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Headline

A successful Integrated Pest and Disease Management (IPDM) programme for organic apple production has been developed which in large scale field trials has been shown to give substantially improved results. The crucial importance of disease resistant varieties has been demonstrated. Where susceptible varieties are grown organically, partial control of scab and mildew may be achieved by early season copper sprays and growing season sprays of sulphur respectively. A wide range of other products evaluated have been shown to be ineffective. Early season sprays of pyrethrum have been shown to give acceptable control of apple blossom weevil, the most important pest, and late season sprays of pyrethrum to give partial control of rosy apple aphid.

Fruit quality evaluation by the consortium, including two major multiple retailers, have identified 11 disease resistant varieties, including one juice and 4 culinary varieties, that are potentially suitable for organic apple production. Six of these are suitable for medium to long-term storage. This list will be further narrowed in 2004 before publication at the end of the project

Background and deliverables.

The fourth year of a 5 year research project funded under the DEFRA Horticulture LINK scheme to identify suitable varieties and develop an effective Integrated Pest and Disease Management (IPDM) programme for organic apple production has been completed.

Summary of the project and main conclusions

Objective 1. Development of an effective Integrated Pest and Disease Management programme

The main elements of a successful IPDM programme have been identified and refined though there are still important gaps where adequate solutions are not available for individual pests and diseases that are important in organic apple production.

- The crucial importance of the use of disease resistant varieties has been demonstrated in every year of the project. The extent to which copper sprays for scab and sulphur sprays for mildew are required will depend directly on the extent to which varieties grown are susceptible to these two diseases respectively.
- Use of early copper sprays for scab control (two sprays are better than one) is vital and the first of these should be applied early before bud burst.
- The third experiment in the series in this project tested alternatives to urea for post harvest treatment to encourage leaf rotting. Overwintered leaves are important sources of scab infection in spring No practical and effective treatment to enhance leaf rotting has yet been identified but work is ongoing
- Sulphur sprays have been shown to be moderately effective for mildew control and must be continued until the end of extension growth.
- Sooty blotch contamination of harvested fruit has been shown to be a significant problem where there is poor air circulation and abundant sources of infection in adjacent hedgerows. In 2003, a replicated small plot orchard experiment evaluated sprays of copper oxychloride, sulphur, kaolin or extract of coconut + citrus (Crop

Life)+calcium carbonate applied on 4 occasions from late July to September at 1000 litres per hectare. None of the treatments controlled sooty blotch. The kaolin treatment whitened the trees and left an unsightly deposit on the fruits at harvest. No effective control measures for this disease have yet been identified. Work on this disease was not contracted in this project.

- Apple blossom weevil has been shown to be the most important pest in organic production causing significant yield loss. Early (bud-burst) pyrethrum treatment has been shown to give partial control of the adults weevils, two sprays being better than one. A SOLA for pyrethrum has been obtained.
- Early caterpillar feeding causes significant losses in quality with up to 10% of fruits damaged at harvest. Bud burst treatments with pyrethrum and early season sprays of *Bacillus thuringiensis* have made little difference to levels of damage at harvest. Codling moth has not caused significant fruit injury despite above threshold pheromone trap catches.
- N deficiency has been shown to be an important problem in organic apple production and has not been corrected by applications of organic N fertiliser. Removal of competition from ground herbage is likely to be the best way of overcoming this problem and is likely to be an important component of successful organic apple production. Work on nutrition and weed control was not contracted in this project.
- The highest yields highest yield (26.3 t/ha in 2003) and the best gradeout (41.8% class I in 2003) have been achieved by the IPDM programme in every year of the project which has consistently and substantially outperformed the growers pest and disease management programme, both of which considerably outperformed the untreated control. Different numbers of fruit per tree caused by different levels of scab infection and of apple blossom weevil attack have been the main reason for the differences in the yield.

Objective 2. To identify 4-6 varieties of apple of low susceptibility to diseases that have high fruit quality, a range of seasons (storage potentials) and markets (dessert, culinary, processing) and are suitable for organic production:

- One of the main reasons for the poor performance of organic apples in the UK is the lack of suitable varieties. Most of the popular commercial varieties in organic cultivation have little or no resistance to the major diseases scab and mildew.
- A world-wide search for promising disease resistant / tolerant apple varieties was undertaken. 160 varieties were scrutinised by the consortium including fruit technologists from Sainsbury's and Waitrose. An initial selection of around 40 promising varieties was made.
- This selection was reduced to a total of 28 varieties by further taste evaluation and a variety trial orchard of these was planted at East Malling and has now established well. The trees produced a very light maiden crop in 2003.
- So far, assessments have revealed that although most of the 28 varieties selected are resistant to scab, mildew continues to be a problem.
- Further fruit quality evaluations in 2003 have reduced the list to 11 including 4 culinary and a juice variety. Preliminary trials on variety performance in air and CA storage have shown that 6 of these are suitable for medium to long term storage.

Objective 3. To determine the activity (eradicant, protectant, antisporulant), persistence and efficacy of eight alternative organically acceptable fungicides for scab and mildew control

- None of wide range of alternative products tested to date have significant effects against scab and mildew, except Wetcol and sulphur.

Objective 4. To determine and optimise the efficacy of six organically acceptable foliar spray treatments for control of rosy apple aphid:

- A series of large scale field experiments to examine the efficacy of autumn treatment to control rosy apple aphid was continued. The strategy is promising though the organically acceptable aphicides tested have only been partially effective. Of these, pyrethrum appears the most promising.

Financial benefits

The gross economic output (£/ha) from the IPDM trial in the established organic Fiesta orchard is given below.

Year	2000	2001	2002	2003	Average
Untreated	2,725	7,646	115	17,600	7,021
Growers	10,519	9,647	831	23,727	11,181
IPDM	12,420	18,270	8,016	26,751	16,364

The above benefits are for a particular orchard with disease susceptible variety. The potential benefits across the whole industry are thus large, especially if disease resistant varieties identified under objective 2 are widely planted and marketed.

Action points for growers

- Choice of variety for new organic orchards should take into account the list of suitable varieties to be published at the end of this project

- The Integrated Pest and Disease Management (IPDM) programme developed in this project should prove improving results in organic apple production

Scientific summary

The fourth year of a 5 year research project funded under the DEFRA Horticulture LINK scheme to identify suitable varieties and develop an effective Integrated Pest and Disease Management (IPDM) programme for organic apple production has been completed. The main findings and conclusions from the fourth year of the work are as follows:

Objective 1. Development of an effective Integrated Pest and Disease Management programme

Existing organic orchard of the scab susceptible variety Fiesta (site 1, Sussex)

Scab at site 1
The risk of scab infection in the early part of 2003 was very low. By the time of the first scab period 25 April, most overwintering leaf litter had disappeared. Scab increased subsequently but more rapidly and to a higher level on the untreated and the grower's plots than on the experimental plots where two early copper sprays had been applied. The incidence of scab at harvest was much lower on the experimental plots than the grower's or the untreated plots in 2003, and much lower than at the previous harvest. High levels of scab present on the leaves at leaf fall pose a high risk for next year. These results suggest the two early copper sprays were more effective than a single treatment and that copper should be applied early before bud burst. Two post bud burst sprays of Wetcol should be evaluated in 2005. It is important that overwintering leaf litter is macerated if any remains before bud burst.

Mildew at site 1
The experimental orchard at Robertsbridge is in a lower mildew risk area. Primary mildew in spring 2003 was negligible. Secondary mildew levels rose on all plots through the growing season, but more rapidly and to a higher level on the growers and the untreated control plots where no sulphur was applied. Sulphur sprays to experimental plots reduced mildew significantly. However, it would have been preferable if a greater number of mildew sprays had been applied. This indicates that sulphur sprays should be continued until the end of extension growth.

Sooty blotch at site 1
Sooty blotch contamination of harvested fruit, though at lower levels in 2003 than previous years, remains a significant problem in this orchard where there is poor air circulation and abundant sources of infection in adjacent hedgerows. No effective control measures for this disease have yet been identified (see below).

Apple blossom weevil at site 1
Apple blossom weevil remains the most important pest causing significant yield loss by capping blossoms and reducing fruit numbers per tree at harvest. 2003 results corroborate previous years findings that early pyrethrum treatment gives partial control of the adults weevils and showed that two sprays were better than one.

Other pests at site 1
Early caterpillar feeding continues to cause significant losses in quality with up to 10% of fruits damaged at harvest. Bud burst treatments with pyrethrum and early season sprays of *Bacillus thuringiensis* made little difference to levels of damage at harvest. Levels of rosy

apple aphid were generally very low. Interestingly, codling moth caused very little damage despite moderate pheromone trap catches and no control measures.

Nutrition at site 1
N deficiency remains a problem in the orchard despite annual spring applications of organic N fertiliser. Removal of competition from ground herbage would be the best way of correcting this deficiency.

Yield and quality at site 1
Much higher yields were obtained 2003 compared to 2002 when the yields and quality had been abysmal. The highest yield (26.3 t/ha) and the best gradeout (41.8% class I) were achieved by the experimental treatment, closely followed by the growers treatment, both of which considerably outperformed the untreated control (18.9 t/ha and 29.5% class I). Different numbers of fruit per tree were the main reason for the differences in the yield

Economic performance at site 1
The good apple growing year resulted in the highest yields and financial returns, since the trial began. Even the control plots achieved yields, which were higher than typical organic ones. The financial output from the experimental plots was £26,751/ha or 102p/kg of fruit grown, 13% greater that the financial output from the grower's plots, £23,727/ha or 92p/kg. The cost of sprays from the experimental plots was £755/ha or 3p/kg, as against £298/ha or 1p/kg, from the growers plots. The costs of sprays were small and estimated to be only 5% (experimental plots) of the total costs of production and marketing. The additional costs of sprays of £458 in the experimental plots as against the grower's plots can easily be justified in terms of achieving an increase in financial output of £3024. This means that the pest and disease damage caused on the grower's plots are significant. Once other costs of production are added in, the experimental plots are estimated to achieve a net margin of £12,263/ha (37p/kg) against £10464/ha (£29p/kg) from the grower's plots.

Newly planted orchard of less disease susceptible varieties (site 2, East Kent)

Scab at site 2
No scab was found on the Topaz, a scab resistant variety. Low levels of scab infection were present on Pinova in July and at harvest. Levels were slightly lower on the plots that had been sprayed but differences were small. Pinova was found to be a scab susceptible variety and there is a risk that more severe fruit infection could occur in years where there is a higher scab risk. The only obvious way to counter this threat is to apply more early season copper sprays.

Mildew at site 2
The incidence of primary mildew infection was much greater than at site 1. East Kent is a higher risk mildew area. There was a higher incidence of primary mildew on the untreated plots than the plots that received two early sulphur sprays. Secondary mildew rose sharply during the growing season with a higher incidence on Pinova than Topaz. There was also more secondary mildew on the untreated than the treated plots indicating the sulphur sprays had some effect. In order to control mildew in this orchard, a programme of sulphur sprays will be needed post blossom.

Sooty blotch at site 2
The incidence of sooty blotch infection on fruits at harvest was very low. The young open trees and better air circulation make this orchard less favourable for sooty blotch than the orchard at site 1.

Rosy apple aphid at site 2
2003 was a low risk year for rosy apple aphid generally but a small but significant proportion of trees of both varieties became severely infested with rosy apple aphid in spring. Topaz was worse affected than Pinova and is a highly susceptible variety to this pest. High numbers of migrants in autumn 2003 indicate a high risk in spring 2004. Pre-emptive early sprays of pyrethrum should be considered.

Yields and quality at site 2
There were so few fruits present in 2003 that no yield records were taken.

Nutrition and weed control at site 2
Leaf N levels were marginal to deficient and fruit N levels were low for the variety Topaz. Attempts were made to control the competition from ground herbage by use of a flame weeder but the grass sward was thick and caught fire. Flame weeding is a promising method but it is important that it is done starting from the bare soil situation and continued regularly.

Economic results at site 2
There was insufficient yield of fruit to sell in 2003, so no income was gained. The only costs incurred in this young orchard were for sprays and weed control at £ 77/ha. A flame burner was used to control weeds and grasses in a strip either side of the tree. The costs were estimated at £124/ha per pass. If it had been used at the beginning of the season and for 6 times during the growing season then the cost is estimated at £745/ha.

Leaf rotting experiment

The third experiment in the series in this project tested alternatives to urea for post harvest treatment to encourage leaf rotting. Treatments tested were urea (5%), Nu-gro, Nu-gro+Digester, Digester, Fish oil (2 rates), Liquid Vinasse and compost tea. Unfortunately, leaf rotting was too rapid in this experiment to distinguish treatment effects.

Sooty blotch experiment

In 2003, a single replicated small plot orchard experiment was done to evaluate a range of products for control of sooty blotch (*Gloeodes pomigena*) in organic apple production. The experiment was located in a mature Jonagold apple orchard at Oakwood Farm, Robertsbridge, East Sussex. Treatments were a programme of sprays of copper oxychloride, sulphur, kaolin or extract of coconut + citrus (Crop Life)+calcium carbonate applied on 4 occasions from late July to September using a mist blower at 1000 litres per hectare. A randomised block design with 5 replicate single tree plots was used. None of the treatments controlled sooty blotch. The kaolin treatment whitened the trees and left an unsightly deposit on the fruits at harvest.

Objective 2. To identify 4-6 varieties of apple of low susceptibility to diseases that have high fruit quality, a range of seasons (storage potentials) and markets (dessert, culinary, processing) and are suitable for organic production:

One of the main reasons for the poor performance of organic apples in the UK is the lack of suitable varieties. Most of the popular commercial varieties in organic cultivation have little or no resistance or tolerance to the major diseases scab (*Venturia inaequalis*) and mildew (*Podosphaera leucotricha*) and pests such as rosy apple aphid (*Dysaphis plantaginea*),

codling moth (*Cydia pomella*) and tortrix (*Archips podana* and *Adoxophyes orana*). If the organic apple market in the UK is to be developed, varieties which are appealing to consumers, but which are also able to withstand pest and disease pressure, must be found. In order to address the lack of suitable varieties, a world-wide search for promising disease resistant / tolerant apple varieties was undertaken. The search focussed mainly on dessert varieties, but also embraced a review of culinary varieties suitable for the processing market and varieties deemed suitable for juicing. At the outset of the project, 160 varieties were scrutinised by fruit technologists from the major retailers Sainsbury's and Waitrose. Using taste-test panels set up to evaluated fresh fruit samples (some from unsprayed or organic orchards), an initial selection of around 40 promising varieties was made. Over the next two years, this selection was reduced to a total of 28 varieties, which included many new disease resistant selections from breeding programmes overseas, together with old, established UK varieties. Budwood of the selected 28 varieties was obtained and grafted onto 2-year old ex-Saturn trees in the winter of 2000-2001, with a view to establishing a variety trial orchard for these most promising varieties on registered organic land in research grounds at East Malling.

Despite some losses to canker, the organic apple variety planting (VF216) has now established well and the trees produced a very light maiden crop in 2003. Pest and disease monitoring is carried out each year in June and the varieties are also assessed for shoot growth, precocity and overall agronomic performance. Pollination requirements and floral precocity will be assessed on selected varieties in the final year of the project (2004). So far, preliminary assessments have revealed that although most of the 28 varieties selected are resistant to scab, mildew continues to be a problem. In 2002, the variety Goldrush was by far the worst affected with mildew, but in 2003, the varieties Discovery, Howgate Wonder, Pikant and Rebella appeared most prone. Applications of sulphur made to half the orchard successfully reduced the incidence of mildew on most varieties. So far, only one variety (Pinova) has showed any symptoms of susceptibility to scab (brought on by the very wet spring of 2002). Aphids (rosy apple aphid and green apple aphid) also appeared to be a particular problem for some of the varieties in 2003, notably Rubinstep, Discovery, Ecolette, Howgate Wonder, Red Falstaff, Encore and Pilot. Measurements of shoot growth carried out during the winter of 2001-2002 (one year after planting) showed that the most vigorous varieties were Ariwa, Judeline, Delorina, Florina and Worcester Pearmain. Preliminary records of precocity during the first cropping year of 2003 have revealed that the varieties Ariwa, Red Falstaff, Pinova, Pilot, Rebella and Delorina were the earliest to bear fruit in any substantial quantity. However, it would be premature to draw any firm conclusions on the agronomic performance of these varieties at this stage. The orchard is still in its infancy and quality of budwood used in propagation is likely to have a marked bearing on variety performance during the early years of establishment.

Having established an organic apple variety trial based on the selection of 28 promising varieties for organic production, the taste panel assessment of suitable varieties continued during 2002 - 2003 with a view to selecting a final short-list of around 10 at the end of 2003. These varieties would undergo large-scale taste testing at the Sainsbury's Centre in the final year of the project (2004). After reviewing fruits tasted during 2003, and taking previous assessments into consideration, a short-list of 11 varieties has now been made. Subject to agreement with the consortium, these varieties will be closely reviewed during 2004 and a final list of 4-6 varieties will be recommended to organic growers at the end of the year, on the basis of results obtained. The current list of 11 varieties comprises the dessert varieties Ceeval, Discovery (early season), Rajka, Resi, Rubinstep, Rubinola (mid-season), Ariwa, Pinova, Red Falstaff (mid-late season), Delorina, Liberty (late season), the culinary varieties Edward VII, Encore, Howgate Wonder, Pikant and the juicing variety Judeline. Preliminary trials on variety performance in air and CA storage, have shown that of these most promising

varieties, Ariwa, Rubinstep, Pinova, Rubinola, Edward VII and Pikant are likely to be most suitable for long-term storage. The variety Resi has so far shown susceptibility to soft-scald when stored in CA at a temperature of 1.5-2°C.

Objective 3. To determine the activity (eradicant, protectant, antisporulant), persistence and efficacy of eight alternative organically acceptable fungicides for scab and mildew control

None of alternative products tested to date have significant effects against scab and mildew, except Wetcol and sulphur. Overall, it is disappointing that almost all the alternative products tested so far were not very effective against apple scab and powdery mildew, apart from sulphur and copper products. Only the Lime Sulphur and Wetcol 3 (a copper-based product) were effective against scab and mildew, respectively. In 2004, the final year, further testing the efficacy of combining Wetcol bud burst application with a few selected alternative products in field conditions is proposed as well as testing the efficacy of compost tea against scab and powdery mildew on potted trees.

Objective 4. To determine and optimise the efficacy of six organically acceptable foliar spray treatments for control of rosy apple aphid:

Two further large scale field experiments were conducted examining the efficacy of autumn treatment to control rosy apple aphid. No firm conclusions about the efficacy of the treatments could safely be drawn because the degree of infestation that occurred in the two experiments done was too low to determine treatment differences. In one experiment, a programme of autumn sprays of Aphox (pirimicarb) (a conventional insecticide used as a standard) gave complete control of the very low populations of rosy apple aphid present whereas similar 3 spray programmes of sprays of Majestic (natural plant products), Surround (kaolin) or Py Insect Killer (pyrethrum) did not. In the other experiment, sprays of Majestic or Py Insect Killer showed partially effective against apple grass aphid. Two further experiments are currently in progress.

Objective 1. To evaluate and refine an innovative Integrated Pest and Disease Management (IPDM) programme for organic apple production in the UK

INTRODUCTION (OBJECTVE I, YEAR 4)

The aim of objective 1 of this project is to develop, evaluate and refine and IPDM programmes for organic apple production in the UK based on the organically- acceptable control approaches at two sites representing two contrasting scenarios in which it is considered that organic apples will be produced in future. One is the situation where an established orchard will be converted to organic production. The other is the situation where a new orchard is established as the land is converted (providing the option for varieties and the planting pattern to be selected specifically for organic production). The aim is that the IPDM programme should contain appropriate methods for each situation. In the first two years of the project (2000 & 2001), a preliminary IPDM programme was evaluated in an existing established organic Fiesta apple orchard at Oakwood farm, Robertsbridge, E. Sussex, (site 1) in comparison with the growers organic pest and disease control programme and untreated controls (for details see table 1a in year 2 report). A new organic apple orchard of 8 apple varieties (E II/20, Julia, Meridian, Pinova, Rajka, Red Falstaff, Santana, Topaz) was planted with bench grafted trees in replicated plots at North Court Fruit farm, Old Wives Lees, Canterbury, Kent (site 2).

In the first year (2000), the weather was very favourable for scab. A programme of 15 sprays of sulphur at low volumes and reduced rates to the experimental and growers plots failed to give acceptable control of scab which infected 54-58% of fruits at harvest on the sulphur treated plots compared to 81% on the untreated plots. Mildew control was acceptable but a high degree of cosmetic infection of the surface of fruits by sooty blotch developed in August and September. This was not controlled by sprays of sulphur and 41-60% of fruits had moderate or severe sooty blotch infection by harvest. Apple blossom weevil, rosy apple aphid and tortrix moth caterpillars were the main damaging pests in 2000. Apple blossom weevil larvae capped the blossoms of 26-35% of flowers with 10-39% of larvae being parasitised by the parasitic wasp *Scambus pomorum*. At harvest, 12.8-21.1% of fruits had malformation damage (flattened, dense, cat-faced) due to the weevil. It was concluded that development of an effective control measure for this pest in organic production is an important requirement. Rosy apple aphid also caused significant fruit losses (11.4-15.9% by weight) at harvest, natural enemies being insufficiently effective. Total yields were low (10.6-13.6 t ha^{-1}) for the treated plots in 2000, there being no significant difference between the experimental and the growers treatments, but both treatments had a significantly greater yield than the untreated control (5.3 t ha^{-1}). Nutrient analysis of leaves and fruits showed that the trees had a low nitrogen level in 2000 and the soil pH was low. This probably contributed substantially to the low yield performance of the orchard.

Growth of the bench-grafted trees in the new orchard at site 2 was weak. No sprays were applied.

In the second year (2001), to try to overcome the scab problem at site 1, it was decided to test full sulphur rates (10 kg ha^{-1}) and much higher spray volumes (1000 l ha^{-1}) and to include an early season spray of copper oxychloride for scab control for the experimental programme in the second year, 2001. This treatment was compared with the growers programme of low volume reduced rate sulphur sprays. A period of weather favourable for scab occurred shortly

after bud-burst. The scab risk from green cluster to petal fall was low but there was a second period of high risk during fruitlet development in June 2001 .A pre-bud burst spray of copper oxychloride followed by a programme of sprays of sulphur at the full dose of 10 kg ai ha^{-1} per spray at a spray volume of 1000 l ha^{-1} to the experimental plots gave markedly superior control of scab (0.9% fruits infected at harvest) than the growers programme of reduced rate sprays at low volume (125 l ha^{-1}) (8.1% fruits infected at harvest) which had similar levels of scab to the untreated control (7.8% fruits infected at harvest). It is suspected that the early season use of copper was a significant contributory factor to improved control. The full dose, high volume sprays of sulphur also gave superior control of mildew. The experimental spray programme also reduced levels of sooty blotch infection on the surface of the fruits at harvest, a disease that the project has identified as a significant economic problem in organic apple production, though infection was less severe than in 2000. For apple blossom weevil in 2001, it was decided to test the use of an early season spray of pyrethrum against adult weevils. Apple blossom weevil was the most damaging pest. A single spray of pyrethrum applied only to the experimental plots shortly after bud burst gave partial control of adult weevils. The percentage flowers infested with blossom weevil larvae was reduced from 37-39% to 19% by this treatment. At harvest, 40-55% of fruits were damaged by the weevil on the growers and the untreated control plots compared to 30% fruits damaged on the experimental plots. Furthermore, the apple blossom weevil was a major contributory factor to reduced yield in these plots as many damaged blossoms (i.e. those capped by larvae) fell from the tree. The early season spray of pyrethrum also gave incidental control of rosy apple aphid, which only occurred at low levels in 2001 and was controlled subsequently on all plots by physical removal by the grower after blossom. Pheromone trap catches of codling moth were only just above threshold and the incidence of fruit infestation by codling moth larvae was low, even on the untreated control plots. Codling moth had not increased in the orchard as expected and this was thought to be due to a high levels of natural enemies in the orchard. The effectiveness of sprays of codling moth granulovirus, applied for the experimental treatment, could not be demonstrated because of the low incidence of pest codling moth attack. To correct the N deficiency, organic fertiliser was applied to the base of the trees of the experimental plots in spring 2001.

The bench-grafted trees grew very poorly in 2001. It was clear that the trees would take several years to establish and it was considered unlikely that the trees would bear fruit before the end of the project. It was, therefore, decided to grub the bench-grafted trees and replant with well grown nursery trees in spring 2002.

In the third year (2002), a high incidence of scab infected leaf litter combined with exceptionally favourable weather posed a very high scab risk in the established in spring 2002. A pre-bud burst copper spray gave partial control of scab and was more effective than a programme of multiple high dose sprays of sulphur applied subsequently. Over 90% of fruits were infected with scab at harvest on the growers and the untreated plots compared to 71.2 % on the experimental plots where the early copper had been applied. Fruits from the growers and the untreated plots were mainly severely infected, distorted and small whereas those in the experimental plots where the early copper had been applied were only slightly or moderately affected. The differences between treatments in scab infection had a large affect on yield and fruit quality. A high carry over of inoculum into 2003 will occur unless the problem of overwintering leaf litter is dealt with. The results in 2002 in particular reaffirmed that scab susceptible varieties such as Fiesta are unsuitable for organic apple production in the UK because adequate control of scab cannot be achieved in years of high scab risk. Results also indicated that a pre-bud burst spray of copper is beneficial for scab control. A programme of sulphur sprays gave good control of mildew. Confirming that a programme of sprays of sulphur can give adequate control of mildew at sites with moderate to low mildew risk. Over

90% of fruits had sooty blotch infection at harvest, > 50% moderate or severe. There were no treatment differences. This resulted in a large proportion of the crop being downgraded to second or juice quality. No effective treatment for control of sooty blotch in UK organic apple production has been identified and control of this disease is a high priority for future research.

Apple blossom weevil was the most damaging pest in 2002. Two early season sprays of pyrethrum significantly reduced the amounts of adult feeding injury to trusses, the percentage flowers attacked by larvae (capped blossoms) and the percentage of fruits damages at harvest. This contributed to the much greater yields and higher percentage class I grade out on the experimental plots at harvest. The grower's treatment with Derris was ineffective. The parasite *Scambus pomorum* did not prevent significant fruit losses on the untreated or growers plots. The results indicate that two early season sprays of pyrethrum give fairly good control of blossom weevil, a very damaging pest in organic apple production and that Derris is ineffective. For the third season, codling moth and sawfly did not cause significant damage in 2002, even though pheromone trap catches of the former pest were high. A further April application of composted mycelium fertiliser appeared to be starting to correct the previously severe N deficiency in the orchard but further applications are needed.

The new organic orchard at North Court fruit farm, originally planted with bench grafted trees of 8 apple varieties in spring 2000, was grubbed. The bench-grafted trees had made very poor growth and it was concluded that the use of such trees was unsuitable for establishing an organic orchard. In March 2002, the orchard was replanted with well-grown nursery trees of the scab resistant variety Topaz and the variety Pinova, considered to be of low scab susceptibility. The new planting has alternating pairs of rows of the two varieties and has been divided into 6 plots, 3 of which received a spray of copper pre-bud burst followed by a programme of 3 sprays of sulphur up to petal fall in mid-May. The other three plots were untreated.

No scab was found on the variety Topaz. However, significant levels of scab infection occurred on Pinova. The levels of scab on the untreated controls were greater than on the sprayed plots indicating that the spray programme did give partial control of scab. However, the levels of scab infection on the Pinova on the treated plots were still too high. The results indicate that Topaz is highly resistant to scab but Pinova is moderately susceptible. The spray programme of early copper followed by 3 early season sulphur sprays was not sufficiently effective in a high risk year on Pinova. Significant levels of primary mildew infection were present on the trees after planting resulting from infection that occurred in the nurseries. Significant levels of secondary mildew developed in June. The spray programme did not provide control because the sulphur sprays were confined to the early part of the season for scab control only. The results indicate that the sulphur spray programme is likely to be needed throughout the growing period. No treatments were applied for rosy apple aphid in 2002. Both varieties had significant infestation and damage. Composted green waste mulch was applied in April 2002 and foliar nutrients were also applied. Leaf analysis showed that N levels were slightly below the minimum of 2% indicating slight deficiency. Levels of the other nutrients in the leaves were adequate. In fruits at harvest, N levels were marginal.

METHODS AND MATERIALS (OBJECTVE I, YEAR 4)

Experiment 1 at site 1 in existing orchard, Robertsbridge

Site

The whole of an existing organic 1.4 ha apple orchard cv Fiesta (orchard No.6) at Oakwood farm, Poppinghole lane, Robertsbridge, East Sussex was used for the experiment. The orchard was planted in 1994 on MM106 rootstocks. The row spacing is 4.95 m and the spacing between trees in the row is 3.3 m.

Treatments

The following treatments are being evaluated at site 1:
Al. Experimental IPDM programme
A2. Grower's organic pest and disease control programme
A3 . Untreated control
The spray programme applied in 2003 at site 1 is given in Table 1.For disease control in the fourth year of the experiment (2003 growing season) a dormant season then a mouse ear spray of copper oxychloride was followed by 2 sprays of sulphur at the reduced rate of (5 kg of 80% sulphur SG ha^{-l}), applied at a high spray volume of 1000 l ha^{-l} to the experimental plots (see Table 1). No other fungicides were applied, though the experimental (red) plots also received a programme of 8 sprays of compost tea from green cluster to early August at the lower volume of 350 l/ha. The growers plots received the pre-bud burst spray of copper oxychloride plus the same sprays of compost tea but no sulphur sprays.

For pest control in the fourth year (2003 growing season), the IPDM plots received two early sprays of pyrethrum for apple blossom weevil adults and a spray of *Bacillus thuringiensis* at green cluster for caterpillars. The grower's plots (yellow) received the first pyrethrum spray only and no other insecticides. Note that unlike in previous years, no sprays of codling moth granulovirus were applied. No treatments were applied to the untreated control plots. There were so few primary infections and so little rosy apple aphid in 2003 that no action to remove them from the orchard was taken.

To correct the N deficiency, Lawes high N organic fertiliser (Laws, Wisbech, 9%N analysis 6:3:3) was applied to all plots at a rate of 1.0 tonnes/ha to the tree rows only on 21 March 2003 continuing the series of annual spring applications.

Experimental design

For experiment I, a randomised block design with three replicates was used. The treated plots in experiment I were 6 rows wide and ran the whole length of the orchard (Figure 1). However, all assessments were done on a sub-plot of 20 trees (two adjacent sets of 10 trees) in the central two rows of the plot. This was to minimise the effects of spray drift contamination from adjacent plots. The location of the sub-plots in the rows was chosen to avoid areas of weak growth caused by water-logging. The treated plots were in the same locations as in 2000-03. However, as has been done each year, the unsprayed (indicator) plots were moved to new locations at the ends of three of the plots and were six rows wide by 6 trees long (see Figure 1).

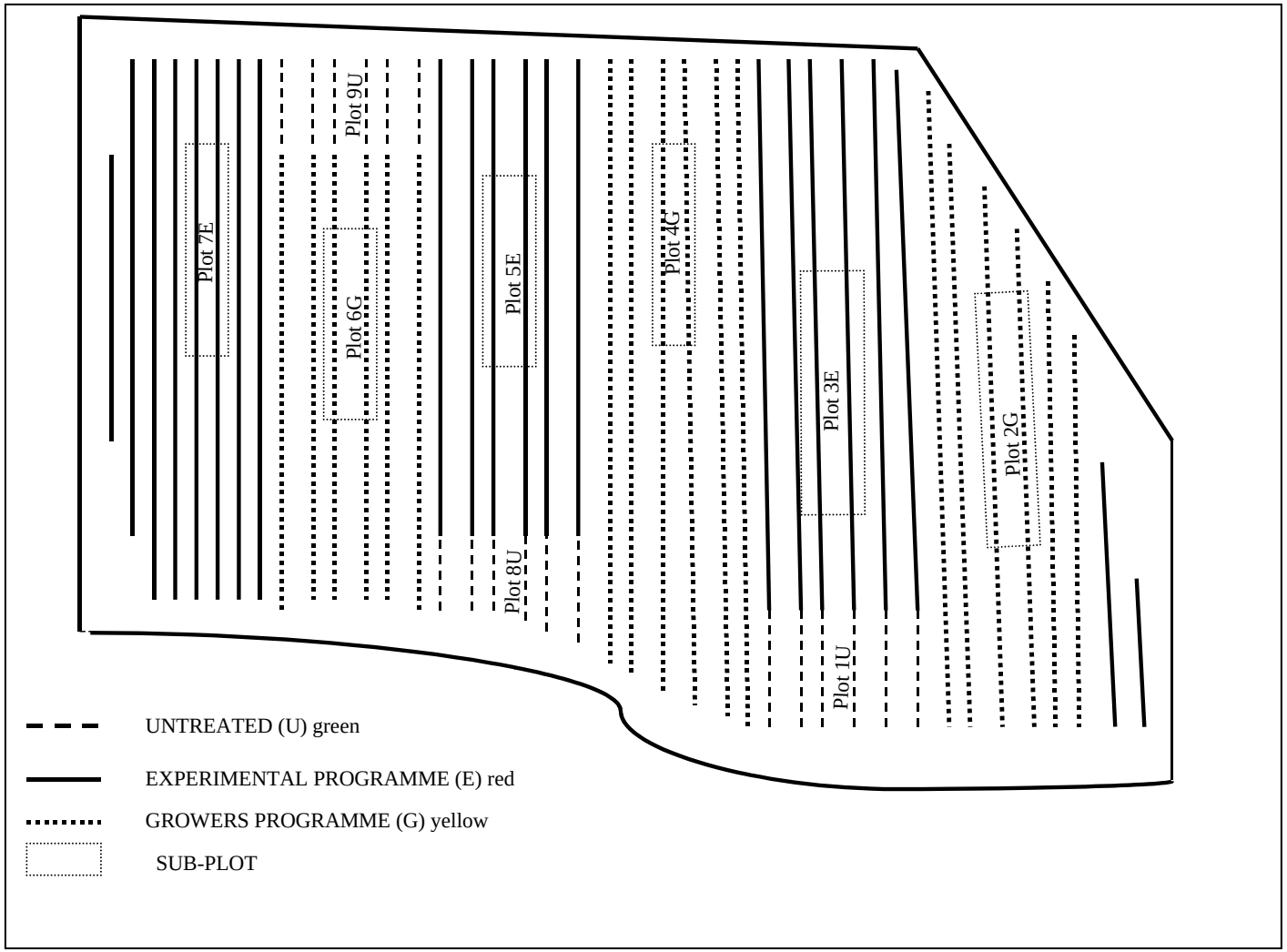


Figure 1. Experimental layout in the IPM trial at Oakwood farm in 2003. Note the untreated control plots have been relocated.

Assessments

Diseases: On 24 April 2003, at the pink bud to early flower growth stage, the incidence of overwintered leaf litter on the surface of the ground in each plot was assessed using the point transect method. The number of points out of 100 at which leaf litter was found in each plot was determined. On the same day, a general visual inspection of each of 10 trees in the central sub-plot of each plot were made for the presence or absence of scab on the whole tree. The incidences of primary blossom and vegetative mildew were also assessed by examining 400 blossom trusses per plot. On 6 June, 14 July and 2 September 2003, shoot mildew (using the method of method of Butt & Barlow (1979)) and scab were assessed on a sample of 50 growing shoots per plot. A sample of 50 fruits was collected at random from the adjacent Fiesta orchard on 27 June, 14 July and 22 July 2003. They were incubated in a damp chamber in the laboratory at East Malling and assessed for sooty blotch on the surface of the skin after one month. At harvest on 5-12 September, the percentage fruits infected with scab, the incidence of severe, net-like russeting on fruits at harvest, caused by mildew infection, was assessed on a sample of up to 1000 fruit per plot (see below). The severity of sooty blotch infection on the skin each individual fruit of a random sample of 100 fruits per plot was scored into categories of severity (none, slight, moderate, severe). The number of fruits in each category was calculated. Just pre leaf fall on 14 October, a sample of 100 leaves was taken from each plot for assessment for levels of late scab infection. The samples were stored in a fridge until they were assessed in November. The degree of infection on each leaf was scored into none, slight, moderate and severe categories. The percentage infected was calculated.

Pests: Full pest assessments on each plot were done on 17 April (green cluster –pink bud) and 28 May 2003 (fruitlet). General inspections of the plots in June and August indicated that additional full pest assessments were not worthwhile: No new pest or damage was present in sufficient numbers to justify a full assessment. For the two full pest assessments, 20 trees (in the central sub- plot) were assessed per plot. On 17 April, the numbers of trusses per tree infested with rosy apple aphid were counted. Five trusses per tree were examined closely for the full range of pests and damage including capsid, tortrix and winter moth, rosy apple and apple grass aphid, apple sucker and apple blossom weevil adults. The same general method was used on 28 May but the number of flowers with apple blossom weevil larval damage (capped blossoms) and the number parasitised by *Scambus pomorum* were also counted so that the percentage larvae parasitised could be calculated.

The incidence of damage caused by pests on fruits was also assessed at harvest (see below).

Codling moth and tortrix moth adults: One pheromone trap (standard delta design) for each of the three main pest species (codling moth, fruit tree tortrix moth and summer fruit tortrix moth) was set in the centre of the experimental orchard at site 1 on 28 May 2003. The number of male moths of each species was recorded at approximately weekly intervals until 5 September 2003. Lures were renewed on 19 June, 24 July and 22 August 2003. Sticky based were frequently renewed as necessary.

Arthropod and plant biodiversity: No arthropod samples were taken in 2003 and the flora of the orchard was not surveyed.

Nutritional status: A sample of 50 leaves, selected from the mid-point of the current seasons extension growth, was taken from each treatment (i.e. overall from 3 plots) on 22 August 2003 and subjected to nutrient analysis in the laboratory (under contract with Direct laboratories, Wolverhampton). A sample of 15 fruits of approximately 60mm diameter was taken from each treatment (combining 5 fruits from each plot for that treatment) for nutrient analysis at harvest on 5-9 September 2003. Fruit analysis was done at NRM Ltd, Bracknell, Berks.

Yield and quality at harvest: At harvest on 5-12 September 2003 all the fruits on 10 trees in the central sub-plot of each plot were harvested. The total number and weight of fruit on each tree was recorded. The fruit from each plot was then separated into Class I, Class II, Class ill (Juice) and outclass quality grades. A lower size threshold for the Class I quality grade of 60 mm was applied. Discoloration due to sooty blotch infection (which was present on the surfaces of a large proportion of the fruits). The total weight of fruit in each quality grade was recorded for each plot. Each fruit was then individually examined for blemishes due to each pest and disease and the number and weight of fruit damaged by each recorded. Many fruits had blemishes caused by two or several pests and diseases and each was recorded.

Economic analysis: The total and marketable yields from the three plots have been multiplied by current organic apple prices (£1.20/kg for a combined Class I&II and £150/t for juice). This results in the total financial output for each plot; this has been compared with typical organic outputs obtained from a previous study (Firth, 1999) and with typical yields and financial outputs which could have been obtained if the orchard had remained in conventional production. The four years data from the study are also compared. The costs of the three spray programmes are also costed out for comparison purposes and these are related to their relative financial output. All other costs of production (direct and overheads costs) have been modelled in to arrive at estimated net margins per hectares and per kilogram of fruit grown.

Table 1. Sprays applied to the IPDM experiment at site 1 (Oakwood farm) in 2003.

Experimental plots (red)					Growers plots (yellow)				
Date (2003)	**Growth stage**	**Product(s) applied**	**Dose rate (product/ ha)**	**Spray volume (litres/ha)**	**Date (2003)**	**Growth stage**	**Product(s) applied**	**Dose rate (product/ ha)**	**Spray volume (litres/ha)**
21 Mar	Dormant	Cuprokylt FL	5 l	1000	21 Mar	Dormant	Cuprokylt FL	5 l	1000
24 Mar	Bud burst	Py Insect Killer	10 l	1000	24 Mar	Bud burst	Py Insect Killer	10 l	1000
2 Apr	M ear	Wetcol 3	50 l	1000	21 Apr	Bloom	Compost tea + Maxicrop	* 2.8 l	350
2 Apr		Py Insect Killer	10 l	1000	5 May	Petal fall	Compost tea	*	350
18 Apr	G cluster	Dipel DF	1 kg	1000	26 May	Fruitlet	Compost tea	*	350
21 Apr	Bloom	Compost tea	*	350	11 Jun		Compost tea	*	350
5 May	Petal fall	Sulphur 80% SG	5 kg	1000	23 Jun		Compost tea	*	350
5 May		Compost tea	*	350	8 Jul		Compost tea	*	350
26 May	Fruitlet	Sulphur 80% SG	5 kg	1000	22 Jul		Compost tea	*	350
26 May		Compost tea	*	350	5 Aug		Compost tea	*	350
11 Jun		Compost tea	*	350					
23 Jun		Compost tea	*	350					
8 Jul		Compost tea	*	350					
22 Jul		Compost tea	*	350					
5 Aug		Compost tea	*	350					

* compost tea made from 60 kg compost in 2000 l water, agitated for 18 hours then used immediately

Experiment 2 at site 2 in new orchard, Old Wives Lees, Canterbury, Kent.

Site

The new apple orchard in 'Lower Profits' field (1.6 ha), North Court Fruit Farm, Old Wives Lees, Canterbury. Kent was originally planted with bench grafted trees on 8 May 2000. However, these made very poor growth in both 2000 and 2001. It was grubbed and replanted with well-grown, feathered organically certified nursery trees of two varieties: Pinova (from the Netherlands) in December 2001 and Topaz from Italy in March 2002. The whole planting is alternating pairs of rows of the two varieties. The row spacing: is 4.0 m and the spacing between trees in the row is 2.2m.

Treatments and experiment design

For experiment 2, a randomised design with four replicates of two treatments, the experimental IPM programme versus an untreated control, was used (Figure 2). Sprays applied at site 2 in 2003 are shown in Table 2.

Table 2. Sprays applied to the IPDM experiment at site 2 (North Court) in 2003.

Experimental plots (red) (1000 l/ha)				
Date (2003)	**Growth stage**	**Product(s) applied**	**Dose rate (product/ ha)**	**Spray volume (litres/ha)**
14 Mar	Dormant	Cuprokylt FL	2.5 l	1000
2 Apr	Green cluster	Sulphur	4.0 l	1000
		Maxicrop organic	3.0 l	
30 Apr		Sulphur	4.0 l	1000
		Maxicrop organic	3.0 l	
28 May	Fruitlet	Sinclair Nu Gro	5.0 l	1000

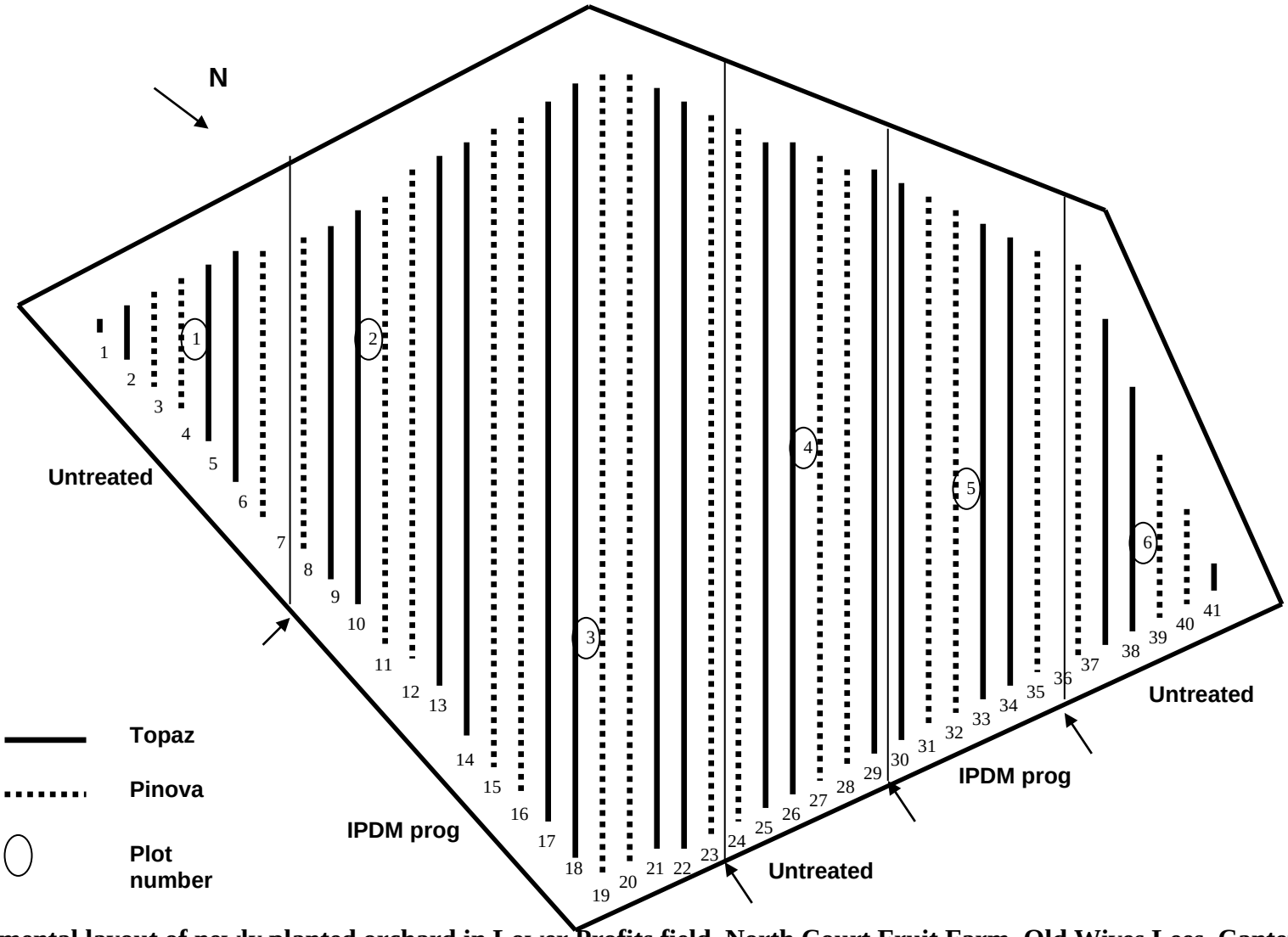


Figure 2. Experimental layout of newly planted orchard in Lower Profits field, North Court Fruit Farm, Old Wives Lees, Canterbury, Kent

Assessments

Pest and disease assessments were done on each variety on 2 May, 17 June, 23 July and at harvest on 25 September 2003. On 2 May, ten trees of each variety were examined in each plot. The whole tree was examined for rosy apple aphid, scab and primary mildew. The severity of rosy apple aphid infestation was scored on a 0 (= none) to 3 (whole tree severely infested) scale. Presence or absence of scab infection on the whole tree was recorded and the number of primary mildew infections counted. Five individual blossom trusses were carefully examined for pests including caterpillars, caterpillar damage and capsids. On 17 June the secondary mildew and rust mite bronzing were assessed. Ten trees of each variety were assessed in each plot. Two shoots per tree were assessed for presence or absence of secondary mildew in the five terminal leaves and for presence or absence of scab infection. One fully expanded leaf per tree was assessed for rust mite infestation and bronzing, scored on a 0 (= zero) to (3 =severely infested and bronzed) scale. Only a small crop of fruit was present in 2003, so a full assessment of yield and quality was not appropriate. However, on 25 September 2003 when the fruit had reached maturity, 25 trees of each variety per plot were assessed from the central rows of each plot. The numbers of fruits on each tree was counted. The severity of scab and sooty blotch infection and of russet on the skin of two individual fruits per tree was scored into categories of severity (none, slight, moderate, severe). The percentages of fruits in each category were calculated. On 10 October, a sample of 100 leaves was collected from each variety in each plot. The samples were stored in a fridge until they were assessed in November. The degree of scab infection on each leaf was scored into none, slight, moderate and severe categories. The percentage infected was calculated.

Leaf rotting experiment at site 1 in winter 2002/03

A separate experiment, the third in the series being done in this project, was conducted to test alternatives to urea for post harvest treatment to encourage leaf rotting. Fiesta leaves were collected from the experimental Fiesta orchard at Oakwood farm, Robertsbridge in the first week of November 2002 and stored at 4 ºC in a fridge until December. On 11 December 2002, aqueous solutions of a range of products (Table 3) were prepared for dipping treatments. For each treatment, a sample of 120 leaves (in a sprout net) from the organic Fiesta at Oakwood farm were dipped into each solution for half a minute, stirring to ensure thorough mixing. The leaves in their nets were allowed to dry overnight. A similar net of leaves was left untreated. The following day, they were spread in batches of 30 on the surface of the ground herbage under the trees in the organic Fiesta orchard at Oakwood farm in a randomised block design. Each batch of 30 (a plot) was held in place by plastic rigid netting which was secured to the ground by metal pins. The percentage leaves remaining under each net was assessed on 23 January and 28 February 2003 and mean values calculated.

Table 3. Treatments applied in the leaf rotting experiment at site 1 in winter 2002/03

Treatment	Product	Concentration (amount/litre)
1	Untreated	-
2	Urea (5%)	50 g
3	Nu-gro (high rate)	20 ml
4	Nu-gro + Digester	20 ml + 100 ml
5	Digester	100 ml
6	Sea Vigour Fish Oil	12.5 ml
7	Sea Vigour Fish Oil (high rate)	50 ml
8	Liquid Vinasse	50 ml
9	Compost tea	undiluted

Evaluation of products for control of sooty blotch - 2003

In 2003, a single replicated small plot orchard experiment was done to evaluate a range of products for control of sooty blotch (*Gloeodes pomigena*) in organic apple production. The experiment was located in a mature Jonagold apple orchard at Oakwood Farm, Robertsbridge, East Sussex. The orchard had Ida Red pollinators. The tree spacing was 3.1m between trees in the row and 4.5m between rows. Treatments were a programme of sprays of 4 different chemical products applied on 24 July, 7 August, 20 August, 11 September 2003 (Surround was not applied on this date), and an untreated control. Sprays were applied using a mist blower at 1000 litres per hectare are shown in Table 4. Single tree plots were used. Trees were chosen so they had 50-100 fruits per tree. Each treatment was replicated 5 times in a randomised block design.

Table 4 – Treatments applied in the sooty blotch experiment 2003.

Product	Active ingredient	Product rate per hectare
1. Untreated	-	-
2. Cuprokylt	Copper oxychloride	0.45 litres
3. Headland Sulphur 80 SC	Sulphur	10 litres
4. Surround	Kaolin	50 kg
5. Crop Life + calcium carbonate	Extract of citrus and coconut	300ml + 250gm $CaCO_3$

RESULTS (OBJECTIVE 1, YEAR 4)

Experiment 1 at site 1 in existing orchard, Robertsbridge

Scab at site 1

The early part of the season in 2003 was dry and the risk of scab infection was consequently very low. The first scab infection period occurred on 25 April 2003 at East Malling. By that time, most overwintering leaf litter had disappeared in varieties like Fiesta. At the assessment of the amount of litter present on 24 April 2003 using the point transect method, only one leaf was found in one of the growers plots. The leaf litter had also disappeared from the adjacent Jonagold orchard.

No scab was found on the trees on the 24 April 2004 (Table 5). On 6 June 2003, the incidence of scab on shoots was significantly lower in the experimental plots than in the grower's or the untreated controls. The incidence of scab was greater on 14 July on all plots but the same treatment differences were still present. By 2 September 2003, the incidence of scab had risen on all plots such that most shoots were infected and no treatment differences were apparent. Because no post-blossom scab treatments had been applied, scab levels steadily increased on all plots, but starting from a lower level on the experimental plots, partly due to the early treatments but also probably due to disease carryover from 2002. Lower levels of scab were present in the experimental plots in 2002. The incidence of scab at harvest was much lower on the experimental plots than the grower's or the untreated plots in 2003, and much lower than at the previous harvest in 2002. This reflects the low scab risk in the early part of the season and the differences in inoculum from the previous season. High levels of scab were present on the leaves sampled pre leaf fall from all plots in October 2003. This inoculum poses a high risk for next year unless the overwintering leaf litter degrades before the fist scab periods in 2004.

These results suggest the two early copper sprays were more effective than the single treatment applied in the grower's plots. In 2004, it is important that the first early copper spray (of Cuprokylt) should be applied early before bud burst in the experimental plots. Two post bud burst sprays of Wetcol should also be applied for this treatment. The high level of scab infection on leaves in autumn 2003 poses a high risk in 2004. It is important that overwintering leaf litter is macerated if any remains before bud burst.

Table 5. Mean percentage infection with scab at site 1 in 2003

Date (2003)	Growth stage	Assessment	Mean % scab infection		
			Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
24 Apr	Pink bud/early flower	Leaf litter at 34 points per plot	0	0.3	-
24 Apr	Pink bud/early flower	Trees infected/10	0	0	0
6 Jun	Fruitlet	% shoots	13.3	30.0	28.3
14 Jul	Fruitlet	% shoots	35.3	70.7	64.7
2 Sep	Pre-harvest	% shoots	97.5	100	96.7
5 Sep	Harvest	% by no. fruits	6.6	35.8	23.7
		% by weight fruits	6.6	36.0	23.8
14 Oct	Pre-leaf fall	% leaves infected	88.3	93.3	89.0

Mildew

The incidences of primary mildew in the Fiesta orchard at Robertsbridge were negligible (Table 6) in 2003. Secondary mildew levels rose on all plots through the growing season, but more rapidly and to a higher level on the growers and the untreated control plots. This result indicates that the sulphur sprays applied to the experimental plots had a significant effect on mildew incidence. However, it would have been preferable if a greater number of mildew sprays had been applied to the experimental plots. Sulphur sprays, perhaps at a low rate, should have been continued until the end of extension growth. It is important that this is done in 2004.

Table 6. Mean percentage infection with mildew in 2003

Date (2003)	Growth stage	Assessment	Mean % mildew infection		
			Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
24 Apr	Late bloom	1° % blossom	0	0	0.08
6 Jun	Fruitlet	2° % shoots	26.7	65.9	68.3
14 Jul	Fruitlet	2° % shoots	34.0	94.0	92.7
2 Sep	Pre-harvest	2° % shoots	37.5	84.2	78.3

Sooty blotch

Sooty blotch was not apparent after incubation in the first two samples of fruits taken from the adjacent Fiesta orchard on 27 June and 14 July 2003. At harvest, the incidence of sooty blotch infection was generally lower than in 2002. The amount of sooty blotch infection was somewhat greater on the grower's plots than on the experimental or untreated plots. The reason for this is unclear and the differences are likely to be due to random variation. Effective treatments for inclusion in this IPM experiment in 2004 have not yet been identified.

Table 7. Fruit infection with sooty blotch at site 1 (Oakwood farm) in 2003.

Date (2003)	Growth stage	Assessment	Mean % infested		
			Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
5 Sep	Harvest	% fruits no infection	67.2	46.0	66.0
		% fruit slight	27.6	36.7	25.0
		% fruits moderate	4.9	13.5	8.1
		% fruits severe	0.4	3.8	0.9

Apple blossom weevil

Only small numbers of apple blossom adults were found feeding on the flower buds when the first pest assessment was done on 17 April 2003 at green cluster (Table 8). Inspection is not as sensitive a method for detecting adults as beat sampling but numbers of adults appeared less than previous years. A lower percentage of flower buds was damaged (capped) by larvae on the experimental plots than on the growers or the untreated plots. At harvest, the highest % by weight or number of fruits damaged by the pest were on the untreated control and the lowest for the experimental treatment, which received two early pyrethrum sprays, with the growers treatment, which received only one early pyrethrum spray with intermediate damage. These results indicate that the pyrethrum treatment was giving partial control of the adults weevils, and that two sprays were better than one.

Table 8. Mean % infestation by apple blossom weevil at site 1 in 2003

Date (2003)	Growth stage	Assessment	Mean % infested		
			Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
17 Apr	G cluster	Adults/300 clusters	0	1	0
28 May	Early fruitlet	% capped blossoms	4.9	11.5	10.7
5-12 Sep	Harvest	% by no. fruits damage	6.2	11.5	15.8
		% by weight fruits damaged	5.7	10.5	14.4

Winter moth and tortrix moth caterpillars

Low to moderate levels of winter and tortrix moth caterpillars were present pre-blossom as well as some early caterpillar feeding damage (Table 9). There were no marked treatment differences though levels were greater on the untreated control than on the experimental or growers treatments where the sprays of pyrethrum had been applied. For the experimental treatment, a spray of *Bacillus thuringiensis* was applied on 18 April but at harvest, early caterpillar damage occurred at similar levels on all plots. At harvest, approaching 10% of fruits (by weight or number) in total were found to have been damaged by early caterpillar feeding. The early insecticide treatments did not appear to significantly reduce this.

Table 9. Mean % infestation and damage by winter and tortrix moth caterpillars in 2003

Date (2003)	Growth stage	Assessment	Mean % infested		
			Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
17 Apr	G cluster	Winter moth caterpillars/300 clusters	1	3	4
		Caterpillar damage/300 clusters	12	13	20
5 Sep	Harvest	% by number early cat	4.3	2.5	4.8
		% by weight early cat	4.3	2.7	6.2
		% by number tortrix	5.7	6.2	4.8
		% by weight tortrix	5.5	6.0	4.8

Codling and tortrix moth, apple sawfly

Moderate numbers of codling, fruit tree tortrix and summer fruit tortrix moths were caught in the pheromone traps (Table 10). There were two generations of codling moth, the first in June the second partial generation in August. Numbers exceeded the economic threshold (5 moths per trap per week for 2 weeks) for both generations but levels of codling moth damage to fruits were low (1.1-1.3% on the treated plots, 2.4% on the untreated plots), despite that no sprays to control codling moth (of codling moth granulovirus) were applied in 2003. No apple sawfly damage was recorded in 2003 (Table 11).

Table 10. Catches of male moths in pheromone traps at site 1 in 2003.

Date (2003)	Codling	Fruit Tree Tortrix	Summer fruit tortrix
28 May	Traps set out		
5 Jun	21	9	17
12 Jun	7	* (trap destroyed, replaced)	18
19 Jun	21	14	2
27 Jun	20	30	1
11 Jul	18	12	0
14 Jul	0	8	0
24 Jul	Lures changed		
24 Jul	6	9	2
1 Aug	2	3	0
8 Aug	0	1	0
15 Aug	9	0	16
22 Aug	Lures changed		
22 Aug	8	0	18
29 Aug	1	5	2
5 Sep	0	4	2

Table 11. Incidences and damage by sawfly and codling moth 2003

Assessment	Mean % damaged		
	Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
28 May - % fruitlets sawfly	0	0	0
5 Sep - % by no. fruits sawfly	0	0	0
5 Sep - % by wt fruits sawfly	0	0	0
5 Sep - % by no. fruits codling	1.1	1.3	2.4
5 Sep - % by wt fruits codling	1.1	1.3	2.4

Rosy apple aphid

2003 was generally a low year for rosy apple aphid and levels were very low in the IPM experiment in the Fiesta orchard at Oakwood farm (Table 12). However no aphid infestation was detected at green cluster or damage at harvest in the experimental plots that had received two early season pyrethrum sprays whereas low levels were present in the other plots.

Table 12. Mean % infestation and damage by rosy apple aphid at site 1 in 2003.

Date (2003)	Growth stage	Assessment	Mean % infested		
			Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
17 Apr	G cluster	Total clusters/600	0	1	2
5 Sep	Harvest	% fruits by no.	0	0.2	0.7
		% fruits by wt	0	0.2	0.6

Nutritional status

Mineral analysis of the leaf samples taken on 22 August continued to show that the orchard was suffering from N deficiency, at least compared with the leaf N levels that would be expected in conventional orchards (Table 13). The dry weight N should exceed 2.0%. However, the levels are better than in the early years of the experiment, presumably due to the annual spring application of N fertiliser that has been made. The N deficiency is also apparent in the mineral analysis results of the samples taken at harvest (Table 14). N levels from all three treatments were 39 mg/100g fresh weight, below the optimal for this variety. Ca levels were also low, though no bitter pit was apparent.

Table 13. Mean levels of nutrients in leaf samples taken at site 1 on 22 August 2003.

	% dry weight				
Treatment	**N**	**P**	**K**	**Ca**	**Mg**
Experimental prog. (A1)	1.73	0.20	1.47	0.64	0.16
Growers prog (A2)	1.8	0.46	1.86	1.13	0.15
Untreated control (A3)	2.0	0.30	1.82	0.96	0.20
*EE183 2000	2.31	0.21	1.81	1.05	0.12
	Parts per million				
Treatment	**Mn**				
Experimental prog. (A1)	151				
Growers prog (A2)	107				
Untreated control (A3)	75.2				

*EE183 2000	43.8				

Laws 9% N fertiliser was applied to all plots at site 1 at a rate of 1.0 tonnes/ha to the tree rows only on 21 March 2003.

Table 14. Levels of nutrients in Fiesta fruit samples taken at harvest at site 1 on 5 September 2003.

	Milligrams per 100 grams				
Treatment	**N**	**P**	**K**	**Ca**	**Mg**
Experimental prog. (A1)	39	8.87	103	4.03	4.45
Growers prog (A2)	39	8.75	99.8	3.74	4.43
Untreated control (A3)	39	10.3	115	4.67	4.80
1996 survey - mean	56	9.6	109	6.0	4.8
1996 survey - range	41-69	7.4-11.0	88-122	4.9-7.5	4.4-5.5

Yield and quality of fruit at harvest

Good yields were obtained in general from this orchard in 2003, especially compared to 2002 when the yields and quality had been abysmal. The highest yield and the best gradeout (% class I) were achieved by the experimental treatment, closely followed by the growers treatment, both of which considerably outperformed the untreated control. Different numbers of fruit per tree were the main reason for the differences in the yield (Table 15). Fruit size was similar on all plots (Table 16). Lower numbers of fruits, especially on the untreated control plots, were probably due to a number of factors including apple blossom weevil damage (most capped blossoms fall from the tree) and scab. The degree of russetting of the fruit from the different treatments was similar (Table 17).

Table 15. Yield and quality of fruit at harvest at site 1 in 2003.

Assessment	Mean		
	Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
Mean total yield (kg/tree)	36.7	36.0	26.4
Mean total yield (t/ha)	26.3	25.8	18.9
Mean no. fruits per tree	272.0	272.4	177.9
% by weight class I	41.8	32.6	29.5
% by weight class II	40.8	40.7	48.1
% by weight juice/outgrade	17.3	26.7	22.4

Table 16. % of fruits in size classes at harvest at site 1 in 2003.

Diameter of fruit at harvest (mm)	Mean % fruits in size class		
	Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
<45	0.0	0.3	0.0
45-50	0.1	0.1	1.9
50-55	0.5	0.9	1.1
55-60	1.3	1.7	2.9
60-65	3.9	4.9	5.3
65-70	9.9	11.5	10.7
70-75	20.2	19.5	17.9
75-80	24.9	24.4	19.0
80-85	21.2	20.0	19.9
85-90	12.4	11.6	14.2
90-95	5.2	4.4	6.1
95-100	0.3	0.7	0.9
>100	0.0	0.0	0.1

Table 17. Severity of russeting on fruit at harvest at site 1 in 2003.

Severity category of russet at harvest	Mean % fruits in category		
	Exp. prog (Red, Treat. A1)	Growers Prog. (Yellow, Treat. A2)	Untreated Control (Green, Treat. A3)
None	25.2	28.8	27.6
Slight	31.1	34.0	41.3
Moderate	27.3	26.1	22.5
Severe	16.4	11.1	8.7

Economic results

As in conventional systems, marketable yield (grade out) and prices received for fruit are some of the key determinants of the economics of organic top fruit production. Although higher prices, with premiums for organic fruit commonly of 100% over conventional ones, mean that overall economic returns can be obtained with lower yield levels.

The good apple growing year resulted in the highest yields and financial returns, since the trial began. Even the control plots achieved yields, which were higher than typical organic ones. The addition of prices tends to magnify the differences between the plot marketable yields. Thus the financial output (Table 18) from the experimental plots at £26,751/ha or 102p/kg of fruit grown, is 13% greater that the financial output from the grower's plots, £23,727/ha or 92p/kg. The cost of sprays (Table 20) from the experimental plots are £755/ha or 3p/kg, as against £298/ha or 1p/kg, from the growers plots. The costs of sprays are small and estimated to be only 5% (experimental plots) of the total costs of production and marketing. The additional costs of sprays of £458 in the experimental plots as against the grower's plots can easily be justified in terms of achieving an increase in financial output of £3024. This means that the pest and disease damage caused on the grower's plots are significant. Once other costs of production are added in, the experimental plots are estimated to achieve a net margin of £12,263/ha (37p/kg) against £10464/ha (£29p/kg) from the grower's plots.

Table 18. Organic apple yields and financial output on three plots at site 1 in 2003.

	Experimental	Growers	Control	Typical organic[2]	Conv.[3]
Total yield (t/ha)	26.3	25.8	18.9	10	25
Marketable yield – class I & II (%)	82.6	73.3	77.6	68	85
Marketable yield-class I & II (t/ha)	21.72	18.91	14.67	6.8	21.25
Processing (%)	17.3	26.7	22.4	32	15
Total financial output [4](£/ha)	26,751	23,727	17,600	8803	13,500
Cost of sprays[1] (£/ha)	756	298	0	247	400
Other costs[5] (£/ha)	13,727	12,965	10,480	6,711	
Net margin (ha)	12,263	10,464	7,758	1,682	

[1] Details in Table 20, conventional spray costs based on Nix Farm Management Handbook
[2] Firth, 1999, Economics of organic fruit production
[3] Based on typical conventional yields of Fiesta, and on marketable fruit being sold for 60p/kg.
[4] Organic Class I and II £1.20/kg and juice £0.15/kg
[5] Includes all other costs of production, marketing and all overhead costs. Updated from Firth 1999

Table 19. Quantities and costs of sprays used per hectare for the two spray treatments at site 1 in 2002.

		Experimental		Growers	
Sprays	Costs £/kg or litre	Quantity	Costs	Quantity	Costs
Sulphur (kg/ha)	0.78	10	7.80	0	0
Wetcol 3 (kg/ha)	3.60	50	180	0	0
Cuprokylt (FT) (l/ha)	3.49	5	17.45	5	17.45
Py insect killer (l/ha)	25	20	500	10	250
Dipel-BT (l/ha)	39.30	1	39.30	0	0
Maxi-crop (l/ha)	3.55	0	0	2.8	9.98
Compost tea (£/ha)	2	8	16	8	16
Total costs[1] (£/ha)			**755**		**297**

[1] This was the costs of materials only. The costs of applying the sprays (tractor plus labour) is likely to be £10/ha per spray application, then total costs would be: growers plots (10 spray rounds) £397/ha, experimental plots (12 spray rounds) £875/ha

Table 20: Average economic results 2000-2003 at site 1

	2000	2001	2002	2003	Average
Untreated					
Total yield	3.8	9.0	0.2	18.9	8
Mkt. Yield (t)	2.47	6.39	0.1	14.67	6
Mkt yield (%)	65	71	48	77.6	65
Juice (%)	31	29	52	22	34
Output (£/ha)	2,725	7,646	115	17,600	7,021
Growers					
Total yield	10.6	13.2	1.5	25.8	13
Mkt. Yield (t)	8.8	8.05	0.58	18.9	9
Mkt yield (%)	83	61	39	73.3	64
Juice (%)	16	39	61	27	36
Output (£/ha)	10,519	9,647	831	23,727	11,181
IPDM					
Total yield	13.6	17.5	10.1	26.3	17
Mkt. Yield (t)	10.34	15.23	6.2	21.7	13
Mkt yield (%)	76	87	61	83	77
Juice (%)	24	13	39	17	23
Output (£/ha)	12,420	18,270	8,016	26,751	16,364

The 2003 season was a very good season for both conventional and organic fruit production and this is reflected in the comparison of three years data from this site. Both marketable yields (21.7t/ha) and financial output (£26,751) were above the four-year rolling average for this site.

Experiment 2 at site 2 in new orchard, Old Wives Lees

Scab at site 2

No scab was found on any of the trees on 2 May 2003 (Table 21). This was only shortly after the first scab infection periods and before the first infection would have become visible. No scab was found on the Topaz, a scab resistant variety. Low levels of scab infection were present on Pinova in July and at harvest. Levels were slightly lower on the plots that had been sprayed but differences were too small to be statistically significant. Pinova appears to be a scab susceptible variety and there is a risk that more severe fruit infection could occur in year s where there is a higher scab risk. The only obvious way to counter this threat is to apply more early season copper sprays, as intended for the IPM experiment at site 1.

Table21. Mean percentage infection with scab at site 2 in 2003

Date (2003)	Growth stage	Assessment	Mean % scab infection			
			Exp. prog		Untreated Control	
			Topaz	Pinova	Topaz	Pinova
2 May	Blossom	No./10 trees	0	0	0	0
17 July	Fruitlet	Mean score shoots on 10 trees	0	28	0	32
25 Sep	Harvest	% no. fruits scab	0	1.8	0	4.6
10 Oct	Pre-leaf fall	% leaves infected	2	93	12	95

Mildew at site 2

As expected, the incidence of primary mildew infection per 10 trees was much higher at this site than at site 1 (Oakwood farm) (Table 22). East Kent is a higher risk mildew area. There was a higher incidence of primary mildew on the untreated plots than the sprayed plots. Secondary mildew rose sharply during the growing season with a higher incidence on Pinova than Topaz. There was also more secondary mildew on the untreated than the treated plots indicating the sulphur sprays had some effect. Severe russet at harvest may have been partly due to mildew but was also probably due to other factors such as rust mite and weather conditions. In order to control mildew, a programme of sulphur sprays will be needed post blossom.

Table 22. Mean percentage infection with mildew at site 2 in 2003

Date (2003)	Growth stage	Assessment	Mean			
			Exp. prog		Untreated Control	
			Topaz	Pinova	Topaz	Pinova
2 May	Blossom	1˚ / 10 trees	0.7	1.7	6.6	2.7
17 June	Fruitlet	2˚ % leaves	14.5	50.5	21.0	67.5
23 July	Fruitlet	2˚ % leaves	55	77	75	98
25 Sep	Harvest	% fruits severe russet	12.1	10.6	8.2	26.9

Sooty blotch at site 2
The incidence of sooty blotch infection on fruits at harvest was very low. There were no obvious variety treatment effects though the incidence was marginally greater on the untreated Pinova plots (Table 23). The young open trees and better air circulation make this orchard less favourable for sooty blotch than the orchard at site 1.

Table 23. Mean percentage fruits infected with sooty blotch at site 2 on 25 September 2003

Date (2003)	Growth stage	Assessment	Mean % fruits infected with sooty blotch			
			Exp. prog		Untreated Control	
			Topaz	Pinova	Topaz	Pinova
25 Sep	Harvest	Fruits	0.8	1.6	0.6	4.3

Rosy apple aphid at site 2
2003 was a low risk year for rosy apple aphid generally. A small but significant proportion of trees of both varieties became severely infested with rosy apple aphid in spring (Table 24). These were erratically distributed and were more prevalent in the north western part of the orchard. Topaz was worse affected than Pinova and is a highly susceptible variety to this pest. No autumn treatments have been applied and the high numbers of autumn migrants present in autumn 2003 indicate a high risk of rosy apple aphid infestation in spring 2004. Pre-emptive early sprays of pyrethrum should be considered.

Table 24. Mean percentage infection with rosy apple aphid at site 2 in 2003

Date (2002)	Growth stage	Assessment	Mean % rosy apple aphid infestation or damage			
			Exp. prog		Untreated Control	
			Topaz	Pinova	Topaz	Pinova
2 May	Blossom	Trees/10	2.7	0	0	3
17 July	Fruitlet	Mean score/10 trees	9.0	2.7	4.7	0

Yields and quality
There were so few fruits present in 2003 that no yield records were taken other than a count of the average number of apples per tree (Table 25).

Table 25. Mean number of fruits harvested per tree at site 2 on 25 September 2003

Date (2003)	Growth stage	Assessment	Mean number of fruits per tree			
			Exp. prog		Untreated Control	
			Topaz	Pinova	Topaz	Pinova
25 Sep	Harvest	Fruits	7.5	11.4	6.3	6.5

Nutrition and weed control at site 2
As in the orchard at Robertsbridge (site 1), leaf N levels were marginal to deficient (Table 26) at or below the 2.0 % dry weight threshold. Fruit N levels were low for the variety Topaz (Table 27). Attempts were made to control the competition from ground herbage by use of a flame weeder (manufactured by N Seymour). However, the grass sward was thick and caught fire causing some limited tree damage and the attempt was abandoned. If flame weeding is to be used to control competition from ground herbage, it is important that is done starting from the bare soil situation, e.g. at planting and that the soil surface under the trees is maintained continually free from weeds by regular flame weeding.

Table 26. Levels of nutrients in leaf samples taken in August 2003 at site 2.

	% dry weight				
Variety	**N**	**P**	**K**	**Ca**	**Mg**
Pinova	2.02	0.32	1.78	1.02	0.19
Topaz	1.70	0.37	1.80	0.84	0.15
	Parts per million				
Variety	**Mn**	**Na**	**Zn**	**Cu**	**Bor**
Pinova	82.0	<0.02	17.8	8.2	22.8
Topaz	117	0.04	22.5	7.49	20.7

Table 27. Levels of nutrients in fruit samples at harvest on 30 September 2003 at site 2.

Variety	**Mean fresh Weight (g)**	**Milligrams per 100 grams**				
		N	**P**	**K**	**Ca**	**Mg**
Pinova	100.8	51	15.4	157	6.15	5.42
Topaz	120.3	35	11.4	137	6.65	4.76

Economic results at site 2

Income: Since this orchard was only replanted in 2002, there was insufficient yield of fruit to sell in 2003, so no income was gained.

Costs: The only costs incurred in this young orchard were for sprays (in treated plots) and weed control. Sprays were used to boost nutrition, and control pests and diseases with material costs at £ 77/ha (Table 29). Weed control is an important issue in a young orchard. The owner purchased a flame burner and this was used to control weeds and grasses in a strip either side of the tree. It was not used early in the season (July), and therefore was less effective and when it was used it had a lot of sward to burn, which then caught fire. The costs were estimated at £124/ha per pass. If it had been used at the beginning of the season and for 6 times during the growing season then the cost is estimated at £745/ha (Table 28).

Table 28: Costs incurred at site 2 in 2003

Description	Unit cost (£)	Costs (ha)
Flame weeding:		
Gas- 6.25 bottles per ha	£12	75.00
Depreciation on burner £2000/7 yrs less 20% trade in, used on this orchard 6 times/year		29.76
Tractor and operator, takes 1.23 hrs/ha	15.80/hr	19.00
Costs per ha per pass		124
Total costs in 2003 –6 passes (£/ha)		**745**

Table 29. Quantities and costs of sprays used per hectare for the spray treatments at site 2 in 2003.

		Experimental	
Sprays	**Costs/kg/litre**	**Quantity**	**Costs (£/ha)**
Sulphur 80% FL	0.78	35	27.30
Cuprockylt FL	3.49	5	17.45
Nugro	3.65	3	10.95
Maxicrop	3.55	6	21.30
Total costs[1] (£/ha)			**77.00**

[1] This was the costs of materials only. The costs of applying the sprays (tractor plus labour) is likely to be £10/ha per spray application, then total costs would be: (6 spray rounds) experimental plots £137/ha.

Leaf rotting experiment

Leaf rotting was very rapid, even on the untreated, such that on most treatments most of the leaves had disappeared by the first assessment in late January (Table 30). Liquid Vinasse and Nugro at the high rate appeared to delay rotting. By the second assessment in late February most of the leaves had disappeared and there were no differences between treatments. Leaf rotting was too rapid in this experiment to distinguish treatment effects.

Table 30. Percentage leaves remaining following treatment with various chemicals in the leaf rotting experiment Oakwood Farm in winter 2002/03

Treatment		**23 Jan 2003**	**28 Feb 2003**
1	Untreated	1.3	0.1
2	Urea (5%)	0.3	0
3	Nu-gro (high rate)	14.6	1.6
4	Nu-gro + Digester	1.9	0
5	Digester	3.6	0
6	Sea Vigour Fish Oil	4.0	0.2
7	Sea Vigour Fish Oil (high rate)	5.5	0.4
8	Liquid Vinasse	9.1	1.9
9	Compost tea	2.5	0.1

Leaves treated and laid out in the orchard in December 2002. Percentage of leaves remaining assessed after one and two months

Sooty blotch experiment

Monitoring of fruits in an adjacent Fiesta orchard indicated that the sooty blotch first appeared on fruit in late July 2003. Therefore sooty blotch was already present before the first spray was applied. At harvest on 24 September 2003the incidence of sooty blotch on a sample of 50-100 fruit per plot was assessed as slight, moderate, severe. By harvest up to 80% of fruit were infested by sooty blotch (Table 31). The lowest infestation of sooty blotch occurred on trees left untreated or sprayed with low rate Cuprokylt.

Table 31. Incidence of sooty blotch on fruit at harvest on 24 September 2003 in the sooty blotch trial in the Jonagold orchard at Oakwood farm

Product	% fruit with sooty blotch	% fruit with severe sooty blotch
1. Untreated	67.3	10.2
2. Cuprokylt	74.8	11.0
3. Sulphur	86.3	22.8
4. Surround	83.1	23.3
5. Crop Life + calcium carbonate	81.5	14.4

As the first spray wasn't applied until after sooty blotch infection came in, this may explain why none of the treatments were effective but not why the lowest infection was present on the untreated. Spraying aqueous sprayate to the trees may have even benefited the sooty blotch in the hot, dry conditions that prevailed. It was obvious that the sooty blotch was developing very successfully under the kaolin treatment. This treatment will not be tried again because the trees and the fruit were whitened by the treatment and it was impossible to remove the deposit making the apples unsaleable. Moreover, the apples were unpleasant too harvest the deposit coming off on the pickers hands and causing nasal irritation.

CONCLUSIONS (OBJECTIVE 1, YEAR 4)

Experiment in the established organic orchard of the disease susceptible variety Fiesta at Robertsbridge (site 1)

- These results indicate that two early copper sprays are more effective for scab than a single treatment. Copper should be applied early before bud burst.
- High levels of scab in autumn 2003 pose a high risk of scab in 2004 if overwintered leaf litter does not disappear before the first infection periods
- Sulphur sprays to reduced mildew significantly. However, it would have been preferable if a greater number of mildew sprays had been applied. This indicates that sulphur sprays should be continued until the end of extension growth.
- Sooty blotch remains a significant problem in this orchard. Improving air circulation and removing sources of infection in adjacent hedgerows are possible cultural control measures that could be used where practicable. No effective control measures for this disease have yet been identified (see below).
- Apple blossom weevil remains the most important pest causing significant yield loss by capping blossoms and reducing fruit numbers per tree at harvest. 2003 results corroborate previous years findings that early pyrethrum treatment gives partial control of the adults weevils and showed that two sprays were better than one.
- Early caterpillar feeding continues to cause significant losses in quality with up to 10% of fruits damaged at harvest. Bud burst treatments with pyrethrum and early season sprays of *Bacillus thuringiensis* made little difference to levels of damage at harvest.
- Codling moth caused very little damage despite moderate pheromone trap catches and no control measures.

- N deficiency remains a problem in the orchard despite annual spring applications of organic N fertiliser. Removal of competition from ground herbage would be the best way of correcting this deficiency.
- Much higher yields were obtained 2003 compared to 2002 when the yields and quality had been abysmal. The highest yield (26.3 t/ha) and the best gradeout (41.8% class I) were achieved by the experimental treatment, closely followed by the growers treatment, both of which considerably outperformed the untreated control (18.9 t/ha and 29.5% class I). Different numbers of fruit per tree were the main reason for the differences in the yield.The good apple growing year resulted in the highest yields and financial returns, since the trial began. Even the control plots achieved yields, which were higher than typical organic ones. The financial output from the experimental plots was £26,751/ha or 102p/kg of fruit grown, 13% greater that the financial output from the grower's plots, £23,727/ha or 92p/kg. The cost of sprays from the experimental plots was £755/ha or 3p/kg, as against £298/ha or 1p/kg, from the growers plots. The costs of sprays were small and estimated to be only 5% (experimental plots) of the total costs of production and marketing. The additional costs of sprays of £458 in the experimental plots as against the grower's plots can easily be justified in terms of achieving an increase in financial output of £3024. This means that the pest and disease damage caused on the grower's plots are significant. Once other costs of production are added in, the experimental plots are estimated to achieve a net margin of £12,263/ha (37p/kg) against £10464/ha (£29p/kg) from the grower's plots.

Newly planted orchard of less disease susceptible varieties (site 2, East Kent)

- No scab was found on the Topaz, a scab resistant variety. Pinova was found to be a scab susceptible variety and there is a risk that more severe fruit infection could occur in years where there is a higher scab risk. The only obvious way to counter this threat is to apply more early season copper sprays
- Scab levels were slightly lower on the plots that had been sprayed but differences were small..
- The incidence of primary mildew infection was much greater as East Kent is a higher risk mildew area. There was a higher incidence of primary mildew on the untreated plots than the plots that received two early sulphur sprays. Secondary mildew rose sharply during the growing season with a higher incidence on Pinova than Topaz. There was also more secondary mildew on the untreated than the treated plots indicating the sulphur sprays had some effect.
- In order to control mildew in this orchard, a programme of sulphur sprays will be needed post blossom.
- The incidence of sooty blotch infection on fruits at harvest was very low. The young open trees and better air circulation make this orchard less favourable for sooty blotch than the orchard at site 1.
- 2003 was a low risk year for rosy apple aphid generally but a small but significant proportion of trees of both varieties became severely infested with rosy apple aphid in spring. Topaz was worse affected than Pinova and is a highly susceptible variety to this pest. High numbers of migrants in autumn 2003 indicate a high risk in spring 2004. Pre-emptive early sprays of pyrethrum should be considered.
- Leaf N levels were marginal to deficient and fruit N levels were low for the variety Topaz. Attempts were made to control the competition from ground herbage by use of a flame weeder but the grass sward was thick and caught fire. Flame weeding is a promising

method but it is important that it is done starting from the bare soil situation and continued regularly.

- There was insufficient yield of fruit to sell in 2003, so no income was gained. The only costs incurred in this young orchard were for sprays and weed control at £ 77/ha. A flame burner was used to control weeds and grasses in a strip either side of the tree. The costs were estimated at £124/ha per pass. If it had been used at the beginning of the season and for 6 times during the growing season then the cost is estimated at £745/ha.

Leaf rotting experiment

An experiment testing alternatives to urea for post harvest treatment to encourage leaf rotting gave no useful results as leaf rotting was too rapid in this experiment to distinguish treatment effects.

Sooty blotch experiment

Programmes of sprays of copper oxychloride, sulphur, kaolin or extract of coconut + citrus (Crop Life)+calcium carbonate applied on 4 occasions from late July to September using a mist blower at 1000 litres per hectare failed to control sooty blotch (*Gloeodes pomigena*). The kaolin treatment whitened the trees and left an unsightly deposit on the fruits at harvest.

ACTIONS FOR 2004 (OBJECTIVE 1)

Experiment 1 at site 1 in existing orchard, Robertsbridge

In 2004, it is proposed that the following are investigated

1. Whether 3 early season sprays of copper, 1 pre and 2 post bud burst improve scab control
2. Whether 3 early applications of pyrethrum give improved control of apple blossom weevil adults.
3. To continue to examine the benefits of foliar sprays of composted tea
4. To determine whether the nutritional status of the orchard continues to improve.

The treatment programme given in Table 32 is suggested. The untreated (green) plots are to be relocated.

Table 32. Treatment programme at site 1 for 2004.

Growth stage	Experimental (red) plots Sprays at 1000 l/ha		Growers (yellow) plots Sprays at 375 l/ha	
	Product	**Dose/ha**	**Product**	**Dose/ha**
Applications to individual plots according to treatment				
Pre-bud burst	Cuprokylt FL	5.0 litres	Cuprokylt	5.0 litres
Bud-burst	Wetcol 3 Py Insect Killer	50 litres 10 litres (separate spray)	- Py Insect Killer	 3.75 litres
Mouse ear	Wetcol 3 Py Insect Killer	50 litres 10 litres (separate spray)	-	
Green cluster	Dipel DF	1 kg	-	
Pink bud	Dipel DF	1 kg	-	
Just before blossom	Sulphur 80% SG	11.3 kg		
Petal fall	Sulphur 80% SG	11.3 kg		
June- August	Dipel DF* Sulphur 80% SG‡	1 kg (2 sprays at 10-14 day interval)* 14-21 day prog at 11.3 kg‡		
Leaf fall	Cuprokylt FL	5.0 litre	Cuprokylt FL	5.0 litre
Overall applications to whole orchard				
March 2004	Mow whole area and adjacent Jonagold and Fiesta orchards to destroy overwintering leaf litter			
April 2004	Apply Lawes high N at 1.0 tonnes/ha in rows under trees			
Extension growth	Apply 14 day programme of undiluted compost tea throughout fruit development			

*2 sprays at 10-14 day interval 10 days after threshold tortrix pheromone trap catches
‡ apply a programme of sprays of sulphur for mildew at 2-3 week intervals. Adjust dose and interval as advised by Angela Berrie

Experiment 2 at site 2 in new orchard, Old Wives Lees

It is proposed that the following treatments (Table 33) are applied to the treated plots in 2004 and that the performance of the two varieties is compared on treated and untreated plots:

Table 33. Treatments at site 2 in 2004

Growth stage	Product(s) applied	Dose rate (product/ ha)	Spray volume (litres/ha)
Pre-bud burst	Cuprokylt FL	5.0 l	1000
Bud-burst	Sulphur 80% FL Maxi Crop O Wetcol 3 Py Insect Killer*	10.0 l 2.0 l 50 litres 10 l	1000 1000
Green cluster	Sulphur 80% FL Maxi Crop O Wetcol 3 Py Insect Killer*	10.0 l 2.0 l 50 litres 10 l	1000 1000
Petal fall	Sulphur 80% FL Maxi Crop O	10.0 l 2.0 l	1000
June	Dipel DF*	1 kg (2-3 sprays at 10 day interval)*	1000
14 day programme of sprays from June- August			
Fruitlet	Sinclair Nugro Sulphur 80% FL	3.0 5.0 l	1000

* as a separate spray

Leaf rotting experiment

A further experiment is in progress at two sites, the organic Fiesta orchard at Oakwood farm and in the organic cider planting VF220 at HRI-East Malling, during winter 2003/04. Treatments applied to Fiesta leaves from Oakwood farm for the Oakwood site and from an East Malling organic Fiesta orchard at the East Malling site, are given in Table 34.

Table 34. Treatments that have been applied in the leaf rotting experiment at site 1 in winter 2003/04

Treatment	Product	Concentration (amount/litre)
1	Untreated	-
2	Urea (5%)	50 g
3	Nu-gro	50 ml
4	Sea Vigour Fish Oil	200 ml
5	Bacterial compost tea	undiluted
6	Fungal compost tea	undiluted

Sooty blotch experiment

A further sooty blotch control experiment will be done in 2004. Proposed treatments are shown in Table 35.

Table 35. Treatments to be applied in the sooty blotch experiment in 2004

Treatment	Product	Concentration (amount/litre)
1	Untreated	-
2	Potassium bicarbonate	
3	Crop Life (Coconut oil)	
4	MR formulation (Methionine riboflavin?)	
5	Water only control	

Objective 2. To identify 4-6 varieties of apple of low susceptibility to diseases that have high fruit quality, a range of seasons (storage potentials) and markets (dessert, culinary, processing) and are suitable for organic production:

INTRODUCTION (OBJECTIVE 2, YEAR 4)

Following the ongoing work in 2002 to identify suitable apple varieties for organic production in which apple varieties sourced from the UK were evaluated (see results, year 3, objectives 2.15 & 2.18), further work during 2003 included the assessment of foreign apple varieties and further evaluation of the most promising varieties. Taste-test assessments using panels of fruit technologists were carried out at Sainsbury's and Waitrose on fresh fruit samples harvested from August – November. A meeting was held at the end of the year to review the varieties in detail and make a final short-list of 11 varieties (including, dessert, culinary and juicing varieties) to be put forward for final assessment during 2004. The organic variety trial, established during 2002, continued to be monitored for pests and diseases and a preliminary assessment of agronomic performance was also undertaken. This consisted of measuring shoot growth during winter together with assessments of overall habit and tree precocity (speed of bearing and fruit numbers) during the summer. Having carried out basic air storage tests during 2002, preliminary assessments on the performance of promising apple varieties in CA storage for 6 months were undertaken using fruit harvested in 2003.

The work plan for 2003 consisted of the following objectives (years 3-5):

2.12 Continue to spray three blocks of the variety trial (VF216) with sulphur
2.16 Assess pest and disease levels on VF216 in June and at harvest
2.17 Assess agronomic performance of varieties
2.18 Conduct taste and processing tests
2.19 Conduct preliminary storage tests

MATERIALS AND METHODS (OBJECTIVE 2, YEAR 4)

2.12 Spray half the replicated trial of apple varieties with sulphur
Sulphur (Headland) was applied to blocks I, IV & V of variety trial VF216 from March – August, 2003 (see Table 36 below). Compost was also applied to the crop rows during March. A single spray of Bactura (*Bacillus thuringiensis*) was applied to the whole site in May to control moth pests.

Table 36. Applications to VF216

Product	Application date	Rate	Water
Lawes Compost	31.3.03	250K	
Sulphur	24.3.03	5L	500L
Sulphur	09.4.03	5L	500L
Sulphur	24.4.03	5L	500L
Sulphur	09.5.03	5L	500L
Bactura (*BT*)	22.5.03	0.75L	1000L
Sulphur	22.5.03	5L	500L
Sulphur	02.6.03	5L	500L
Sulphur	23.6.03	5L	500L
Sulphur	03.7.03	5L	500L
Sulphur	11.7.03	5L	500L
Sulphur	25.7.03	5L	500L
Sulphur	04.8.03	5L	500L

2.16 Assess pest and disease levels in June and at harvest

Jerry Cross and Stella Cubison carried out an assessment of pests and diseases on 18th June 2003. Each tree was examined for signs of rosy apple aphid and green apple aphid. One shoot on each tree was examined for symptoms of primary mildew and leaf scab. Each tree received a score for every aphid infestation found. Symptoms of mildew and scab were scored by severity (0=none, 1=slight, 2=moderate, 3 = bad, 4=severe). Some of the weaker varieties continued to grow poorly with little vegetative growth, which made assessment difficult. Several varieties had also been re-grafted owing to losses through canker or failure to establish. Aphid infestations were apparent on some varieties and most varieties showed symptoms of mildew (see results section). No scab was found on any of the varieties during June but leaf samples of each variety were collected on 21st October for late-season scab assessment. Due to the relatively low incidence of pests and diseases, it was agreed that a further assessment at harvest would not be necessary.

2.17 Assess agronomic performance of varieties

Shoot growth records were taken by Jane Spencer at the end of December 2002. Measurements were taken (in decimetres) of the current season's growth for each of three trees per plot in every block. The total amount of new growth from each variety (per plot) was then divided by the number of shoots assessed, giving a mean shoot growth value per plot. Values from each plot were then totalled from all 6 blocks to give an overall value for shoot growth per variety. The results are presented in table 4. (Shoot growth measurements have also now been taken for winter 2003-2004, but data is still being analysed).

Stella Cubison carried out an assessment of tree precocity on 20th August 2003. Notes on tree form and habit were also taken. Scores were allocated per plot for precocity (0 = no fruit, 2 = 1-10 fruits, 3 = > 10 fruits). The score from each plot, (per block), was then totalled up for the whole orchard (x6 blocks). Some of the trees had been hand thinned during June to improve fruit size. Records of aphid infestations per tree were also taken, but were not found to be significantly different from those assessed during June.

2.18 Conduct taste and processing tests

The evaluation of promising apple varieties continued at the Sainsbury's Centre during 2003. Waitrose also agreed to receive fruit for assessment. It was agreed that there were still too many potential varieties for large-scale taste testing at the Sainsbury's Centre, but that screening would continue on a smaller scale until a short list of 10 varieties could be selected at the end of the year. This also allowed adequate numbers of fruits to be available for storage trials (see objective 2.19).

The main objective of the apple evaluations for 2003 was to assess those varieties not evaluated during 2002. These included varieties sourced from abroad (Rebella, Ariwa, D3, Resi and Rubinstep) and the early season varieties Discovery and Worcester Pearmain. In addition to this, most of the other varieties on the original short-list of 27 were also once again evaluated or reviewed, with the view to selecting the best 10 for final large-scale assessment in 2004.

A limited quantity of fruit from most varieties on the trial plot VF216 was available for assessment during 2003. Fruit was also obtained from the National Fruit Collections (Brogdale), Poultry Farm (Marden), Rocks Farm (East Malling) and existing plots at East Malling. Several varieties were obtained from overseas. These included D3 (from Poland), DL11 (from France) and Rubinstep (from Czech Republic). There were sufficient fruits of varieties Ariwa, Resi and Rebella from trees on VF216, so it was not necessary to obtain these varieties from abroad, as had originally been planned.

Fruit samples (20+ fruits of each variety) were supplied to Sainsbury's and Waitrose from August – October. Following harvest, the apples were packed and sent via courier in batches of 2-4 varieties. It was occasionally necessary to hold fruit in storage at 1°C for a short time to await a convenient date for assessment.

Table 37. Dessert apple varieties supplied for taste test assessment at Sainsbury's and Waitrose during 2003.

Early season	Mid season	Mid-late season	Late season
Ceeval	DL11	Ariwa	D3 (Free Redstar)
Discovery	Rajka	Pinova	Delorina
Worcester	Rebella	Red Falstaff	Florina
Pearmain	Resi	Santana	Liberty
	Rubinstep		
	Rubinola		

NB – Owing to constraints with fruit numbers, some varieties were only assessed by one supermarket evaluation panel.

Taste test assessments were carried out on each variety using the profile testing format as described in year 3 report (2002-3), objective 2, materials and methods, section 2.18. Varieties were scored for texture qualities, (firmness, juiciness, crispness, toughness, flouriness), taste (sweetness and acidity) and physical attributes (shape and colour). Each variety also received an overall ranking for acceptability.

A variety review meeting was held on 7th November 2003 to review the evaluations and discuss each variety in detail. The meeting was attended by supermarket representatives

involved in the taste testing and staff from HRI East Malling and HDRA. In addition to those varieties evaluated during the year (as listed in table 2 above), the panel also had the opportunity to sample and discuss any remaining dessert varieties from the original short-list, together with the culinary varieties Edward VII, Encore, Howgate Wonder and Pikant, to review their suitability for fresh sales. At the end of the meeting, the decision was taken to eliminate at least half of the dessert apple varieties from the short-list. The decisions were based on visual appearance and internal fruit quality (i.e likely acceptability by consumers), also taking into account the performance of each variety in taste test evaluations during previous years. The remaining 11 most promising varieties will be put forward for final large-scale taste test assessment in 2004, subject to agreement by the consortium.

2.19 Conduct preliminary storage tests

Following the preliminary air storage trials last year, a basic CA storage trial was set up using fruit harvested during 2003 to observe the behaviour of each variety in controlled atmosphere conditions. Where sufficient fruit numbers were available, varieties were sorted into crates and stored in a low oxygen regime at (<1% CO2 + 2%O2) at 1.5-2°C. Assessments of fruit firmness, diameter, weight and sugar content (% soluble solids) and background colour were carried out at 2, 4 and 6 month intervals on a sample of 5 fruits of each variety. Any signs of physical deterioration or adverse reaction to cold temperatures / low oxygen were also recorded.

RESULTS (OBJECTIVE 2, YEAR 4)

2.16 Assess pest and disease levels on VF216 in June and at harvest

Results of the assessment carried out on 18th June are presented in Table 38 below:

Table 38. Incidence of rosy apple aphid, green apple aphid and secondary mildew on VF216 on 18th June 2003

Variety	Mean % trees rosy apple aphid	Mean % leaves green apple aphid	Mean % of leaves with mildew (ANOVA)					
			%			$Log_{10}(\%+1)$		
			Sulp	None	Mean	Sulp	None	Mean
Ariwa	33.3	0.0	7.8	32.2	**20.0**	0.7	1.1	**0.87**
Bohemia	16.7	19.4	0.0	44.4	**22.2**	0.0	1.6	**0.82**
Ceeval	22.2	5.6	17.2	18.9	**18.1**	0.8	1.3	**1.06**
D3	30.6	0.0	4.4	47.8	**26.1**	0.6	1.4	**1.00**
Delorina	0.0	5.6	5.6	25.6	**15.6**	0.6	1.0	**0.78**
Discovery	55.6	16.7	27.2	75.6	**51.4**	1.3	1.7	**1.51**
DL11	11.1	19.4	6.1	16.0	**11.1**	0.8	1.2	**1.00**
Ecolette	50.0	11.1	5.6	32.2	**18.9**	0.4	1.4	**0.91**
Edward VII	5.6	0.0	5.6	56.7	**31.1**	0.4	1.7	**1.05**
Encore	0.0	27.8	24.4	46.7	**35.6**	1.3	1.5	**1.39**
Florina	22.2	8.3	14.4	46.1	**30.3**	0.9	1.4	**1.17**
Goldrush	0.0	0.0	10.6	50.0	**30.3**	0.8	1.7	**1.26**
Howgate W.	50.0	33.3	18.3	71.7	**45.0**	0.9	1.7	**1.29**
Judeline	5.6	11.1	13.9	17.8	**15.8**	1.1	0.8	**0.93**
Liberty	0.0	0.0	4.4	38.9	**21.7**	0.6	1.6	**1.09**
Pikant	22.2	0.0	21.7	61.1	**41.4**	0.9	1.5	**1.16**
Pilot	27.8	27.8	15.6	22.2	**18.9**	1.1	1.2	**1.17**
Pinova	16.7	16.7	7.8	37.2	**22.5**	0.5	1.5	**0.96**
Rajka	27.8	0.0	8.9	39.0	**23.9**	0.7	1.6	**1.17**
Rebella	33.3	0.0	15.6	64.4	**40.0**	1.1	1.7	**1.44**
Red Falstaff	44.4	0.0	8.9	33.3	**21.1**	0.9	1.5	**1.20**
Red Falstff (g)	0.0	0.0	6.1	45.0	**25.6**	0.6	1.6	**1.08**
Resi	16.7	5.6	5.0	23.3	**14.2**	0.6	1.0	**0.82**
Rubinola	8.3	0.0	59.4	10.0	**34.7**	1.2	0.8	**1.00**
Rubinstep	58.3	0.0	24.4	11.7	**18.1**	1.3	0.8	**1.08**
Santana	11.1	5.6	10.0	11.1	**10.6**	0.8	1.0	**0.89**
Topaz	16.7	16.7	25.6	11.7	**18.6**	1.0	0.5	**0.74**
Worcester P.	27.8	11.1	34.4	15.6	**25.0**	1.1	1.0	**1.01**
Mean			**14.6**	**35.9**	**25.3**	**0.82**	**1.31**	**1.07**
f. probability n.s = not significant * significant at 5%						variety = 0.87 n.s sulphur = 0.049 * sulphur.variety = 0.21n.s		

Although the planting is still relatively young, subtle differences in varietal sensitivity to pests and disease are beginning to emerge. Varieties that appeared to be most prone to rosy apple aphid were Rubinstep, Discovery, Ecolette, Howgate Wonder and Red Falstaff (Mean % = >40). Varieties most prone to green apple aphid included Howgate Wonder, Encore and Pilot (Mean % = >25), although these data have not been statistically analysed. No early season scab infections were found on any of the varieties assessed in June. (Pinova was the only variety to show symptoms during 2002). There was a significant overall effect of sulphur in reducing mildew but differences in the incidence of mildew among cultivars were not significant statistically. Varieties most prone to mildew appeared to be Discovery, Howgate Wonder, Pikant and Rebella.

2.17 Assess agronomic performance of varieties

Table 39. Shoot growth measurements taken winter 2002-03 and precocity (no. of fruits produced the following summer) of apple varieties on VF216

Variety	Total of mean shoot growth (dms) December 2002	Rank	Precocity August 2003 (total score)	Rank	Notes on tree form & habit (August 2003)
Ariwa	86.6	1	16*	1	Very spreading, well branched
Bohemia	62.9	10	4	22	Upright habit, rather spindly
Ceeval	51.1	20	6	17	Upright – slightly spreading
D3	48.7	24	6	17	Upright spreading – sturdy
Delorina	80.9	3	13*	7	Spreading – well branched
Discovery	45.9	26	5	19	Upright, weakly spreading
DL11	68.7	6	0	28	Upright, slightly spreading,
Ecolette	53.3	16	9	13	Spreading, well branched
Edward VII	56.3	13	8	15	Upright, cup-shaped, sturdy
Encore	68	7	1	26	Upright, compact, narrow angles
Florina	72.6	4	10	10	Upright-spreading, good form
Goldrush	63.9	9	12	8	Spreading, very well branched
Howgate W.	51.4	19	4	22	Upright, compact and sturdy
Judeline	82.5	2	2	25	Upright spreading, good growth
Liberty	53.5	14	12	8	Spreading, good growth
Pikant	46.4	25	10	10	Upright – weakly spreading
Pilot	49	23	15	4	Spreading, well branched
Pinova	62.6	11	16	3	Upright spreading, good f'work
Rajka	51.5	18	5	19	Upright, compact, narrow angles
Rebella	43	27	15*	4	Upright spreading, well branched
Red Falstaff	26	28	17	1	Spreading, very well branched
Red Falstaff (g)	64.5	8	1	26	(only recently grafted)
Resi	51	21	14*	6	Spreading, very well branched
Rubinola	53.4	15	4	22	Spreading, rather spindly
Rubinstep	49.5	22	10	10	Upright, strong framework
Santana	53.1	17	9	13	Upright-spreading, good form
Topaz	58.5	12	5	19	Upright, rather compact
Worcester P.	72.4	5	8	15	Upright spreading, sturdy

* Trees hand-thinned in July to improve fruit size. (g) = grafted in 2002.

It can be seen from the results in Table 4. that the most vigorous varieties in terms of shoot growth during 2002 were Ariwa, Judeline, Delorina, Florina and Worcester Pearmain (ranked 1-5). These varieties also appear to have a good spreading habit and have established a good branch framework early on. With the exception of Worcester Pearmain, which is partially tip-bearing, all varieties assessed appear to be spur bearing in habit. Despite being grafted one year later than other varieties, Judeline and Red Falstaff (g) appear to have made extremely good growth. Data from shoo-growth records taken during winter 2003-2004 is still being analysed.

Preliminary observations on variety form and habit have shown that most varieties are upright-spreading. Records of fruiting precocity, taken during the summer, have also revealed some interesting results. The varieties Ariwa, Red Falstaff, Pinova, Pilot, Rebella and Delorina appear to be the earliest to bear fruit (ranked 1-7). Hand-thinning was required for the varieties Ariwa, Delorina, Rebella and Resi. It should be noted, however, that these are preliminary observations from a plantation that has only recently been established. At this stage, it would be premature to reach firm conclusions on tree habit and precocity since quality of grafting material used in tree propagation will still greatly influence variety performance at this stage. During the extremely hot weather of summer 2003, it was noted that the varieties Pinova, Rajka, Red Falstaff and Resi showed signs of drought stress, whilst other varieties appeared to be less affected.

Pollination and floral precocity

Assessment of floral precocity and pollination requirements will be undertaken in spring 2004 on the final short-listed 10+ varieties, owing to the extent of work involved. At this stage, it may only be feasible to attempt basic pollination assessments (e.g. using standard *Malus* varieties as pollinators to determine compatibility). Although some basic details on pollination requirements have been gained for some of the short-listed varieties, it will also be necessary to determine if any are triploid cultivars. Although some records on flowering periods have already been taken, it will be necessary to assess flowering dates, since varieties which flower particularly early / late may prove difficult to pollinate.

2.18 Conduct taste and processing tests

Dessert apple varieties

The results from taste panel assessments of dessert apple varieties at the Sainsbury's Centre and at Waitrose are given in the following pages, together with general comments and observations on each variety made during the review meeting on 7th November. Average ratings are given for attributes relating to texture, taste and appearance on a scale of 1-4, (1=lowest – 4 = highest score achievable), using the same format as described in Report 3, section 2.18, materials and methods. Graphs showing the spread of opinion rating 'overall acceptability' of each variety are also included.

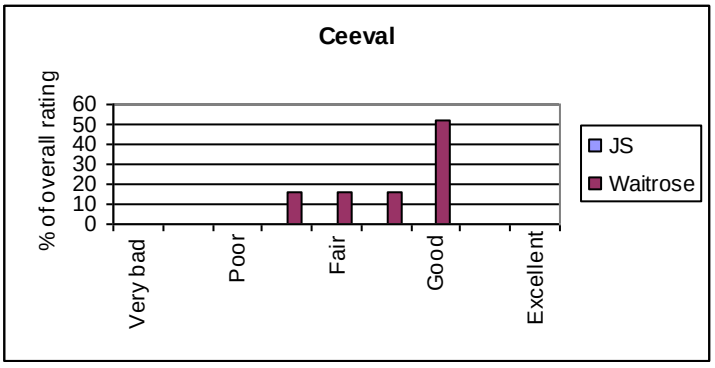
Apple variety evaluation results 2003

Early season varieties

Discovery

Evaluated by Sainsbury's (results not supplied). Although conventional plantings are being reduced, Discovery is an easy variety to grow organically (scab resistant) and consumers anticipate its arrival in stores. The picking date is critical (mixed maturity) and the trees are best picked over several times. It remains on the short-list.

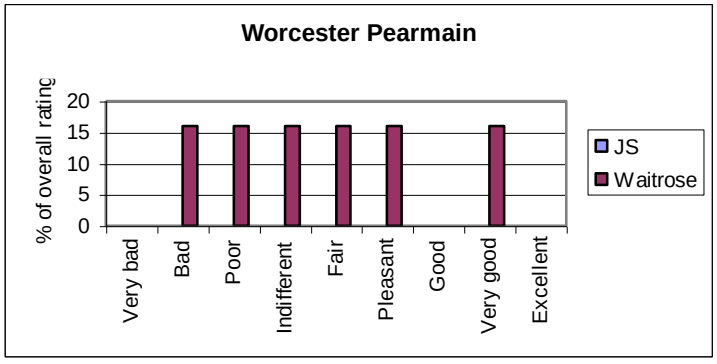
Ceeval



Firmness:	3.8
Juiciness:	3.4
Crispness:	3.5
Toughness:	2.6
Mealiness:	1.5
Sweetness:	2.5
Acidity:	2.5
Shape:	3.5
Colour:	3.3

Evaluated by Waitrose, Ceeval was rated relatively highly. At best, apples are well flavoured, crisp and juicy. There was some concern over mixed fruit maturity (like Discovery) and several pick-overs may be needed to achieve optimum fruit quality. (The season is very short and picking date is critical). It remains on the short-list.

Worcester Pearmain

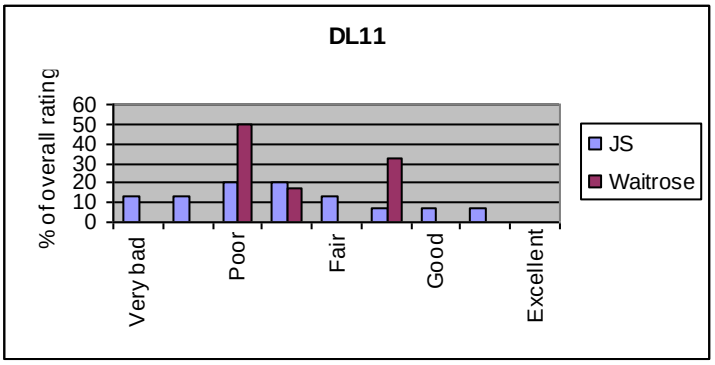


Firmness:	2
Juiciness:	2
Crispness:	2
Toughness:	1.7
Mealiness:	1.6
Sweetness:	2.6
Acidity:	1.2
Shape:	3.7
Colour:	4

Evaluated by Waitrose, Worcester Pearmain has now been eliminated from the short-list due to difficulties in picking the fruit in optimum condition. The fruits must be allowed to remain on the tree until full flavour and colour develop, yet they often fall early before they are ready. The panel decided that a lack of chemical growth regulators in organic cultivation would make keeping fruit on the tree extremely difficult. Any fruit harvested in sub-optimum condition would soon kill the good reputation of the variety. The variety is also scab susceptible.

Mid season varieties

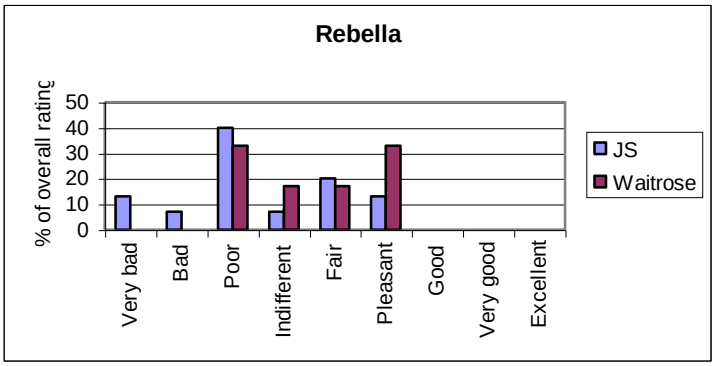
DL11



Firmness:	2.3
Juiciness:	2.9
Crispness:	2.3
Toughness:	3
Mealiness:	2.3
Sweetness:	2.5
Acidity:	1.9
Shape:	3.6
Colour:	3

Evaluated by both Waitrose and Sainsbury's. This variety (sourced from France) was disappointing. Fruit texture was poor (possibly due to the very hot weather?). Flavour was only average and the skin was slightly tough. The apple had an attractive appearance but russet on the fruit skin which was off-putting – although this is apparently not characteristic of the variety and was caused by late frosts. Nevertheless, it has been eliminated from the list.

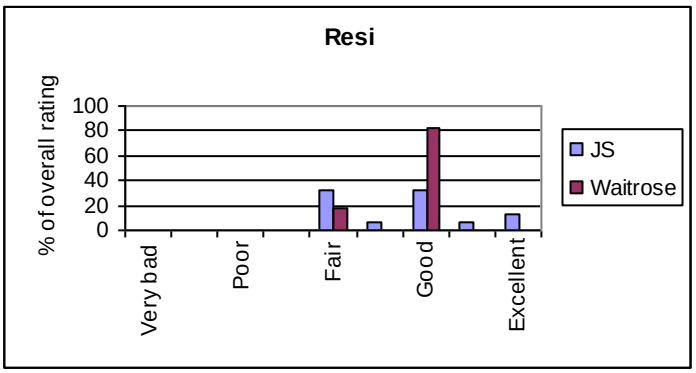
Rebella



Firmness:	3.2
Juiciness:	3.3
Crispness:	3.2
Toughness:	3.5
Mealiness:	2.1
Sweetness:	2
Acidity:	2.7
Shape:	3.1
Colour:	3

Evaluated by Sainsbury's and Waitrose. The panel agreed that this variety had not particular merit. Flavour was only average and slightly acidic, with a rather chewy skin and texture. It has been eliminated from the list.

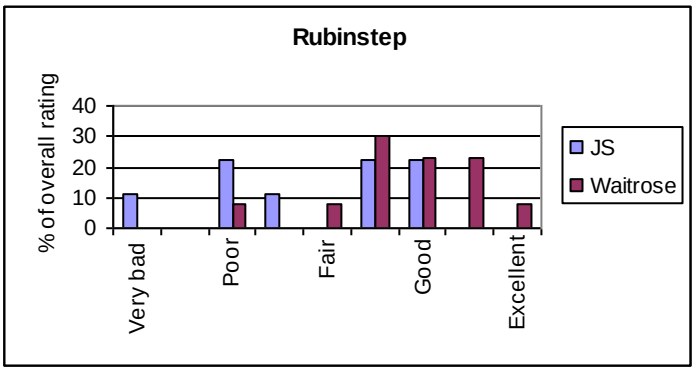
Resi



Firmness:	3.8
Juiciness:	3.2
Crispness:	3.7
Toughness:	2.2
Mealiness:	1.7
Sweetness:	2.9
Acidity:	2.7
Shape:	3.6
Colour:	3.6

Evaluated by Sainsbury's and Waitrose. Resi was rated relatively highly. The fruit was well flavoured with a good sugar /acid balance, slightly Gala-like in appearance with a nice pink-red blush. Fruits were small but improved size could probably be achieved from mature trees and adequate thinning. It remains on the list.

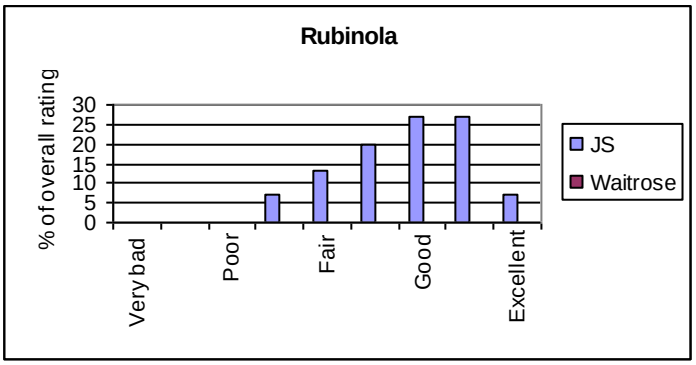
Rubinstep



Firmness:	3.7
Juiciness:	2.5
Crispness:	3
Toughness:	2.4
Mealiness:	2.2
Sweetness:	2.8
Acidity:	2.3
Shape:	3.6
Colour:	3.3

Evaluated by Sainsbury's and Waitrose. Rubinstep received mixed ratings, resulting in an average overall score for acceptability. Many different subtle flavours and taints were detected – but nothing really special. Fruits were sourced from Czechoslovakia (UK-grown apples may perform better without some of the off-flavours?). Fruit size and appearance was good and it remains on the list for the time being.

Rubinola



Firmness:	3.7
Juiciness:	3.2
Crispness:	3.6
Toughness:	2.4
Mealiness:	1.7
Sweetness:	3.7
Acidity:	2.4
Shape:	3.7
Colour:	3.8

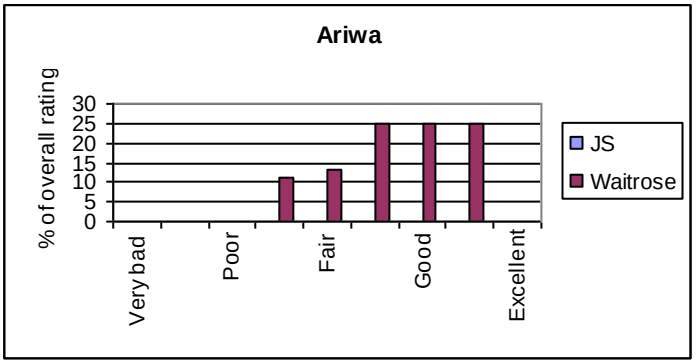
Evaluated by Sainsbury's. Rubinola has performed consistently well throughout the trials. The panel was unanimous in its decision to keep the variety on the short-list. Fruits are sweet, very crisp and juicy. Susceptibility to leaf (lenticel?) spot and cracking around the stalk end continue to be an issue but are not considered to be a significant problem at this stage. Storage life is reputed to be excellent.

Rajka

This variety was not evaluated during 2003, but fruit was sampled during the review meeting. Flavour was very good and since it had performed relatively well in previous assessments, the panel agreed to keep it on the short-list. Early indications have shown that storage in air is poor but CA storage may prove to be more successful. The variety appears prone to developing rather greasy skin so it may be suitable only for short-term keeping.

Mid-late season varieties

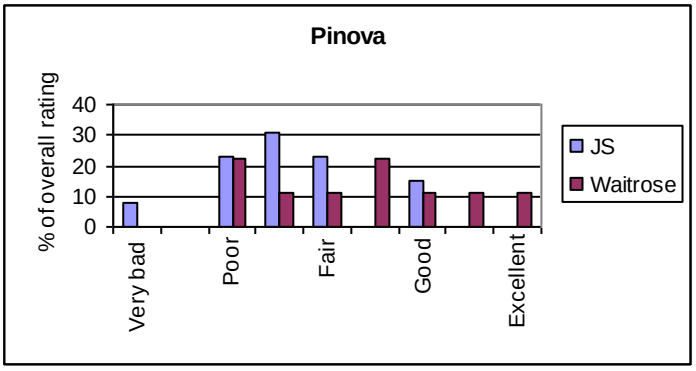
Ariwa



Firmness:	3.6
Juiciness:	3.5
Crispness:	3.4
Toughness:	3
Mealiness:	1.7
Sweetness:	2.6
Acidity:	2.1
Shape:	3.7
Colour:	3.6

Evaluated by Waitrose, Ariwa performed surprisingly well given that fruits were very small and variable in shape. The apples had good texture and were sweet, crisp and juicy, with a slight Gala-like appearance. The shape of the fruit is rather unusual (little or no basin present). Skin was a little waxy and chewy but generally a good eat. It remains on the short-list.

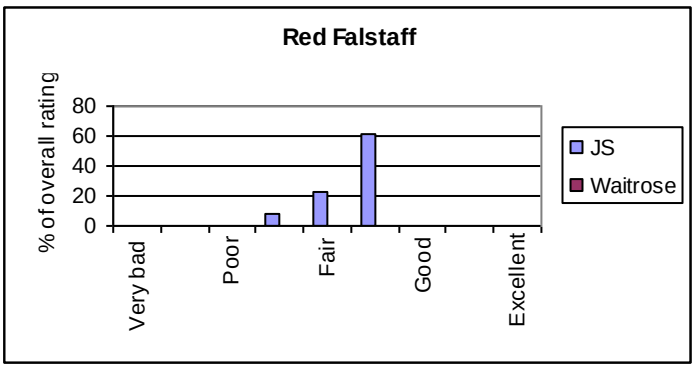
Pinova



Firmness:	3.7
Juiciness:	3.1
Crispness:	2.9
Toughness:	2.7
Mealiness:	2.2
Sweetness:	3
Acidity:	1.5
Shape:	3.2
Colour:	3.3

Evaluated by Sainsbury's and Waitrose. Despite very good results in previous years, Pinova was rated only 'average' in 2003 trials (although individual opinions were very mixed). A rather tough, chewy skin was the main reason for poor performance. This may have been due to the exceptionally hot weather in summer 2003. The apple is very attractive and normally sweet, crisp and juicy. It remains on the short-list for the time being owing to previous favourable performance.

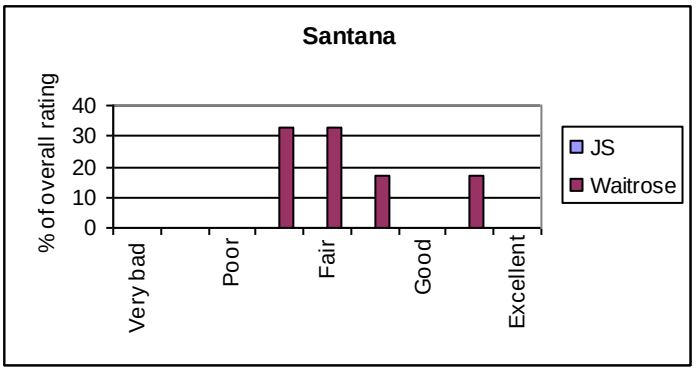
Red Falstaff



Firmness:	2.4
Juiciness:	2.9
Crispness:	3.1
Toughness:	2.4
Mealiness:	2.4
Sweetness:	2.4
Acidity:	2
Shape:	3.7
Colour:	3.6

Evaluated by Sainsbury's, Red Falstaff received an average rating of 'pleasant.' It was difficult to reach a conclusion as to whether it had enough merit to remain on the list. The panel eventually decided that it would remain on the short-list for the time being as it is generally a good cropping variety with few problems and we have a detailed knowledge of optimum storage conditions.

Santana

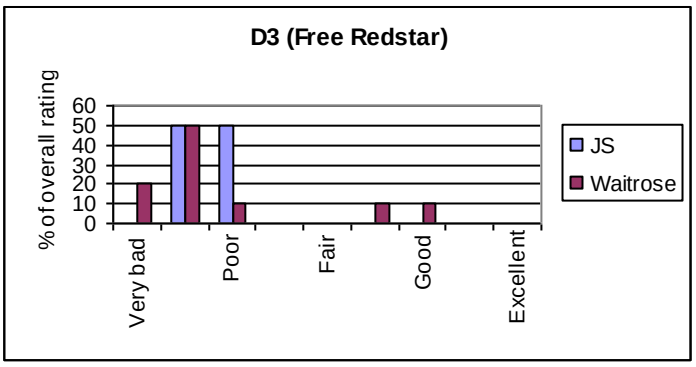


Firmness:	3.7
Juiciness:	3.1
Crispness:	3.7
Toughness:	2.1
Mealiness:	1.8
Sweetness:	1.4
Acidity:	3.8
Shape:	3.2
Colour:	3.6

Santana was evaluated by Waitrose for the first time in 2003 (not previously been assessed due to shortage of fruits). Although it was rated 'fair – good', fruits were found to be greasy and tasted very acidic. There are also some concerns the use of sulphur can noticeably taint the taste of the fruit. It has been eliminated from the short-list.

Late season varieties

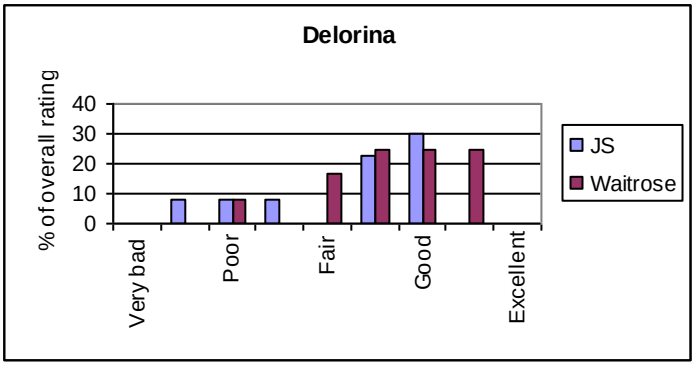
D3 (Free Redstar)



Firmness:	2.3
Juiciness:	2.3
Crispness:	2.1
Toughness:	2.4
Mealiness:	2.6
Sweetness:	1.9
Acidity:	2.4
Shape:	1.9
Colour:	3.4

Evaluated by Sainsbury's and Waitrose. It was unanimously agreed that fruits were extremely poor quality (poor texture, little flavour) and deep shiny red (strong green background) and unattractive, blocky shape. Storage life is questionable due to the very soft texture. Fruits sent from Poland were extremely bruised owing to the poor packaging. It has been eliminated from the list.

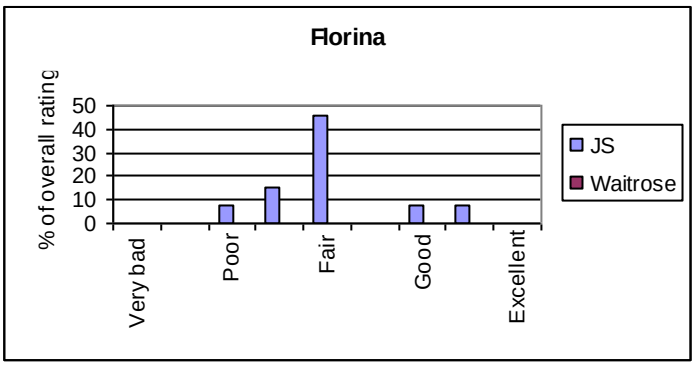
Delorina



Firmness:	3.3
Juiciness:	2.9
Crispness:	3
Toughness:	2.8
Mealiness:	1.7
Sweetness:	2.9
Acidity:	2.4
Shape:	3.1
Colour:	3.7

Evaluated by Sainsbury's and Waitrose. Despite being slightly over mature (yellow background and slightly waxy skin), fruits were rated highly. Flavour and texture were good and the apples were crisp and juicy, although some of the fruits were found to be 'dense' and 'woody' rather than crisp. The variety remains on the short-list for the time being.

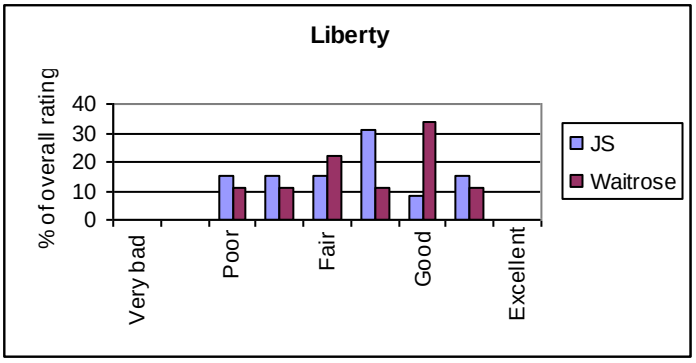
Florina



Firmness:	2.9
Juiciness:	3
Crispness:	3.6
Toughness:	2.7
Mealiness:	1.6
Sweetness:	2.6
Acidity:	2
Shape:	2.1
Colour:	2

Evaluated by Sainsbury's. This variety received only average ratings. Flavour and texture were ok – but nothing special. Although the texture was crisp and juicy, appearance was rather poor (blocky, mi-shapen, russetted) and it was agreed that it had no visual appeal. It has been eliminated from the list.

Liberty



Firmness:	3.4
Juiciness:	3.6
Crispness:	3.1
Toughness:	2.1
Mealiness:	1.7
Sweetness:	2.8
Acidity:	2.1
Shape:	2.8
Colour:	2.9

Evaluated by Sainsbury's and Waitrose. Despite some concerns over the deep purple-red colour and mis-shapen fruits, the variety performed relatively well in taste tests. It appears that fruit maturity (and therefore flavour) can be very mixed and trees need picking over regularly to achieve optimum results. Apples are sweet, crisp and juicy at their best and shelf life / storage looks promising. The variety remains on the short-list.

Bohemia

This variety was not evaluated this year due to lack of fruit, although some fruits were examined during the review meeting. It was agreed that owing to the relatively poor visual appeal of the apples (over-sized fruits and greasiness), the variety would be eliminated from the list. Past assessments had indicated that flavour was quite good, but this was not found to be the case this year.

Pilot

Pilot was not evaluated this year owing to poor performance in taste panel assessments during 2002. Fruit was tested during the meeting but it was confirmed that the variety was too tough, chewy and generally disliked. It has now been eliminated from the list.

Topaz

Again, this variety was not evaluated during 2003, but fruits were sampled during the meeting. A unanimous decision confirmed that the fruit was far too acidic to be acceptable, despite its reputation in Europe as a good variety for organic production. It has been eliminated from the list.

Goldrush

This variety was harvested in early November and sampled during the meeting. It was agreed that the variety had not particular merit and poor fruit appearance was very off-putting, even after the ideal growing conditions of 2003. Fruit skin blemishes were very visible against the yellow/green background. The apples are prone to sooty

blotch and insect pest and disease damage since the variety is very late maturing. Flavour and texture were average – but nothing special. Despite its reputation for excellent storage life, the decision was taken to eliminate it from the list.

In many cases, opinions on the acceptability of each variety varied widely, and it was difficult to reach an overall conclusion on the performance of the fruit. However, during the variety review meeting of 7th November, each variety was reviewed by the panel in detail, with previous year's assessments also taken into consideration. Of all the varieties evaluated during 2003, Ceeval, Resi, Rubinola, Ariwa and Delorina were the most favoured and received good overall ratings for acceptability. The varieties Discovery, Rubinstep, Rajka, Pinova, Red Falstaff and Liberty generally received ratings of 'average – good' and will remain on the short-list for final assessment during 2004. The varieties Worcester Pearmain, DL11, Rebella, Santana, D3 (Free Redstar), Florina, Bohemia, Pilot, Topaz and Goldrush, were rated rather poorly and were therefore eliminated from the short-list.

Culinary varieties
Having previously been assessed for processing by Fourayes Farms Ltd, the four short-listed culinary varieties (most suitable for processing), were assessed by the supermarket evaluation panel for fresh sales during the variety review meeting of 7th November 2003. It was agreed that all four varieties (Edward VII, Encore, Howgate Wonder and Pikant) would be suitable, providing there was not too much top colour present on the skin.

Juicing varieties
Owing to lack of fruit in 2002, juice trials using the French juicing variety Judeline were postponed until 2003. It was hoped that the trees (cropping at Poultry Farm, Marden) would have produced enough fruit to supply the commercial juice press at Matthew Wilson's farm. However, although the trees cropped well during 2003, they failed to produce sufficient volume of fruit to supply the half-tonne requirement of the press. Although the apples have been put through a domestic small press, it would be interesting to note how the variety performs in a commercial situation. Unless enough fruit is produced during the coming year, attempts will be made to source ready-bottled juice from France. As an extremely disease resistant and heavy cropping variety with a good reputation for juicing, it will be interesting to compare this variety to other popular UK juicing varieties such as Red Falstaff, Cox and Bramley.

Revised list of promising varieties
Following taste-test assessments carried out during 2003 and the variety review meeting held in November, the final short-list of varieties is outlined below (Table 39). This now consists of 11 dessert, 1 juicing and 4 culinary varieties. Large scale taste-tests will be held at the Sainsbury's Centre in London during 2004. A final selection of the best 4-6 dessert varieties will be chosen towards the end of the year on the basis of these results, together with a review of pest and disease resistance and agronomic suitability.

Table 39 Revised list of promising varieties

Early Season	Mid Season	Mid-Late Season	Late Season	Culinary	Juicing
Ceeval Discovery	Rajka Resi Rubinstep Rubinola	Ariwa Pinova Red Falstaff	Delorina Liberty	Edward VII Encore Howgate W. Pikant	Judeline

2.19 Conduct preliminary storage tests

Table 40. Mean fruit firmness (Newtons) of CA-stored organic apple varieties

Variety	Firmness (N) at harvest	Firmness (N) 2 Months	Firmness (N) 4 Months	Firmness (N) 6 Months
Ariwa	93.7	90.58	76.6	61.5
Bohemia	64.2	45.6	42.4	*
Ceeval	70.7	45.4	27.4	*
DL11	64	54.95	54.6	52.1
Edward VII	88.5	86.8	69.2	47.2
Encore	73.7	69	50.4	42.1
Florina	77.5	57.6	42.5	42.8
Goldrush	92.2	92.2 (fresh)	97.4	89.8
Judeline	86	68.2	52.0	47.3
Liberty	79	80	58.2	53.7
Pikant	88.6	78.1	67.1	44.3
Pilot	93.3	92.1	88.1	82.8
Pinova	71.6	73.8	70.8	71.3
Rajka	83.2	71.3	60.9	49.4
Rebella	79.4	78.7	67	*
Red Falstaff	69.5	68.2	59.7	56.2
Resi	90	86.8	70.9	*
Rubinola (early pick)	87.7	77.5	68	52.9
Rubinola (late pick)	86.1	83.7	62	51.9
Rubinstep	94.4	85.7	74.5	*
Santana	72.5	80.9	81.7	*
Topaz	82.3	75	65.3	53.7

***** = no fruit available

Having completed the 6-month CA storage trials, clear trends in cultivar performance can be seen. The variety Pilot, which performed exceptionally well in air storage trials during 2002, also retained its firmness very well in CA (average firmness dropping by 93.3 – 82.8N over 6 months). The variety Santana (not previously evaluated in storage trials owing to lack of fruit) also appeared to perform well in CA, and maintained a firmness of around 80N over a four month period, although a shortage of fruit meant that there were no fruits available for assessment after 6 months. The late maturing variety Goldrush (harvested in early November)

also appears to have excellent storage life. Unfortunately, these varieties have now been eliminated from the short-list of promising varieties owing to poor eating quality.

Of the more promising short-listed dessert apple varieties to be selected by Sainsbury's and Waitrose, it is encouraging that the varieties Ariwa and Pinova maintained a very good fruit firmness of above 60 N over the six month period. The varieties Rubinstep, Resi and Rubinola also appeared to perform relatively well in CA, maintaining an average firmness of over 60 N over a four month period, but did not hold their firmness for six months. Observations of appearance and quality of fruit removed from CA store have confirmed that the variety Resi is prone to soft-scald at temperatures below 2°C. The closely-related variety Rebella is also affected in this way but no longer remains on the short-list of promising varieties. Hopefully, this kind of physiological disorder can be overcome by modifying the temperature at which the fruits are stored.

The promising dessert varieties Red Falstaff, Rajka and Liberty (which had performed well in air storage trials during 2002-2003) maintained an average firmness at or just under 60 N in storage – indicating that these varieties may not be suitable for long-term storage. However, none of these other varieties showed any negative reaction to the CA regime and it may be possible to extend storage life by reducing the temperature to 0-0.5ºC and /or by applying a more extreme CA treatment. The variety Ceeval performed particularly poorly, but since this is an early apple (season similar to Worcester Pearmain) it was not expected to last well. Of the culinary varieties tested, Edward VII and Pikant proved to be the best keepers, maintaining a firmness of just under 70 N over four months. The juicing variety Judeline did not hold its firmness well in CA (dropping from 86 – 47.3 N over six months) and is unlikely to be suitable for long term storage. There was not enough fruit of the varieties Delorina and Howgate Wonder to carry out assessments. The variety D3, which had been sourced from Poland, was not stored owing to extremely poor fruit quality (bruising).

Although the storage trials have given us good indications of typical responses of each variety held in air and CA regimes, it should be noted that these are only preliminary trials and further, more detailed storage work will be required for any varieties selected for recommendation during 2004. In many cases, there was little fruit available for storage work (the best apples having been sent for taste test assessment). Having been sourced largely from unsprayed plots, much of the fruit also had skin blemishes which may also have affected storage performance. In addition to fruit pressures, other post-harvest quality measurements including background colour, % soluble solids, fruit diameter and weight have been recorded for all varieties tested and data will be added to the existing information in the variety database.

CONCLUSIONS (OBJECTIVE 2, YEAR 4)

- Many trees in the organic apple variety planting (VF216) produced a first light crop of fruit during 2003, some of which required hand thinning. Most of the trees have now established, with others recently re-grafted to compensate for losses due to canker or poor establishment. Half of the trial (blocks I, IV & V) continued to receive applications of sulphur from March – August 2003. Compost was applied to the crop rows in March to boost fertility and a *Bt* spray to control moth pests was also applied in May. A pest and disease assessment, carried out on 18th June, revealed that although the plantation is still relatively young, differences in varietal sensitivity to pests and diseases are apparent. Varieties most prone to mildew were Discovery, Howgate Wonder, Pikant and Rebella (in 2002 Rajk and Goldrush were worst affected). As in 2002, applications of sulphur

reduced the incidence of mildew, although cultivar differences failed to reach statistical significance.

- In addition to the pest and disease assessments carried out on VF216, shoot growth measurements and a record of precocity (cropping), overall growth and tree habit were also carried out during 2003. Varieties that were most vigorous in terms of shoot growth were Ariwa, Judeline, Delorina, Florina and Worcester Pearmain. Most varieties have also established a reasonably good framework. In terms of precocity, the varieties Ariwa, Red Falstaff, Pinova, Rebella and Delorina were the earliest to bear fruit in 2003, although grafting material used in the initial stages of propagation may still be influencing variety performance at this early stage. Records of pollination requirements and floral precocity will be undertaken in 2004 on the most promising varieties.

- Fruit samples were supplied to Sainsbury's and Waitrose from August – November for taste test assessment. The varieties Ceeval, Resi, Rubinola, Ariwa and Delorina received the best ratings for overall acceptability. Discovery, Rubinstep, Rajka, Pinova, Red Falstaff and Liberty received average – good ratings. Each variety was reviewed in detail during a meeting with fruit technologists on 7th November. Having taken into consideration each variety's performance in previous years, the decision was taken to eliminate varieties that had performed relatively poorly in taste test assessments. These included the varieties Worcester pearmain, DL11, Rebella, Santana, D3 (Free Redstar), Florina, Bohemia, Pilot, Topaz and Goldrush. The culinary varieties Edward VII, Encore, Howgate Wonder and Pikant were deemed suitable for fresh sales, provided that not too much top colour was present. Trees of the juicing variety Judeline (cropping at Poultry farm, Marden) failed to produce enough fruit for a commercial juice trial and attempts will be made in 2004 to source juice from France for comparison with other standard UK juicing varieties. The short-list of promising varieties, which will be evaluated in 2004, now consists of 11 dessert, 4 culinary and 1 juicing apples. The dessert apples will undergo large-scale taste testing at the Sainsbury's Centre, with a view to selecting the best 4-6 for recommendation to growers at the end of the year.

- Preliminary CA (1.5-2ºC, <1% CO2 + 2%O2) storage trials were carried out on fruits (where available) and data from the full 6 months of assessments has now been collected. Of the most promising apple varieties remaining on the short-list, the varieties Ariwa, Pinova, Rubinstep, Resi and Rubinola appear to perform well in CA and are likely to be suitable for long-term storage of at least four months (Ariwa and Pinova appear suitable for six month storage). Resi was the only variety to show any adverse reaction to the low temperature of 1.5-2ºC. The varieties Red Falstaff, Rajka and Liberty maintained an acceptable firmness of around 60 N for a 4 month period but are unsuitable for long-term keeping. The culinary apples Edward VII and Pikant retained good firmness in CA over four months, but the juicing variety Judeline appears to be unsuitable for long-term storage.

- The apple variety database is continually being updated as data on each of the promising apple cultivars is collated. This includes information regarding pest and disease resistance, agronomic performance and data from fruit storage trials. The database is being currently being formatted in a Microsoft Access package, which will enable the data to be sorted into categories and the information viewed more easily.

ACTIONS FOR YEAR 5 (OBJECTIVE 2)

- **Assess pest and disease levels in June and at harvest**
- **Assess agronomic performance**
- **Conduct final taste-tests at the Sainsbury's Centre**
- **Collate and evaluate data**
- **Identify best varieties**

Objective 3. To determine the activity (eradicant, protectant, antisporulant), persistence and efficacy of eight alternative organically acceptable fungicides for scab and mildew control.

INTRODUCTION (OBJECTIVE 3, YEAR 4)

One of the main reasons for the poor performance of current organic apple production methods is inadequate pest and disease control. Apples are subject to attack by a wide range of highly damaging pests and diseases. The diseases scab and mildew are particularly debilitating. They severely reduce tree growth, yield and quality. The range of plant protection products available for disease control in organic production in the UK is very limited (copper oxychloride, Bordeaux mixture, sulphur). There is an urgent need to discover novel organic-compatible products that can effectively be used to manage apple scab and mildew. The third objective of this project is therefore to determine the activity, persistence and efficacy of alternative fungicides for scab and mildew control.

In the first two years, we have conducted glasshouse experiments on small potted rootstock plants (MM106) to determine the activity and relative persistence of the alternative products for control of scab and mildew in addition to several copper and sulphur formulations. Disappointingly, none of alternative products had significant effects against scab when applied as a curative or protectant product. Most products showed some efficacy against mildew whether as a curative, protectant or anti-sporulant products. As expected, the two sulphur products were the best against mildew and Wetcol against scab. In year 3, we have selected a few products for further testing on potted trees in the sand-bed in addition to two new products (Serenade and Farmphos). Furthermore, we also evaluated the effects of spring application of copper on the subsequent development of scab and mildew. The results further confirmed the findings from the first two years. None of the new products (apart from Wetcol and sulphur) are very effective against scab and mildew.
In the last year, we selected a few product in addition to Wetcol and sulphur for testing in an organic orchard at East Malling.

MATERIALS AND METHODS (OBJECTIVE 3, YEAR 4)

We have selected seven products: early copper (Wetcol) at pre-bud-burst, routine copper at low rate, Milsana, Serenade, liquid silica, sulphur and compost. Unfortunately, we were not able to obtain the compost tea making facility well into the season. Therefore, compost tea was not included as a treatment. In addition, an untreated control was also included.
The experimental area was divided into three blocks. In each block, each treatment has three trees. From April, each product (apart the early copper) was applied routinely (every 10-14 days weather permitting). However, in early summer, because of bad weather (either too windy or wet), this interval of spray was not possible. Red Pippin and Saturn were included for testing.
Scab and mildew were assessed three times: June, July and August. For each assessment, one tree from each block, located in the middle, was assessed for each treatment. For assessing mildew, five shoots were randomly selected and presence of mildew was recorded on the top five fully unrolled leaves. For scab assessment, it was the same as mildew for the first two assessments. For the last assessment, only fruit scab was assessed. All the fruits on the tree

was assessed for the presence of scab lesions. Number of scab lesions was counted on those infected fruits.

RESULTS (OBJECTIVE 3, YEAR 4)

Powdery mildew

In the June assessment, the percentage of mildewed leaves was very high, reaching 73% for the untreated. Only routine low copper had significantly less mildew (61%), whereas liquid silica and Milsana appeared to increase mildew (83%) on Red Pippin. Results on Saturn were generally similar apart from the fact that mildew level is generally lower than on Red Pippin (Table 41).

Table 41. Percentage of leaves infected by mildew in June and July

	June			July	
	Red Pippin	Saturn		Red Pippin	Saturn
LowCopper	61	56		92	47
Milsana	80	63		99	76
Prebud	76	56		97	59
Serenade	73	60		97	73
Silica	83	63		100	63
Sulphur	72	59		91	42
Untreated	73	63		93	55

For the July assessment, almost all the leaves on Red Pippin was infected by mildew (Table 41). In contrast, mildew remained at the similar level to that in June on Saturn. In addition, both sulphur and low rate copper had significantly less mildew than untreated, whereas Milsana, silica and Serenade resulted in significantly more mildew than untreated. Because of the hot weather in the summer, all the extension shoots stopped growth by the time of third assessment in August, hence the mildew was virtually unchanged from July.

Scab

There were no scab lesions observed on Saturn. There were very few leaves infected by scab particularly for the June assessment. Hence data on leaf scab were not presented.

Table 42. Summary of scab epidemics on trees subjected to various treatments

	Average number of fruits per tree	Average number of fruits with scab	% incidence	Average number lesions per infected fruit
Early Copper	99	16	16	1.6
Low Copper	181	10	5	3.3
Milsana	145	27	19	2.8
Serenade	83	18	22	3.2
Silica	94	13	13	3.6
Sulphur	129	2	2	2.5
Untreated	129	23	18	3.6

About 18% of fruit was infected with scab for the untreated. Of all the treatment, only the treatment (low rate copper and sulphur) had significantly reduced the scab incidence (5% and 2%, respective (Table 42). For early copper treatment, even though the incidence was similar to the untreated the severity of the scab was significantly less than the untreated: 1.6 lesions per infected fruit compared to 3.6 lesions per infected fruit.

CONCLUSIONS (OBJECTIVE 3, YEAR 4)

- None of alternative products had significant effects against scab and mildew, except Wetcol and sulphur
- Overall, it is disappointing that almost all the alternative products tested so far were not very effective against apple scab and powdery mildew, apart from sulphur and copper products.

ACTION PLAN FOR YEAR 5 (OBJECTIVE 3)

- Further testing the efficacy of combining Wetcol bud burst application with a few selected alternative products in field conditions.
- Testing the efficacy of compost tea against scab and powdery mildew on potted trees.

Objective 4: To determine and optimise the efficacy of six organically acceptable foliar spray treatments for control of rosy apple aphid.

INTRODUCTION (OBJECTVE 4, YEAR 4)

Experiments in the early years of the project to test foliar sprays of various insecticides against existing infestations of rosy apple aphid in spring did not identify any effective treatments. Subsequent experiments have investigated the alternative strategy of controlling the aphids in the autumn when they have returned from their summer herbaceous host (*Plantago* sp.) to apple. There are two flight periods. The females (gynoparae) fly first, usually in September and give rise to nymphs, which develop into sexual females (oviparae). The males fly a week or two later and mate with the females (oviparae) which then lay the eggs that overwinter. The aim of any control approach would be either to deter or control either the winged females or males, or both. The timing of the migration is difficult to monitor. The flight of the rosy apple aphid is no longer recorded as part of the Rothamsted Insect Survey. The aphids generally occur only in very low numbers in the autumn and individuals are very difficult to find and identify. A sex pheromone is available which attracts males but it is not specific and catches males of many other species making its use of monitoring purposes impractical.

The **first** autumn control experiment was done in 2000/01 in a commercial Bramley orchard at Poultry Farm, Marden to evaluate the efficacy of foliar sprays of test products for control of rosy apple aphid on apple in the autumn. In the experiment, programmes of multiple sprays of various spray treatments were tested to determine whether or not such treatments could control autumn migrants or their autumn offspring and hence lead to reduced populations of rosy apple aphid in spring. Programmes of 5 sprays of potassium soap (Savona), rotenone (Derris), garlic extract (Envirepel) and pirimicarb + cypermethrin (Aphox + Toppel) between 22 September and 1 November 2000 were applied to large replicated plots. The results showed that control of rosy apple aphid by autumn applications of aphicides can be effective. Of the products tested, the pirimicarb + cypermethrin treatment was the most effective. It completely controlled the low numbers of aphids that occurred. The organic experimental treatments with rotenone, potassium soap or garlic extract were less effective than the pirimicarb + cypermethrin treatment but because the populations were very low and variable and the data is unsuitable for statistical analysis, it was not possible to determine whether they reduced populations significantly compared to the untreated control.

The **second** autumn application experiment evaluated programmes of 3 sprays (1000 l/ha) of Aphox+Toppel, Savona, Derris or garlic extract (Envirepel) applied on 27 September and 11 and 25 October 2001, repeated the previous experiment at the same site (but with 3 rather than 5 spray applications). Large replicated plots in a 4 ha Bramley orchard at Poultry Farm, Marden (by kind permission of Peter Hall) were used. The programme of 3 autumn sprays of the standard Aphox + Toppel treatment was 100% effective. The garlic treatment had virtually the same numbers of damaged and infested leaves as the control. The Derris and Savona treatments had approximately 50% of the numbers of damaged and infested leaves of the control. This indicated that none of the 3 organically acceptable treatments tested, Savona, Derris or garlic extract (Envirepel) are sufficiently efficacious to provide an adequate degree of control of rosy apple aphid when applied in the autumn.

The **third** autumn application experiment also done in 2001/02 was located in a large Bramley orchard at Yopps Green (by kind permission of Robert Mitchell). Three timings of single sprays of Aphox+Toppel or Savona+Derris with a programme of three sprays of each mixture and an untreated control were compared. Sprays were applied on 26 September and 10 and 24 October 2001 at 500 l/ha. As in the second autumn application experiment, the programme of three sprays of the Aphox + Toppel treatment was 100% effective. The latter two timings of single spray treatments of this insecticide mixture both reduced the numbers of damaged and infested leaves significantly compared to the control, and the first spray timing nearly so. The second timing (11 Oct) was clearly the most effective followed by the third (25 October) timing with the first application least effective. The programme of 3 sprays of Savona + Derris did not significantly reduce the numbers of aphids nor did any of the single treatments.

The autumn application strategy is promising but Savona and Derris are insufficiently effective, even when multiple sprays are applied in admixture. Garlic is completely ineffective. The high degree of control achieved with the conventional standard, Aphox+Toppel , indicates that autumn application is a promising approach. In 2002, of the 3 timings tested, 11 October was the most effective.

Here we report the results of the fourth and fifth autumn application experiments done in winter 2002/03 to investigate the efficacy pyrethrum, kaolin and natural plant extracts (Majestik) for autumn control of rosy apple aphid.

METHODS AND MATERIALS (OBJECTIVE 4, YEAR 4)

Fourth autumn application experiment

Objective

The objective of the fourth autumn application experiment was to evaluate the efficacy of programmes of three sprays of the organically acceptable products Majestic (natural plant products), Surround (kaolin) or Py Insect Killer (pyrethrum) in comparison with an Aphox (pirimicarb) standard.

Site

The experiment was located in Parsonage Bramley orchard (southern half, *circa* 4 ha area), Poultry farm, Marden, Kent). OS Landranger sheet 188, MR 741 440). The plant spacing was 18’ x 12’ = 5.49m x 3.66m (tree density = 498.4 trees/ha).

Treatments

Treatments (Table 43) were programmes of 3 sprays of different products, applied on 27 September, 18 October and 28 October 2002 with the growers axial fan orchard airblast sprayer at a volume of 1000 l/ha.

Table 43. Treatments applied in the fourth rosy apple aphid autumn application experiment at Poultry farm, Marden, Kent in October 2002.

Treat no.	Colour code	a.i.	Product	Dose product (l /ha)	Conc (ml/l)
1	Red	Natural plant extracts	Majestik	25 l	25 ml
2	Blue	Pyrethrum	Py Insect Killer	10 l	10 ml
3	Grey	Kaolin	Surround	50 Kg	50 g
4	Yellow	Pirimicarb	Aphox	560g	0.56g
5	Green	Untreated	-	-	-

† Three sprays were applied on 27 September, 18 October and 28 October 2002

Experimental design and layout

A randomised complete block design was used with 4 replicate half row plots per treatment. Plots were half rows (approximately 25 trees per plot) with two unsprayed guard rows between plots.

Assessments

On 21 April 2003 at the pink bud to early bloom growth stage, the number of rosy apple aphid and the number of apple grass aphid colonies were counted on the central 20 trees in each plot.

Statistical analysis

As so few aphid colonies developed, statistical analysis of the data (eg. analysis of variance) was not appropriate. The total number of colonies of each aphid species for each treatment was calculated.

Fifth autumn application experiment

Objective

The objective of this experiment was to test three timings of single sprays in early, mid versus late October or a programme of 3 sprays at all 3 timings of pyrethrum (Py Insect Killer) or Majestic for the control of rosy apple aphid in organic apple production.

Site

The experiment was located in the Egremont Russet/Discovery orchard (M9 rootstock) 'Bean Field' at Hartley Lands farm, Cranbrook. The orchard was approximately 1.5 ha in area and consisted of 37 rows of 46-58 trees. Each variety was planted in whole double rows with the two varieties alternating. The row spacing was 4.0 m and trees are spaced 1.8m in the row. The orchard was certified as organic by the Soil Association.

Treatments

Treatments were single sprays of Py Insect Killer or Majestic applied on 17, 17 or 29 October versus a programme of 3 sprays of each material at all three timings. Sprays were applied at 1000 l/ha with an axial fan air assisted sprayer by a contractor (Steven Brooks) under the supervision of HRI staff.

Table 44. Treatments applied in the fifth rosy apple aphid autumn application experiment at Hartley Lands farm, Cranbrook, Kent in October 2002.

Treat. no.	Product	Active ingredient	Dose rate (/ha)	Date(s) of application
1	Py Insect Killer	Pyrethrum 10 g/l	10 l	7 Oct
2	Py Insect Killer	Pyrethrum 10 g/l	10 l	17 Oct
3	Py Insect Killer	Pyrethrum 10 g/l	10 l	29 Oct
4	Py Insect Killer	Pyrethrum 10 g/l	10 l	7 + 17 + 29 Oct
5	Majestic	Natural plant products	25 l	7 Oct
6	Majestic	Natural plant products	25 l	17 Oct
7	Majestic	Natural plant products	25 l	29 Oct
8	Majestic	Natural plant products	25 l	7 + 17 + 29 Oct
9	Untreated	-	-	-

Experimental design

A randomised complete block experimental design with 4 replicates of the nine treatments (= 36 plots) was used. Plots were 4 rows wide and 12 trees long. The central two rows, one row of each variety was sprayed only.

Assessments

On 24-25 April 2003 at the pink bud to early bloom growth stage, the number of rosy apple aphid and the number of apple grass aphid colonies were counted on the central 20 trees, 10 of each variety, in each plot.

Statistical analysis

As so few aphid colonies developed, statistical analysis of the data (eg. analysis of variance) was not appropriate. The total number of colonies of each aphid species for each treatment was calculated.

RESULTS (OBJECTIVE 4, YEAR 4)

Fourth autumn application experiment

The very low numbers of rosy apple aphid and apple grass aphid that developed in spring 2003, even on the untreated control plots, meant that it was difficult to draw any firm conclusions form the data. The pirimicarb treatment did appear to give complete control of the very low populations of aphids that occurred.

Table 45. Total number of rosy apple aphid colonies per treatment on 21 April 2003 in the fourth rosy apple aphid autumn application experiment at Poultry Farm, Marden.

Treat no.	a.i.	Product	Total rosy apple aphid colonies per treatment	Total green apple aphid colonies per treatment
1	Natural plant extracts	Majestik	12	11
2	Pyrethrum	Py Insect Killer	6	1
3	Kaolin	Surround	12	8
4	Pirimicarb	Aphox	0	0
5	Untreated	-	13	4

Sprays applied at 1000 l/ha on 27 September, 18 October and 28 October 2002

Fifth autumn application experiment

Numbers of rosy apple aphid were so small that no conclusions about the efficacy of the treatments can be drawn from the data. However, both Py Insect Killer and Majestic did appear to be having an effect on apple grass aphid.

Table 46. Total number of rosy apple aphid (RAA) and apple grass aphid (AGA) colonies per treatment on 24-25 April 2003 in the fifth rosy apple aphid autumn application experiment at Hartley Lands farm, Cranbrook, Kent.

Treat. no.	Product	Dates of application (2002)	Total RAA colonies		Total AGA colonies	
			Disc	Egre	Disc	Egre
1	Py Insect Killer	7 Oct	1	0	27	18
2	Py Insect Killer	17 Oct	0	0	46	13
3	Py Insect Killer	29 Oct	1	1	9	11
4	Py Insect Killer	7 + 17 + 29 Oct	0	0	14	6
5	Majestic	7 Oct	2	0	55	3
6	Majestic	17 Oct	4	1	37	9
7	Majestic	29 Oct	2	7	97	40
8	Majestic	7 + 17 + 29 Oct	0	1	33	17
9	Untreated	-	6	0	100	38

CONCLUSIONS (OBJECTIVE 4, YEAR 4)

No firm conclusions about the efficacy of the organic autumn treatments for control of rosy apple aphid could safely be drawn because the degree of infestation that occurred in the two experiments done was too low to determine treatment differences. In one experiment, a programme of autumn sprays of Aphox (pirimicarb) (a conventional insecticide used as a standard) gave complete control of the very low populations of rosy apple aphid present whereas similar 3 spray programmes of sprays of Majestic (natural plant products), Surround (kaolin) or Py Insect Killer (pyrethrum) did not. In the other experiment, sprays of Majestic or Py Insect Killer showed partially effective against apple grass aphid.

ACTIONS FOR YEAR 5 (OBJECTIVE 4)

Two further efficacy experiments are in progress at the time of writing (February 2004), both testing the same treatments (Tables 47 & 48)

Table 47. Treatments applied in sixth rosy apple aphid autumn control trial at Parsonage Bramley Orchard, Poultry Farm Marden in 2003/04

Treat no.	Colour code	a.i.	Product	Dose product (l /ha)	Conc (ml/l)
1	Red	Natural plant extracts	Majestik	25 l	25 ml
2	Blue	Pyrethrum	Py Insect Killer	10 l	10 ml
3	Grey	Kaolin	Surround	50 Kg	50 g
4	Yellow	Pirimicarb	Aphox	560g	0.56g
5	Black	coded	coded	3l	3g
6	Green	Untreated	-	-	-

† Two sprays to be applied – the first starting in early October and the second 10-14 days later (mid October).

Table 48. Treatments applied in seventh rosy apple aphid autumn control trial in no 10 M26 Bramley orchard at Broadwater farm, West Malling in 2003/04

Treat no.	Colour code	a.i.	Product	Dose product (l /ha)	Conc (ml/l)
1	Red	Natural plant extracts	Majestik	25 l	25 ml
2	Blue	Pyrethrum	Py Insect Killer	10 l	10 ml
3	Grey	Kaolin	Surround	50 Kg	50 g
4	Yellow	Pirimicarb	Aphox	560g	0.56g
5	Black	coded	coded	3l	3g
6	Green	Untreated	-	-	-

† Two sprays to be applied – the first starting in early October and the second 10-14 days later (mid October).

Milestones – revised Nov 2002

Objective, task No., due date		Milestone (progress target)
1.1	30/04/00	Experimental approval for CpGV and *Quassia* applied for. □
1.2	30/04/00	Experimental protocols established for IPDM trials and trials laid out. □
1.3	30/04/00	Varieties chosen and ordered for site 2. □
2.1	30/04/00	Selection criteria for preliminary variety screen determined. □
3.1-3	30/04/00	Protocols formulated and potted trees and products for glasshouse scab/mildew tests acquired. □
4.1-3	30/04/00	Protocol formulated, products acquired and site selected for first rosy apple aphid orchard experiment. □
3.4	30/06/00	First glasshouse scab experiment completed. □
4.4	31/07/00	Firsts rosy apple aphid experiment completed. □
1.8-10	30/09/00	Treatment applications and assessments at site 1 in first season completed. □
1.1	30/09/00	Exp. approval for CpGV and *Quassia* obtained. □
1.11	30/09/00	Farm walk at site 1 occurred. □
2.2	30/09/00	Data base for candidate varieties created. □
3.5	30/09/00	First glasshouse mildew experiment completed. □
2.4	30/11/00	Preliminary taste & processing tests completed. □
1.12-13	31/12/00	Economics of IPDM at site 1 in year 1 determined. Strengths and weaknesses identified. □
2.5-7	**31/12/00**	**20 most promising apple varieties short-listed. □**
3.8	**31/12/00**	**Preliminary evaluation of fungicides for scab and mildew control in the glasshouse completed. □**
4.5-7	**31/12/00**	**Results of first rosy apple aphid experiment evaluated. Active products for direct control identified. □**
2.8	31/01/01	Bud-wood of 20 short-listed varieties obtained and grafted. □
1.7	**31/03/01**	**Experimental IPDM orchard planted at site 2. □**
3.9-10	30/04/01	Protocols formulated and potted trees and products for second years glasshouse scab/mildew tests acquired. □
3.11	30/06/01	Second glasshouse scab experiment completed. □
4.8-10	30/06/01	Protocol formulated, products acquired and site selected for second rosy apple aphid orchard experiment. □
1.8-10	30/09/01	Treatment applications and assessments at sites 1 and 2 in year 2 completed. □
1.11	30/09/01	Farm walk at site 2 occurred. □
3.12	30/09/01	Second glasshouse mildew experiment completed. □
3.15	**31/12/01**	**Most promising products for scab and mildew control identified.**

3.16-17	31/02/02	Protocol established and site selected for scab/mildew control orchard experiment in year 3.
2.10-11	**31/03/02**	**Replicated variety experiment at East Malling planted.**
4.13-15	**31/03/02**	**Results of second rosy apple aphid experiment evaluated. Active products for control in autumn identified.**
4.16-17	31/03/02	Protocol established and site selected for rosy apple aphid control orchard experiment in year 3.
1.14	30/04/02	Draft handbook for IPDM in organic apple production produced. Results to date reported at EMRA members day.
1.8-10	30/09/02	Treatment applications and assessments at sites 1 and 2 in year 3 completed.
2.12-13	30/09/02	Sulphur spray programme applied and pest and disease levels assessed on variety experiment at East Malling in year of establishment.
Old		
3.18	30/10/02	Orchard experiment evaluating active fungicide products at full dose and volume completed.
New		
3.18	30/10/02	Sand-bed experiments evaluating active alternative products at full dose and volume against scab and mildew completed.
1.12-13	31/12/02	Economic performance of IPDM programme at sites 1 and 2 in year 3 determined. Strengths and weaknesses identified.
1.15	**31/12/02**	**Performance of preliminary IPDM programme on disease susceptible and disease resistant cultivars at two sites determined.**
2.14	**31/12/02**	**Variety trial at East Malling established.**
2.15	31/12/02	Taste tests on fruit for varieties available in year 3 done.
1.16	**28/02/03**	**Refined IPDM programme formulated.**
4.18-20	**31/03/03**	**Results of third rosy apple aphid experiment evaluated. Most promising timing(s) identified.**
4.16-17	31/03/03	Protocol established and site selected for rosy apple aphid control orchard experiment in year 4.
1.17-19	30/09/03	Refined IPDM programme applied and assessments at sites 1 and 2 in year 4 completed.
1.20	30/09/03	Third growing season farm walk occurred.
Old		
3.19	30/10/03	Orchard experiment evaluating best fungicide product(s) at range of doses and spray intervals completed.
New		

3.19	30/10/03	Sandbed experiment evaluating the combination of best alternative product(s) with bud-burst copper spray completed.
3.20	30/10/03	Orchard experiment evaluating the efficacy of bud-burst copper spray at various doses completed.
2.16-17	30/11/03	P&D susceptibility and agronomic performance of varieties in experiment in first cropping year determined.
1.21-22	31/12/03	Economic performance of refined IPDM programme at sites 1 and 2 in year 4 determined. Strengths and weaknesses identified.
2.18	**31/12/03**	**Taste and processing tests on varieties in trial done.**
4.18-20	**31/03/04**	**Results of fourth rosy apple aphid experiment evaluated. Most promising dose and application method identified.**
4.16-17	31/03/03	Protocol established and site selected for final rosy apple aphid control orchard experiment.
1.17-19	30/09/04	Refined IPDM programme applied and assessments at sites 1 and 2 in year 5 completed.
1.20	30/09/04	Fourth growing season farm walk occurred.
Old		
3.20	30/10/04	Orchard experiment evaluating best fungicide product(s) repeated to validate results.
New		
3.21	30/10/04	Orchard experiment evaluating best strategies for managing scab and mildew completed.
2.16-17	30/11/04	P&D susceptibility and agronomic performance of varieties in experiment in second cropping year determined.
1.21-22	31/12/04	Economic performance of refined IPDM programme at sites 1 and 2 in year 5 determined. Strengths and weaknesses identified.
1.24	**31/12/04**	**Performance of preliminary IPDM programme on disease susceptible and disease resistant cultivars at two sites determined.**
2.18	**31/12/04**	**Taste and processing tests on varieties in trial done on fruit from second cropping year.**
3.24	**31/12/04**	**Most effective alternative fungicide treatment for scab and mildew control determined.**
4.20-22	**31/12/04**	**Best treatment for rosy apple aphid identified.**
1.20	29/02/05	Results of work reported at EMRA members day.
2.19	29/02/05	Preliminary storage tests complete.
1.23	**31/03/05**	**IPDM programme fully developed. Grower handbook on IPDM in organic apple production produced. Results of IPDM trials submitted for publication in refereed journal.**
2.22	**31/03/05**	**4-6 apple varieties for organic apple production identified.**
3.22-23	**31/03/05**	**Results of fungicide evaluations written up and submitted for publication in a refereed journal. Registration of best treatment by parent company fostered.**

4.21-22	**31/03/05**	**Results of evaluations of products for control of rosy apple aphid evaluations written up and submitted for publication in a refereed journal. Registration of best treatment by parent company fostered.**