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| **Previous reports:** | None |
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The results and conclusions in this report are based on a series of experiments 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.

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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.

.....D S Johnson
Signature

Date .....

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# Grower Summary

## Headline

A three year programme of work is planned that will evaluate novel chemicals as potential thinning agents for use on apples in the UK. Potential thinning agents will be assessed for their thinning efficiency and compared with applications of ATS (ammonium thiosulphate) and hand thinning. The major records will be on fruit size and quality at harvest and ex-store but observations will be made on other effects also including phytotoxicity. At the end of the project a range of chemicals suitable for use in organic and integrated fruit production systems will have been evaluated for use as thinning agents for UK apples.

## Background and expected deliverables

The overall objective of this 3 year project is to provide the UK apple industry with suitable 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 65mm 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

In 2003 a replicated orchard experiment was carried out in a Royal Gala orchard at East Malling Research to evaluate 7 coatings / pollenicides for their effectiveness in reducing fruit set and improving fruit size at harvest. This was the first year of a 3 year project where the aim was to identify promising thinning agents for further evaluation in 2004.

- ATS as the proprietary formulation ‘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.
- Sodium chloride 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 on method of application to minimise the risk of russet is not justified unless other promising materials are eventually discounted.
- It is proposed to continue work with sodium chloride, polyethylene glycol and mono-ammonium phosphate with the aim of maximising their ability to thin through alteration of dose and timing.

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## Financial benefits

It is too early in the project to establish the financial benefits of the work.

## Action points for growers

It is too early in the project to make any specific recommendations to growers.

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# 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 (2002a & 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 proposal 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.

## Commercial Objective

The overall objective is to provide the UK apple industry with suitable 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 65mm 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.

## Objective for 2003/04

The specific objective in 2003 was 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.

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## Materials and Methods

*Site*

13 year-old trees of Royal Gala on M9 rootstock were used from two orchards (CW120 and CW121) on the Home Farm site of HRI East Malling. Trees used were planted in single adjacent rows spaced at 1.94 metres apart with 4 metre wide alleys (1288 trees $ha^{-1}$). Trees were planted in 1 metre wide herbicide strips with grassed alleys between the strips. All trees were trained to grow as slender spindles.

*Treatments*

Each spray treatment comprised one application of each thinning product made on 29th April 2003 when the majority of trees were judged to be at full bloom (Table 1). The hand thinning treatment comprised of thinning fruitlets to two per cluster on the 29th and 30th May 2003 when fruitlet size was approximately 10-12mm.

**Table 1.** Treatments evaluated in the thinning experiment in 2003.

| Treat No. | a.i. | Product | Concentration ml/l |
|---|---|---|---|
| 1 | - | Unthinned control | - |
| 2 | - | Hand thinned | - |
| 3 | Sulphur & Ammonia | 'Sulphur F3000' | 18.5 |
| 4 | Potassium salts of fatty acids | 'Savona' | 40 |
| 5 | Fish solids | 'Sea Vigour' | 10 |
| 6 | Glycoprotein extract | 'Biostim' | 30 |
| 7 | Natural plant extracts | 'Eradicoat' | 25 |
| 8 | Sodium Chloride | Common salt | 12 g |
| 9 | Polyethylene Glycol | 'PEG 100' | 20 g |
| 10 | Mono ammonium phosphate | MAP | 15 |

*Spray Application*

Treatments were applied at high volume (approximately 0.6 litres / tree) with a hand held pressurised mist sprayer. Trees were sprayed to ensure good coverage without incurring run-off. Weather conditions favoured fast drying conditions to all treatments applied (see *Meteorological records*).

*Damage to petals, flowers and leaves*

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

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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.

*Experimental design and layout*

Eighty trees were selected for the experiment and the numbers of floral buds (spur, terminal and axillary) on each tree were counted. There were 8 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 29th April 2003 was 16.4°C and Relative Humidity was 67%.

*Assessments*

The entire crop of fruit from each tree was harvested on 16th September 2003 and transported immediately to the Jim Mount Building. The fruit was stored in air at 0-0.5°C until early December. On removal from store the crop from each tree was size graded (<55, 55-59.9, 60-64.9, 65-69.9 and 70+mm) 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. A sub-sample of 20 fruit was taken (random selection) from the crop from each tree and inspected for the presence of rots. The percentage area of red colour on each apple was estimated and assigned to one of six categories i.e. 0, 1-5, 6-10, 11-20, 21-50 and >50% that were ascribed a score of 0, 1, 2, 3, 4 and 5 respectively. The maximum score for red colour in a 20-fruit sample was 100. There was no attempt to assess the intensity of red colour. The number of russetted apples was recorded and the percentage of affected fruit was calculated. Where russet was present the severity was assessed according to the surface area of the apple affected. Apples were placed into one of five categories i.e.1-5, 6-10, 11-20, 21-50 and >50% and allocated a score of 1, 2, 3, 4 or 5 respectively. The maximum score for russet in a 20-fruit sample was 100.

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Firmness measurements were made on the opposite sides of each of 10 fruit using an LRX (Lloyd Instruments) materials testing machine fitted with an 11mm probe. Measurements were made in the equatorial region after removal of the peel. Firmness was the maximum force (N) recorded during the insertion of the probe to a depth of 8mm. Each fruit was cut at the calyx end and at the equator and examined for the presence of disorders.

*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.

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## Results

Hand thinning of the trees did not reduce significantly the number of fruits remaining on the trees at harvest compared with the untreated controls and consequently no size benefits accrued. It appeared that a reduction in fruit number of at least 25% was required to achieve a beneficial effect on fruit size.

Only 3 chemical treatments reduced the number of fruits at harvest in proportion to the initial number of flower buds. The greatest thinning effect was achieved by the use of Sulphur F3000 followed by sodium chloride and lastly by 'Savona' (Table 2). The 'Sulphur F3000' treatment resulted in a reduced yield of fruit per tree. 'Sulphur F3000', sodium chloride and 'Savona' increased mean fruit weight and the percentage (expressed by number or weight) of fruit above 65 mm diameter. The magnitude of the effects of the 3 treatments reflected the extent of their thinning effect.

The effects of treatments on size grade-out were generally consistent irrespective of whether the number or weight of fruit in each 5-mm size category was used for statistical analysis. Transforming the percentage data to angles prior to analysis was helpful in confirming the statistical significance of some of the treatments but to simplify the presentation of the results the transformed data are not presented. However subsequent consideration of significant treatment effects includes the outcome of an analysis performed on transformed data.

**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 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 | 29.27 | 396 | 146.9 | 76.1 | 11.9 | 9.2 |
| Hand thinned | 29.96 | 351 | 133.9 | 89.2 | 26.9 | 22.6 |
| Sulphur F3000 | 22.55 | 194 | 72.4 | 119.0 | 62.0 | 54.0 |
| Savona | 26.85 | 296 | 107.6 | 96.7 | 34.6 | 29.6 |
| Sea Vigour | 33.35 | 400 | 143.2 | 85.8 | 17.2 | 13.6 |
| Biostim | 34.02 | 410 | 156.8 | 85.4 | 16.8 | 12.8 |
| Eradicoat | 32.85 | 407 | 143.8 | 83.9 | 19.9 | 15.8 |
| Sodium chloride | 26.29 | 263 | 97.7 | 103.1 | 48.6 | 41.1 |
| PEG | 30.35 | 386 | 141.1 | 85.9 | 26.7 | 20.3 |
| MAP | 29.05 | 351 | 132.7 | 84.6 | 28.0 | 25.9 |
| SED (70 d.f.) | 3.478 | 56.6 | 11.26 | 9.03 | 11.14 | 10.36 |

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'Sulphur F3000', sodium chloride and 'Savona' increased the percentage of the crop (number and weight) in the higher size (diameter) bands i.e. 65-69.9 and >70mm and reduced the percentage of the crop in the lower size bands i.e. 55-59.9 and >55mm (Tables 3 and 4). These treatments were the most effective and consistent and the magnitude of their effects reflected the extent of their thinning effect (see above). PEG also showed beneficial effects on grade-out with less fruit in the 55-59.9 mm category and more fruit in the 65-69.9 mm category although this was not associated with any thinning effects (Table 2).

**Table 3.** The effect of chemical thinning sprays applied to open flowers and hand thinning of fruitlets (10-12mm diameter) 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 | 21.4 | 35.2 | 31.5 | 10.3 | 1.6 |
| Hand thinned | 12.3 | 26.9 | 33.8 | 17.8 | 9.1 |
| Sulphur F3000 | 1.7 | 9.8 | 26.5 | 31.7 | 30.3 |
| Savona | 10.6 | 22.9 | 31.9 | 21.7 | 12.9 |
| Sea Vigour | 11.5 | 30.5 | 40.8 | 14.6 | 2.6 |
| Biostim | 13.0 | 31.3 | 38.9 | 14.8 | 2.0 |
| Eradicoat | 23.0 | 24.9 | 32.2 | 14.7 | 5.2 |
| Sodium chloride | 2.9 | 13.5 | 35.0 | 33.6 | 14.9 |
| PEG | 10.3 | 20.3 | 42.8 | 20.9 | 5.8 |
| MAP | 13.4 | 25.6 | 33.0 | 18.3 | 9.7 |
| SED (70 d.f.) | 6.98 | 6.76 | 6.12 | 6.34 | 6.28 |

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**Table 4.** The effect of chemical thinning sprays applied to open flowers and hand thinning of fruitlets (10-12mm diameter) 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 | 25.7 | 40.1 | 24.9 | 8.1 | 1.1 |
| Hand thinned | 18.4 | 28.3 | 30.7 | 15.0 | 7.6 |
| Sulphur F3000 | 3.0 | 13.6 | 29.4 | 29.5 | 24.5 |
| Savona | 14.3 | 25.0 | 31.0 | 19.3 | 10.2 |
| Sea Vigour | 17.6 | 32.4 | 36.4 | 11.7 | 1.9 |
| Biostim | 18.0 | 33.2 | 36.0 | 11.5 | 1.4 |
| Eradicoat | 27.4 | 26.3 | 30.4 | 12.1 | 3.8 |
| Sodium chloride | 5.3 | 17.1 | 36.5 | 29.6 | 11.5 |
| PEG | 14.4 | 22.1 | 43.1 | 16.2 | 4.1 |
| MAP | 16.6 | 29.7 | 27.8 | 16.6 | 9.4 |
| SED (70 .f.) | 7.48 | 5.97 | 5.67 | 6.08 | 5.36 |

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None of the treatments affected the amount of red colour, incidence of skin russet, fruit firmness or the incidence of rotting (Table 5). However, 'Savona' increased the severity of skin russet compared to the untreated control fruit.

**Table 5.** The effect of chemical thinning sprays applied to open flowers and hand thinning of fruitlets (10-12mm diameter) on skin quality (area of red colour and degree of russet), firmness and incidence of rotting in Royal Gala apples.

| | Red Colour | Skin russet | | Firmness | Rotting |
|---|---|---|---|---|---|
| | Index (max 100) | (%) | Index (max 100) | (N) | (%) |
| Untreated | 87.91 | 46.8 | 10.25 | 67.52 | 1.88 |
| Hand thinned | 93.24 | 39.0 | 8.62 | 69.83 | 1.88 |
| Sulphur F3000 | 94.51 | 41.0 | 9.12 | 68.49 | 4.38 |
| Savona | 94.44 | 61.2 | 19.88 | 68.99 | 1.88 |
| Sea Vigour | 86.69 | 46.4 | 9.88 | 67.68 | 2.50 |
| Biostim | 90.11 | 47.9 | 10.62 | 67.05 | 1.25 |
| Eradicoat | 85.99 | 47.1 | 9.88 | 68.00 | 3.75 |
| Sodium chloride | 95.75 | 50.0 | 11.38 | 68.91 | 0.00 |
| PEG | 91.35 | 51.6 | 11.62 | 68.22 | 3.75 |
| MAP | 88.75 | 39.4 | 9.62 | 66.74 | 1.25 |
| SED (70 d.f.) | 3.600 | 7.73 | 2.416 | 1.413 | 1.948 |

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## Discussion

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 (Tables 2 and 3) 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 assessments 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.

The only thinning chemical currently available to UK growers is the nutrient ammonium thiosulphate or ATS which in this trial was represented by the commercial product 'Sulphur F3000'. 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 2 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. New Zealand experience with sodium chloride showed that an optimum thinning response was achieved on Fuji trees with 12 g/L whereas, 16g/L resulted in over-thinning (McArtney, Campbell, and Foote, 2000). These authors also report effective thinning of Braeburn trees using multiple applications of sodium chloride at 8g/L. Sodium chloride did not cause russet on Fuji which is consistent with no increase in russetting on the Gala apples in our study. Generally the remaining chemical treatments that were tried in 2003 did not provide statistically significant responses in terms of crop reduction or improvement in fruit size but polyethylene glycol (PEG) and mono ammonium phosphate (MAP) provided consistent trends in the results that merit their inclusion in any further investigations. In contrast there was insufficient indication of any potential benefits of 'Sea Vigour', 'Biostim' or 'Eradicoat' to justify their inclusion in further work.

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## Conclusions

- ATS 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.
- Sodium chloride 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 on method of application to minimise the risk of russet is not justified unless other promising materials are eventually discounted.
- It is proposed to continue work with sodium chloride, PEG and MAP with the aim of maximising their ability to thin through alteration of dose and timing.

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