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## APRC PROJECT REPORT

**Project SP10 (B)** Fertigation of fruit trees

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### Background

Earlier work at HRI, East Malling has shown the benefits of the application of residual herbicides overall to harvest yield of apple trees and the deleterious effects on soil fertility. By supplying water and nutrients directly to the tree roots, fertigation offers potential for conserving soil fertility and reducing herbicide use without loss of harvest yield. Initially this APRC-funded work considered the effects of fertigation on growth, yield and fruit quality of Cox's Orange Pippin apple trees grown in wide herbicide strips. This trial, planted in 1987 examined the effects of a compound soluble 19:6:6 fertiliser (Kristalon, lilac) applied by fertigation at rates between 10 and 80 g N per tree, compared with irrigation alone, 80 g N per tree broadcast and untreated controls. The potential for both trickle irrigation alone and fertigation to increase yield was identified. Rates of fertigation greater than 40 g N per tree caused excessive axillary flower bud development which led to bare wood. High levels of broadcast fertiliser or fertigation also caused apples to be more acidic than those receiving irrigation only or low levels of fertigation. Unfortunately, high quantities of the fertiliser caused a rapid increase in soil acidity to a level considered harmful to the trees. Thus, a maximum fertigation rate of 20 g N per tree was recommended. The trial was discontinued after cropping in 1992. It was not possible to distinguish between the effects of the nitrogen, phosphorus and potassium in the compound fertiliser used in the initial trial. However, recent evidence from Canada suggested that the increase in cropping from fertigation was due to phosphorus rather than nitrogen. Furthermore, other evidence from HRI indicated that fertigation had the potential to be used as an alternative to soil sterilisation.

Thus, another trial (2) was planted in spring 1990 to examine further the potential benefits of fertigation/irrigation by comparing the effects on soil conditions and growth and fruit quality of Queen Cox/M.9 trees of irrigation, nitrogen (as fertigation or as broadcast fertiliser), phosphorus (as fertigation or as broadcast fertiliser) and soil sterilisation. In this trial, trees were grown in narrow (50 cm) herbicide strips.

### Summary of Results from Trial 2 (Queen Cox/M.9), 1993

Fruit buds, fruit set, harvest yield and shoot growth

Ideally, trees of Queen Cox should be managed to maximise the number of buds and fruit set on spur and terminal wood and minimise those in axillary positions which tend not to set fruit. Trees receiving irrigation had larger numbers of spur and terminal fruit buds and produced more fruitlets than those not receiving supplementary water. The irrigated trees also carried more fruit through to harvest. Supplementary nitrogen fertiliser tended to increase the number of axillary fruit buds (Table 1) and the combination of supplementary nitrogen and irrigation produced the largest number of axillary buds, but, this had no influence ultimately, on harvest yield. Supplementary phosphorus fertiliser either broadcast or in fertigation had no effect on the number of fruit buds or fruit set. The trees were young so harvest yields were low. Irrigated trees produced a 37% greater harvest yield and 55% greater mean weight of Class I fruit larger than 65 mm diameter than unirrigated trees (Table 2) and trees receiving fertigation of phosphorus had the greatest yields. Irrigation increased total shoot length by 40% compared to unirrigated trees (data not presented). This was associated with a large increase in the number of shoots and a small increase in shoot length. Nitrogen and phosphorus fertilisers applied by fertigation or broadcasting also increased shoot lengths but the effects were smaller than irrigation alone.

Leaf and fruit mineral analysis

Generally, the concentrations of all minerals in the leaves sampled from the trees in late August were within the levels considered sufficient for growth (Table 3). Irrigation reduced the concentration of nitrogen and manganese whereas, supplementary nitrogen fertiliser had the opposite effect. The concentration of phosphorus in leaves was increased by irrigation alone but trees which received phosphorus by fertigation had the greatest concentration in the leaves. Nitrogen fertiliser supplied either by broadcasting or fertigation reduced phosphorus and potassium concentration in the leaves. Soil sterilisation had no effect on the concentration of any minerals in the leaves.

The concentrations of minerals in fruit at harvest (Table 4) were also all within the levels considered acceptable for long term storage. Irrigation slightly reduced potassium concentration and increased calcium. Nitrogen fertiliser as broadcast fertiliser or fertigation increased nitrogen concentrations, whereas supplementary phosphorus fertiliser either applied by broadcasting or fertigation had only a small positive effect on phosphorus concentration.

Soil acidity and extractable phosphorus concentration

Irrigation slightly increased the pH of soil (Table 5), whereas nitrogen or phosphorus fertiliser had the opposite effect. Phosphorus fertiliser applied either broadcast or as fertigation increased phosphorus concentration in the soil at 0-15 cm depth (Table 5). However, fertigation also increased the concentration of phosphorus at 15-30 cm whereas broadcast fertiliser had no effect at this depth (data not presented).

**Summary of results from trial 3 (Queen Cox/M.9 and MM.106), 1993**

Early results from trial 2 indicated that shoot growth of trees planted into soil previously under an apple orchard receiving fertigation/irrigation was as good or better than those planted into sterilised soil. Irrigation is not available to all growers so in the next trial planted in spring 1992 the number of alternative treatments to soil sterilisation was widened to include slow release fertiliser, potting compost and water-holding polymers. Furthermore, the differences in response of MM.106 and M.9 rootstocks were considered.

Fruit buds, fruit set, harvest yield and shoot growth

In the second season production of spur and terminal buds on the Queen Cox/M.9 trees was uninfluenced by any of the soil management treatments (Table 6). However, trees not receiving fertiliser produced fewer axillary fruit buds than those receiving normal or slow release nitrogen. Trees planted into potting compost had the largest number of axillary buds resulting from the large shoot growth produced in the previous year. By harvest, differences in the number of set fruit between any of the soil management treatments were small and this was reflected in harvest yield which showed only small differences between treatments (Table 7). Irrespective of the other soil management treatments, irrigation increased yield by 40%. Harvest yields were very low (<4 kg per tree) due to the young age of the trees. The blossom and fruit set results for Queen Cox/MM.106

trees were broadly similar to those found for Queen Cox/M.9. The soil management treatments caused large differences in the new shoot growth of trees on both rootstocks (Table 8). Trees grown in sterilised soils or in compost grew better than those receiving conventional fertiliser or no fertiliser at all. The water-holding polymer had a slightly adverse affect on growth.

Soil pH

The pH of the potting compost was 2 units below that of the unfertilised soil (Table 9). Nitrogen fertiliser also caused a decline in soil pH but the slow release fertiliser had no effect.

**Summary of results for Trial 4 (Bramley M.9), 1993**

Two further trials (4 & 5) were added in 1992 to consider alternatives to residual herbicides on Queen Cox/M.9, Queen Cox/MM.106 and Bramley/M.9 apple trees.

Trial 4 compares the effects of plastic woven mulch, straw mulch, non-residual herbicides (allowable under IFP rules) and residual herbicide on the growth of Bramley/M.9 trees. Cropping, shoot growth, mineral status and soil properties are being measured.

Trees growing in herbicide strips maintained bare by non-residual herbicides grew less than those grown with residual herbicides, plastic mulch or straw (Table 10). The trees were too young to obtain cropping data in 1993. Leaf nitrogen concentrations were also lowest for the non-residual herbicide treatment and phosphorus concentrations were low for all treatments (Table 11). Soil acidity was unaffected by any of the soil management treatments (Data not presented).

**Summary of results from Trial 5 (Queen Cox/M.9 and MM.106), 1993**

Results for the Queen Cox on either M.9 or MM.106 rootstocks were similar, in that neither rootstock showed an effect of soil management on number of fruit buds or fruit set. However, total harvest yield and weight of class I fruit greater than 65 mm diameter were heaviest for trees grown in plastic mulch and least for those grown with a straw mulch (Table 12). Again, harvest yields were low due to the young age of the trees. The shoot growth of M.9 rootstocks was only slightly affected by soil management. Trees on MM.106 grown in plastic mulch or straw mulch grew more than those in soil receiving either non-residual or residual herbicides (Table 13).

**Conclusions from 1993 data**

Trickle irrigation alone, clearly benefits the growth and yield of young trees of Queen Cox/M.9 and MM.106 by increasing the number of fruit set in spur and terminal positions. Although leaf nitrogen concentrations were generally sufficient, trickle irrigation reduced these concentrations, indicating the potential future need for supplementary nutrition. Fertigation is a more efficient method of application than broadcasting fertiliser alone, however, a combination of broadcast fertiliser and trickle irrigation had similar effects on growth and yield in trial 3.

In all the trials, the trees are young and have not yet achieved full cropping. A light crop puts less stress on the trees' resources so the full effects of many of the treatments on tree nutrient status, cropping and fruit quality is yet to be determined. Trial 2 will crop more heavily in 1994 and therefore provide more representative results in terms of fruit quality and mineral concentrations.

Potting compost supplemented with slow release nitrogen is a promising alternative to soil sterilisation, although its high acidity after two years may be a drawback. The effects of potting compost are greatest when combined with trickle irrigation.

Poor weed control by non-residual herbicides may cause reduction in growth and leaf nitrogen concentration especially on more vigorous rootstocks or scions. Trees of Bramley or Queen Cox planted in plastic or straw mulch grew better or as well as those planted in soil treated with residual soil acting herbicides.

Table 1
The main effect of soil sterilisation, nitrogen fertiliser and phosphorus fertiliser on number of fruit buds and fruit set of Queen Cox/M.9 in 1993 (Trial 2)

| | Spur and Terminal | | | | Axillary | | | |
|---|---|---|---|---|---|---|---|---|
| Main effects | No. of fruit buds | No. of fruitlets per branch | | | No. of fruit buds | No. of fruitlets per branch | | |
| | | Initial set | Final set | Pre harvest | | Initial set | Final set | Pre harvest |
| No soil sterilisation | 11 | 40 | 13 | 12 | 9 | 9 | 1 | 1 |
| Soil sterilisation | 17 | 58 | 19 | 18 | 8 | 7 | 1 | 1 |
| SED (4 df) | 2.9 | 9.4 | 2.2 | 1.7 | 2.5 | 2.3 | 0.3 | 0.3 |
| Significance level | ns | ns | ns | P<0.05 | ns | ns | ns | ns |
| | | | | | | | | |
| No irrigation | 10 | 35 | 13 | 11 | 6 | 6 | 1 | 1 |
| Irrigation | 18 | 64 | 20 | 18 | 11 | 10 | 1 | 1 |
| SED (56 df) | 1.5 | 4.9 | 1.5 | 1.4 | 1.5 | 1.8 | 0.3 | 0.3 |
| Significance level | P<0.001 | P<0.001 | P<0.001 | P<0.001 | P<0.001 | P<0.05 | ns | ns |
| | | | | | | | | |
| No nitrogen fertiliser | 15 | 50 | 18 | 16 | 6 | 6 | 1 | 1 |
| Nitrogen fertiliser | 14 | 48 | 15 | 14 | 11 | 10 | 1 | 1 |
| 20g N per tree | | | | | | | | |
| SED (56 df) | 1.5 | 4.9 | 1.5 | 1.4 | 1.5 | 1.8 | 0.3 | 0.3 |
| Significance level | ns | ns | ns | ns | P<0.01 | P<0.05 | ns | ns |
| | | | | | | | | |
| No phosphorus | 15 | 52 | 17 | 16 | 7 | 7 | 1 | 1 |
| fertiliser | 13 | 46 | 16 | 14 | 10 | 8 | 1 | 1 |
| Phosphorus fertiliser | | | | | | | | |
| 20g P per tree | 1.5 | 4.9 | 1.5 | 1.4 | 1.5 | 1.8 | 0.3 | 0.3 |
| SED (56 df) | ns | ns | ns | ns | ns | ns | ns | ns |
| Significance level | | | | | | | | |

Table 2

Total harvest yield and yield of Class I > 65 mm fruit (kg/tree), Queen Cox/M.9, 1993 (Trial 2)

| Treatment - main effect | Total | Class I > 65 mm |
|---|---|---|
| No soil sterilisation | 8.1 | 2.6 |
| Soil sterilisation | 11.1 | 2.5 |
| SED (4 df) | 1.20 | 0.47 |
| Significance level | ns | ns |
| | | |
| No irrigation | 7.7 | 2.0 |
| Irrigation | 11.5 | 3.1 |
| SED (56 df) | 0.55 | 0.27 |
| Significance level | $P<0.001$ | $P<0.001$ |
| | | |
| No nitrogen fertiliser | 9.5 | 2.5 |
| Nitrogen fertiliser 20g N per tree | 9.7 | 2.6 |
| SED (56 df) | 0.55 | 0.27 |
| Significance level | ns | ns |
| | | |
| No phosphorus fertiliser | 9.4 | 2.5 |
| Phosphorus fertiliser 20g P per tree | 9.9 | 2.6 |
| SED (56 df) | 0.55 | 0.27 |
| Significance level | $P<0.05$ | ns |

Table 3
Leaf mineral analysis (% dry matter, except Mn ppm) Queen Cox/M.9, August 1993 (Trial 2)

| Treatment | N | P | K | Mn |
|---|---|---|---|---|
| No soil sterilisation | 2.99 | 0.239 | 1.56 | 83.7 |
| Soil sterilisation | 2.78 | 0.244 | 1.62 | 86.5 |
| SED (4 df) | 0.118 | 0.0089 | 0.077 | 6.86 |
| Significance level | ns | ns | ns | ns |
| | | | | |
| No irrigation | 3.02 | 0.229 | 1.60 | 97.4 |
| Irrigation | 2.75 | 0.253 | 1.58 | 72.9 |
| SED (56 df) | 0.063 | 0.0112 | 0.046 | 4.85 |
| Significance level | P<0.001 | P<0.05 | ns | P<0.001 |
| | | | | |
| No nitrogen fertiliser | 2.81 | 0.274 | 1.64 | 75.3 |
| Nitrogen fertiliser 20g N per tree | 2.97 | 0.208 | 1.53 | 95.0 |
| SED (56 df) | 0.063 | 0.0112 | 0.046 | 4.85 |
| Significance level | P<0.05 | P<0.001 | P<0.05 | P<0.001 |
| | | | | |
| No phosphorus fertiliser | 2.88 | 0.232 | 1.57 | 83.5 |
| Phosphorus fertiliser 20g P per tree | 2.89 | 0.250 | 1.60 | 86.8 |
| SED (56 df) | 0.063 | 0.0112 | 0.046 | 4.85 |
| Significance level | ns | ns | ns | ns |

Table 4
Fruit mineral analysis of Queen Cox/M.9 (mg/100g fresh weight), September 1993 (Trial 2)

| | N | P | K | Ca |
|---|---|---|---|---|
| No soil sterilisation | 56 | 13.5 | 165 | 4.7 |
| Soil sterilisation | 54 | 12.6 | 155 | 4.9 |
| SED (4 df) | 4.2 | 0.36 | 4.7 | 0.18 |
| Significance level | ns | ns | ns | ns |
| | | | | |
| No irrigation | 57 | 12.9 | 165 | 4.6 |
| Irrigation | 53 | 13.2 | 156 | 4.9 |
| SED (56 df) | 4.3 | 0.34 | 3.8 | 0.11 |
| Significance level | ns | ns | $P<0.05$ | $P<0.01$ |
| | | | | |
| No nitrogen fertiliser | 48 | 13.1 | 157 | 4.8 |
| Nitrogen fertiliser 20g N per tree | 63 | 13.0 | 163 | 4.8 |
| SED (56 df) | 4.3 | 0.34 | 3.8 | 0.11 |
| Significance level | $P<0.001$ | ns | ns | ns |
| | | | | |
| No phosphorus fertiliser | 53 | 12.8 | 157 | 4.8 |
| Phosphorus fertiliser 20g P per tree | 58 | 13.3 | 163 | 4.7 |
| SED (56 df) | 4.3 | 0.34 | 3.8 | 0.11 |
| Significance level | $P<0.05$ | ns | ns | ns |

Table 5
Soil pH and extractable soil P measured on unsterilised plots only, August 1993 (Trial 2)

| | pH | | Extractable soil P ppm dry soil | |
|---|---|---|---|---|
| Treatment - main effect | 0 - 15 cm | 15 - 30 cm | 0 - 15 cm | 15 - 30 cm |
| No irrigation | 6.2 | 6.8 | 115 | 85 |
| Irrigation | 6.6 | 6.7 | 120 | 107 |
| SED (56 df) | 0.16 | 0.13 | 13.1 | 13.1 |
| Significance level | P<0.05 | ns | ns | ns |
| | | | | |
| No nitrogen fertiliser | 6.8 | 6.8 | 124 | 98 |
| Nitrogen fertiliser 30g N per tree | 5.9 | 6.7 | 111 | 93 |
| SED (56 df) | 0.16 | 0.13 | 13.1 | 13.1 |
| Significance level | P<0.001 | ns | ns | ns |
| | | | | |
| No phosphorus fertiliser | 6.6 | 6.9 | 55 | 60 |
| Phosphorus fertiliser 20g P per tree | 6.2 | 6.6 | 180 | 131 |
| SED (56 df) | 0.16 | 0.13 | 13.1 | 13.1 |
| Significance level | P<0.05 | ns | P<0.001 | P<0.001 |

Table 6

The effects of irrigation, soil sterilisation, conventional N fertiliser, slow release N fertiliser, water holding polymer, and potting compost on the total number of fruit buds and the final fruit set per tree Queen Cox/M.9 and Queen Cox/MM.106, 1993 (Trial 3)

| Queen Cox M.9 | Fruit buds | | Fruit set | |
|---|---|---|---|---|
| Soil management | Spur + Terminal | Axillary | Spur + Terminal | Axillary |
| No fertiliser | 58 | 8 | 31 | 2 |
| Soil sterilisation | 64 | 40 | 23 | 5 |
| Water holding polymer (Broadleaf P4, 200g per tree) | 60 | 11 | 26 | 3 |
| Nitrogen fertiliser (20g N per tree) | 58 | 27 | 28 | 4 |
| Slow release nitrogen (20g N per tree) | 71 | 36 | 26 | 4 |
| 40 litre compost and slow release fertiliser (20g N per tree) | 53 | 65 | 24 | 9 |
| Water holding polymer (200g per tree)+ slow release fertiliser (20g N per tree) | 71 | 22 | 28 | 4 |
| Fertigation | 52 | 46 | 30 | 6 |
| SED (52 df) | 14.9 | 10.9 | 6.6 | 1.8 |
| Significance level | Soil management $P<0.001$ Axillary only | | | |

| Queen Cox MM.106 | | | | |
|---|---|---|---|---|
| Soil management | Spur + Terminal | Axillary | Spur + Terminal | Axillary |
| No fertiliser | 90 | 16 | 32 | 4 |
| Soil sterilisation | 78 | 57 | 26 | 9 |
| Nitrogen fertiliser (20g N per tree) | 101 | 19 | 34 | 6 |
| 40 litre compost + slow release fertiliser (20g N per tree) | 102 | 70 | 32 | 15 |
| Fertigation | 76 | 70 | 27 | 13 |
| SED (32 df) | 16.2 | 14.8 | 7.1 | 3.4 |
| Significance level | Soil management $P<0.001$ Axillary only<br>Irrigation $P<0.05$ Spur + Terminal and Axillary | | | |

Table 7

The effects of irrigation, soil sterilisation, conventional N fertiliser, slow release N fertiliser, water holding polymer, and potting compost on the total yield per tree (kg) Queen Cox/M.9 and Queen Cox/MM.106 trees, 1993 (Trial 3)

| Queen Cox M.9 | | | |
|---|---|---|---|
| Soil management | No irrigation | Irrigation | Mean |
| No fertiliser | 2.4 | 2.9 | 2.7 |
| Soil sterilisation | 2.3 | 3.2 | 2.8 |
| Water holding polymer (Broadleaf P4, 200g per tree) | 1.5 | 2.9 | 2.2 |
| Nitrogen fertiliser (20g N per tree) | 2.3 | 3.1 | 2.7 |
| Slow release nitrogen (20g N per tree) | 1.9 | 2.7 | 2.3 |
| 40 litre compost and slow release fertiliser (20g N per tree) | 2.7 | 3.4 | 3.1 |
| Mean | 2.2 | 3.0 | |
| Water holding polymer (200g per tree) + slow release fertiliser (20g N per tree) | 2.1 | | |
| Fertigation | | 3.3 | |
| SED (52 df) | 0.50 | | |
| Significance level: Soil management ns; Irrigation $P<0.001$ | | | |

| Queen Cox MM.106 | | | |
|---|---|---|---|
| Soil management | No irrigation | Irrigation | Mean |
| No fertiliser | 2.7 | 3.4 | 3.1 |
| Soil sterilisation | 2.9 | 3.9 | 3.4 |
| Nitrogen fertiliser (20g N per tree) | 2.6 | 3.5 | 3.1 |
| 40 litre compost + slow release fertiliser (20g N per tree) | 3.7 | 4.6 | 4.2 |
| Mean | 3.0 | 3.8 | |
| Fertigation | | 3.2 | |
| SED (32 df) | 0.51 | | |
| Significance level: Soil management $P<0.05$; Irrigation $P<0.01$ | | | |

Table 8

The effects of irrigation, soil sterilisation, conventional N fertiliser, slow release N fertiliser, water holding polymer, and potting compost on the total new shoot growth (dm) of Queen Cox/M.9 and Queen Cox/MM.106 trees, 1993 (Trial 3)

| Queen Cox M.9 | | | |
|---|---|---|---|
| Soil management | No irrigation | Irrigation | Mean |
| No fertiliser | 33 | 53 | 43 |
| Soil sterilisation | 105 | 122 | 114 |
| Water holding polymer (Broadleaf P4, 200g per tree) | 15 | 55 | 35 |
| Nitrogen fertiliser (20g N per tree) | 37 | 82 | 60 |
| Slow release nitrogen (20g N per tree) | 35 | 70 | 53 |
| 40 litre compost and slow release fertiliser (20g N per tree) | 53 | 152 | 103 |
| Mean | 46 | 89 | |
| Water holding polymer (200g per tree) + slow release fertiliser (20g N per tree) | 40 | | |
| Fertigation | | 72 | |
| SED (52 df) | 27 | | |
| Significance level: Soil management $P < 0.001$; Irrigation $P < 0.001$ | | | |

| Queen Cox MM.106 | | | |
|---|---|---|---|
| Soil management | No irrigation | Irrigation | Mean |
| No fertiliser | 47 | 85 | |
| Soil sterilisation | 110 | 142 | |
| Nitrogen fertiliser (20g N per tree) | 45 | 75 | |
| 40 litre compost + slow release fertiliser (20g N per tree) | 98 | 131 | |
| Mean | | | |
| Fertigation | | 92 | |
| SED (32 df) | 26 | | |
| Significance level: Soil management $P < 0.01$; Irrigation $P < 0.05$ | | | |

Table 9

The effects of irrigation, soil sterilisation, conventional N fertiliser, slow release N fertiliser, water holding polymer, and potting compost on soil pH, 1993 (Trial 3)

| Queen Cox M.9 | Not irrigated | | Irrigated | | Mean | |
|---|---|---|---|---|---|---|
| Soil management (Depth) | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| No fertiliser | 6.5 | 6.8 | 7.0 | 7.0 | 6.8 | 6.9 |
| Soil sterilisation | 6.4 | 6.4 | 6.9 | 6.9 | 6.6 | 6.6 |
| Water holding polymer (Broadleaf P4, 200g per tree) | 6.8 | 6.8 | 7.1 | 7.0 | 7.0 | 6.9 |
| Nitrogen fertiliser (20g N per tree) | 5.5 | 6.4 | 6.8 | 6.9 | 6.1 | 6.6 |
| Slow release nitrogen (20g N per tree) | 6.4 | 5.9 | 6.7 | 6.8 | 6.6 | 6.4 |
| 40 litre compost and slow release fertiliser (20g N per tree) | 4.2 | 4.7 | 4.1 | 4.7 | 4.1 | 4.7 |
| <u>Mean</u> | 6.0 | 6.2 | 6.4 | 6.6 | | |
| Water holding polymer (200g per tree)+ slow release fertiliser (20g N per tree) | 6.4 | 5.9 | | | | |
| Fertigation | | | 6.6 | 6.8 | | |
| SED (52 df) | 0.31 | 0.31 | | | | |

Significance level Soil management $P<0.001$ Both depths
Irrigation $P<0.001$ 0-15 cm, $P<0.01$ 15-30 cm

Table 10
The effect of different soil management treatments on total new shoot length per tree
Bramley/M.9, 1993 (Trial 4)

| Treatment | Length (cm) |
|---|---|
| Non-residual herbicide | 420 |
| Plastic mulch | 566 |
| Residual herbicide | 532 |
| Organic mulch | 578 |
| | |
| SED (36 df) | 60.5 |
| Significance level | $P<0.05$ |

Table 11
The main effect of different soil management treatments on leaf mineral concentration % dry weight, Bramley/M.9, August 1993 (Trial 4)

| Treatment | N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| Non-residual herbicide | 2.11 | 0.17 | 1.58 | 1.50 | 0.204 |
| Plastic mulch | 2.46 | 0.15 | 1.61 | 1.37 | 0.190 |
| Residual herbicide | 2.38 | 0.14 | 1.64 | 1.38 | 0.194 |
| Organic mulch | 2.45 | 0.15 | 1.66 | 1.56 | 0.180 |
| SED (36 df) | 0.044 | 0.008 | 0.056 | 0.056 | 0.0069 |
| Significance level | P<0.001 | P<0.001 | ns | P<0.01 | P<0.05 |

Table 12
The effect of different soil management treatments on total harvest and yield per tree and Class I = > 65 mm (kg/tree), Queen Cox/M.9 and Queen Cox/MM.106, 1993 (Trial 5)

| | M.9 | | MM.106 | |
|---|---|---|---|---|
| Treatment | Yield (kg) | Class I (kg) | Yield (kg) | Class I (kg) |
| Non-residual herbicide | 3.6 | 2.2 | 3.5 | 0.6 |
| Plastic mulch | 4.2 | 2.9 | 5.0 | 2.9 |
| Residual Herbicide | 3.7 | 2.2 | 4.0 | 1.6 |
| Organic mulch | 3.3 | 2.0 | 3.8 | 2.0 |
| SED (56 df) | 0.37 | 0.34 | 0.37 | 0.34 |

Significance level

| | Yield | Class I > 65 mm |
|---|---|---|
| Soil management | $P<0.001$ | $P<0.001$ |

Table 13
The effect of different soil management treatments on shoot length of Queen Cox/M.9 and Queen Cox/MM.106, 1993 (Trial 5)

| Treatment | Rootstock | |
|---|---|---|
| | M.9 Length (dm) | MM.106 Length (dm) |
| Non-residual herbicide | 109 | 78 |
| Plastic mulch | 119 | 174 |
| Residual herbicide | 112 | 108 |
| Organic mulch | 104 | 167 |
| SED (56 df) | 20.5 | 20.5 |

Significance level

Soil management $P < 0.01$