	Number of fruit per tree	Fruit number at harvest per 100 flower buds	Mean fruit weight (g)	The percentage of fruit of diameter 80mm or greater	
					By weight	By number
Untreated	18.92	96.3	143.6	199.2	69.9	56.1
'Sulphur F3000'	18.57	81.8	122.7	229.2	79.9	67.5
Common salt	16.50	68.0	106.8	242.4	86.0	77.0
SED (d.f.)	1.960	10.97	13.62	13.07	3.64	4.74

Table 20. Experiment 2 - Bramley. The effect of chemical thinning sprays applied in 2005 to open flowers on the percentage of the crop (by weight) of Bramley's Seedling apples graded into different size bands

	The percentage of fruit (by weight) in different size categories			
	<80mm	80-89.9mm	90-99.9mm	100mm or more
Untreated	30.1	25.4	33.7	10.8
'Sulphur F3000'	20.1	20.6	27.0	32.3
Common salt	14.0	22.6	36.5	27.0
SED (d.f.)	3.64	3.92	3.79	5.51

Table 21. Experiment 2 - Bramley. The effect of chemical thinning sprays applied in 2005 to open flowers on the percentage of the crop (by number) of Bramley's Seedling apples graded into different size bands

	The percentage of fruit (by number) in different size categories			
	<80mm	80-89.9mm	90-99.9mm	100mm or more
Untreated	43.9	24.2	25.7	6.2
'Sulphur F3000'	32.5	21.9	22.3	23.3
Common salt	23.0	25.3	33.1	18.6
SED (d.f.)	4.74	3.93	3.12	4.31

Conclusions

There are various ways of expressing the impact of thinning treatments on the cropping of trees, all of which help to assess their commercial potential. Presenting the size grade data in percentage terms indicates the effects of treatments on the size distribution. Clearly, this may exaggerate the effects of the more effective treatments since a reduction in fruit number or weight will automatically increase the percentage of fruit in each size category. The commercial significance of thinning treatments relates to the weight of fruit in the more profitable size ranges and from this a commercial assessment of benefits of the various treatments can be made. Clearly, it is important to ensure that the highest proportion of the fruit on the tree achieves sufficient size but where an overall crop reduction may be expected by thinning, the actual saleable weight of fruit in the commercial size ranges is particularly important.

2003

- ATS in the form of ‘Sulphur F3000’ was confirmed as an effective agent for thinning apple flowers and was more effective than any of the other prospective chemical thinners tested on Gala in 2003.

- Common salt and, to a lesser extent ‘Savona’, gave significant reductions in the number of fruits retained on the trees.

- ‘Savona’ increased the severity of russet and further work is not justified unless other promising materials are eventually discounted.

- Further work was proposed with common salt, ‘PEG’ and ‘MAP’ with the aim of maximising their ability to thin through alteration of dose and timing.

- The effects of ‘Sea Vigour’, ‘Biostim’ or ‘Eradicoat’ were insufficient to justify their inclusion in further work.

2004

- ATS in the form of 'Sulphur F3000' was again confirmed as an effective agent for thinning apple flowers on Royal Gala particularly when applied on two occasions.

- Common salt was generally as effective as 'Sulphur F3000' as a thinning agent for Royal Gala.

- Common salt applied at 12g or 16g/L is proposed as a possible alternative to 'Sulphur F3000' but required further testing on other apple cultivars.

- Vinegar has shown particular promise as a potential thinning agent on Gala but increased the incidence and severity of skin russet.

2005

- On Royal Gala 'Sulphur F3000'was generally more effective than sodium chloride (common salt), but the reverse was true on Bramley's Seedling. Both chemicals produced a similar response on Queen Cox.

- On dessert cultivars subsequent hand thinning was required to improve the size grade-out to commercially acceptable levels.

- Vinegar was much less effective in thinning flowers on Royal Gala than either 'Sulphur F3000' or common salt. Diluting vinegar by 50% markedly reduced its efficacy.

- There were no significant thinning effects of 'Azolon' fluid on Royal Gala although number of fruits per tree and the percentage of small fruits tended to be reduced.

The chemical proven to reduce fruit set and currently available to UK growers is the foliar nutrient ammonium thiosulphate or ATS, which in these trials was represented by the commercial product 'Sulphur F3000'. Application of 'Sulphur F3000' on two occasions proved to be an effective thinning treatment and supports the recommendation provided in the Best Practice Guide for UK Apple Production (Defra).

Two applications of common salt (12g/L sodium chloride) were generally as effective as ‘Sulphur F3000’ at thinning the crop. New Zealand experience with common salt was that an optimum thinning response was achieved on Fuji trees with 12 g/L whereas 16g/L resulted in over-thinning (McArtney, Campbell & Foote, 2000). These authors also report effective thinning of Braeburn trees using multiple applications of sodium chloride at 8g/L. Growers may be interested in applying common salt to **small areas** of orchard at a time when they would normally apply ATS (see ‘The Defra Best Practice Guide for UK Apple Production’ for advice on the use of chemicals for thinning of flowers). It is advisable to apply 12 g of common salt per litre of water applied at high volume. Although 16 g per litre of water is likely to be more effective in view of the evidence from abroad, that this may result in over-thinning, interested growers may like to compare the effects of the two rates in **small areas** of orchard.

One of the problems associated with the use of acidic thinning agents such as vinegar is their tendency to damage the surviving fruit. A possible method of achieving effective thinning using vinegar without phytotoxicity has been developed by researchers in the USA and New Zealand. A two-step thinning method is proposed whereby an aqueous solution of sodium bicarbonate (neutralising agent) is applied when approximately 20% of the flowers have been pollinated. The acidic (vinegar) thinner is applied several days later and effectively thins the flowers that have developed since the application of the protective neutralising spray. There has been no experience of the two-step method but this may be justified if vinegar is a considered an acceptable chemical for organic production. Current indications are that common salt and vinegar are unlikely to be acceptable in UK organic production although this may not be so in some other countries.

In summary the three-year evaluation of a range of chemicals as potential thinning agents has shown the following.

Most-effective thinning agents were:

- ‘Sulphur F3000’

- Common salt
- ‘Savona’ (increased russetting)
- Vinegar (increased russetting)

Partially effective thinning agents were:

- ‘PEG 100’
- ‘MAP’

Ineffective thinning agents were:

- ‘Sea Vigour’
- ‘Biostim’
- ‘Eradicoat’
- ‘Codacide’
- Kaolin
- ‘Azolon’

Technology transfer

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