East Malling Trust for Horticultural Research Report

Project SP73: Improving precocity and cropping of pear varieties

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Part I

Final Project Summary Report

A. Commercial implications of results

Importance of Initial Tree Quality at Planting

- Planting large well-feathered trees may increase floral bud and yields in the first year of cropping, but may have little influence after that.

- Larger sized Comice trees do develop more flower buds per tree, but unfortunately failed to show increased yields.

- The rootstock OHF 69 (*Pyrus communis*) was more vigorous than BA 29 (*Cydonia*), but the latter may be more drought tolerant; trees on OHF 69 respond positively to irrigation while those on BA 29 did not.

Ways of Improving Tree Establishment

- Trickle irrigation may be beneficial to the establishment, precocity and fruit size of Concorde pear trees on QC rootstock, particularly in dry summer seasons.

Ways of influencing Flower Initiation

- Trickle irrigation of young Comice trees is not recommended, as it stimulates strong competing extension shoots, and reduces flowering and fruit set.

- Vertical branch orientation is at least as suitable as a more horizontal angle which, failed to increase flower bud number.

- Flower bud initiation was increased in trees which were root-restricted; root-restriction was also a very effective way of reducing shoot growth for several scion rootstock combinations.

- Flower bud initiation was generally not increased in trees, which were root-pruned, despite this being a very effective way of reducing shoot growth.

- Ring barking did reduce shoot growth of Concorde but not Comice.

Ways of Increasing Fruit Set

- Trickle irrigation fails to consistently show any benefits by increasing fruit set.
- Root-pruning (at flowering time) was very effective in reducing extension shoot growth on young Concorde and Comice pear trees, but has adverse effects on fruit set and yields.
- There was no evidence that autumn sprays of urea and boron increased the fruit setting potential of any age or type of flower.
- Sprays of prohexadione-Ca consistently reduced shoot extension growth, but there was no benefit of increased fruit set or cropping observed.
- Branch orientation to a more horizontal angle failed to increase fruit set as noted earlier.
- Ring barking did reduce shoot growth and increase early yields of Concorde the same was not true for Comice as noted earlier.
- Only sprays of GA_3 were shown to be beneficial to fruit set.

Ways of Promoting Flower Quality

- Terminal and axillary flowers are larger and set more fruit than other flower types such as spurs and, therefore, their number should be promoted.
- The higher potential for setting fruit of terminal flower clusters was associated with the following:

  A lower potassium concentration compared to axillaries and spur type flowers

  Higher concentrations of sodium, and also magnesium, manganese, copper and zinc compared to axillaries and spur-type flowers.

- Autumn sprays of urea failed to increase the nitrogen content of ‘Conference’ and ‘Concorde’ flowers.
- Autumn sprays of 'Bortrac' dramatically increased the boron content of ‘Conference’ and ‘Concorde’ flowers.
- Different flower parts have markedly different concentrations of mineral elements.
- Mineral analysis of different flower parts, rather than whole flowers, appears to be the best way to establish correlations with deficiency problems and to determine the benefits of any remedial strategy.

B. Summary of research findings

Improving the precocity and cropping of pear varieties

Work area 1. Factors Influencing Flower initiation

To study factors influencing initiation of flowers in young pear trees.

Rootstock effects

It is known that Quince C (QC) rootstock induces better precocity of yield than Quince A (QA) in UK pears, but less is known of the effects of other quince rootstock clones. Trees of Comice were budded at 15, 30 or 45cm above ground on QR 193/16 or QC rootstocks, and were planted in 1994. Tests on HRI quince clone QR 193/16 showed that it is easy to propagate, of intermediate vigour between QC and QA, and supports fruit production of larger size than on QC. The numbers of flower buds produced in 1996 were greater for the trees on QC than for those on QR 193/16. The numbers of flower buds per tree set per 100 flower buds and yield per tree increased relative to the increasing height of budding on the QC rootstocks; there was no effect of height of budding for trees on QR 193/16 rootstocks. In 1997, the abundance of flowers was better for trees on QC than on QR 193/16 rootstocks; in contrast to 1996, flower abundance was increased for the low-budded QC trees. There may have been a residual effect of the heavier cropping on the higher-budded trees during the preceding year.

Root restriction effects

In 1994 there were two trials on the effects of the restriction of roots of young pear trees. Poorly feathered maiden 'whips' of Conference, on quince rootstock BA 29 or the *Pyrus* rootstock clone OHF 69, were planted within fabric membranes buried in soil and their growth and cropping were compared with that of unrestricted trees grown with or without trickle irrigation. Root-restricted trees on both rootstocks produced much less shoot growth than the unrestricted trees. In 1996 the restriction treatment slightly increased the numbers of flower buds per tree on both rootstocks. The numbers of flower buds per tree were not increased in 1997 by the treatments on a per tree basis. However, the density of flower buds was increased by treatments when related to smaller tree size. Initial and final fruit set, on a per tree and on a per 100 flower buds basis, were increased for root-restricted trees on BA 29 rootstock but were reduced slightly using trees on OHF 69.

Effects of root pruning

Concorde and Comice trees on QC rootstock were root-pruned annually each May, commencing 15 months after planting (spring 1994). Root-pruning significantly reduced the total shoot extension growth of Concorde and Comice. Effects on the production of flower buds per tree were inconsistent but, when differences in tree size was accounted for, the treatments were shown to increase flower density. Because the initial or final fruit set per tree were not increased, there was a reduction in yield.

Effects of ring barking

Young Comice and Concorde trees planted on QC rootstock in spring 1994 were ring-barked annually. The treatment was carried out in either August, late September, early May, or late June and the effects were assessed using untreated trees. The treatments began in the first August (1994) following Spring planting. The growth of shoots of the Concorde trees was reduced by the August, September and May ring barking treatments; there were no effects on Comice trees. The numbers of flower buds were not increased by ring barking; fruit set on the Comice trees was very low in 1995 but was improved slightly by ring barking in either September 1994 or May 1995. Early yields of Concorde were increased only slightly by the August, September and May treatments, while effects on the yields of Comice were inconsistent. It is possible that more severe ring barking, or more frequent application of the treatments to maintain the wound over a longer period, might prove more efficient in the reduction of shoot growth and increased flowering and fruit set.

Effects of branch bending

Maiden trees of cv. Comice were planted and the branches were either orientated to the near horizontal or allowed to grow into their natural upright habit. During the first two years, there were no benefits on the numbers of flower buds or fruit set from orientating branches to the horizontal. By 1996, trees with their branches orientated to the near horizontal set and retained more fruit.

Chemical control of tree growth

The potential of alternatives to CCC for improving the precocity of cropping in Conference have been examined. Sprays of GA_{4+7}, sometimes with small additions of GA_3, showed promise in improving fruit set on pear trees in their second to fourth years following planting as 2-year-old trees. Early results suggest that benefits from precocity of cropping will come from irrigation, branch training, and sprays of gibberellic acid and improvements in tree quality. These advantages can be cultivar-specific and transient. Chemical agents such as cycocel (CCC) are effective in reducing unwanted shoot growth and in stimulating the production of good quality flower buds and yield. However, such growth retardants are not approved for use in the UK, and the UK grower must seek other methods to improve pear precocity.

Work area 2. Examine Ways of Improving Tree establishment

To study the means of achieving better tree establishment in the orchard.

Effects of supplementary irrigation

Trickle irrigation was used during the establishment of Comice and Concorde trees on

QC rootstocks. Vegetative growth was stimulated by irrigation without any increase in the abundance of flower buds. Eventually, irrigation increased the numbers of flower buds per tree on Comice but much of this effect was due to the larger size of the trees, stimulated by irrigation. Fruit set of Concorde trees in 1995 was increased slightly by irrigation. Irrigation of Concorde trees had no benefits in 1996 or on Comice trees in either year. The yields of Concorde were increased by irrigation treatments in 1995 and 1996; these increases were largely attributable to improved fruit size.

Work area 3. Assess the Importance of Initial Tree quality

To study the ways in which tree quality at planting might influence precocity.

Effects of maiden tree size and feathering

The growth and precocity of two sets of 2-year-old trees were compared in a trial of Concorde and Comice planted in spring 1994 on QC rootstocks. One set of trees had a few feathers, the second set were larger with abundant feathers. In spring 1995, the larger Concorde trees developed more than twice the number of flower buds compared to the smaller trees. The initial and final fruit set per 100 flower buds were higher on the larger Concorde trees, however, the size of individual fruits was reduced by 24%. The improved precocity of flowering on the larger Concorde trees was of short duration; after one year, there were no differences in the abundance of flowers between the two sizes of tree.

Improving the flower quality and fruit setting capacity of pears

Work area 1. Investigation of flower quality

Flowers were collected from ‘Conference’ and ‘Concorde’ and were dissected into 5 parts; the different parts were analysed separately for a range of major and minor nutrients. The analysis performed on flower parts showed that the concentration of all the mineral elements determined varied greatly within different parts of the flower and cultivars. This flower analysis showed that petals had the lowest concentrations of all the major nutrients.

The mineral concentration of different sized flower clusters (numbers of flowers) of ‘Conference’ pear was examined, for a range of flower types. The mineral concentrations varied very little between flowers of different size; there was, however, a significantly higher concentration of boron in small sized clusters. Differences in the mass of the different sized flower clusters were largest for terminal flowers, followed by axillaries and 2- and 3-year-old spurs. ‘Conference’ and ‘Concorde’ trees set more fruit on larger sized flower clusters.

Experiments showed that terminal and axillary flowers had a greater potential to set and retain fruit. The final measurements made in August for ‘Conference’ and ‘Concorde’ showed that fruit set was not only greater on flowers produced on younger wood (terminal and axillary positions), but also on flower clusters, which morphologically contained more individual flowers and had a greater mass.

Work area 2. Examine Ways of Promoting Flower Quality

Applications of nitrogen, as urea, did not show any effects on the nitrogen concentration of any flower parts for either 'Conference' or 'Concorde' flowers. Urea-treated trees also did not show any indirect changes in the concentration of other minerals in their flowers. The failure to see an increase in flower tissue nitrogen concentration, particularly in the spur leaves, is surprising considering the evidence for apple. The situation was clearly different with flowers that had been treated by autumnal sprays of 'Bortrac'. Flowers of 'Conference' and 'Concorde' showed significantly higher concentration of boron in all flower parts measured.

Neither autumn spray application of urea nor 'Bortrac' could be shown to significantly change flower bud number or final fruit set for either cultivar. Changes in set associated with flowers treated with urea might not be expected because of the lack of evidence to show an increase in tissue nitrogen concentration. For the 'Bortrac' applications, however, benefits to fruit set might be expected from the increases in boron within all 'Conference' and 'Concorde' flower parts. The effects of 'Bortrac' and urea sprays on this pattern of final fruit set remained unchanged compared to the controls.

Work area 3. Determine Ways of Increasing Fruit Set

Evidence suggests that prohexadione-Ca, a GA biosynthesis inhibitor, restricts the extension growth of shoots. 'RETAIN™' (aminoethoxyvinyl-glycine, AVG), which is an inhibitor of ethylene production, was also applied to some trees to determine whether fruit set could be enhanced. The results show that the spraying of prohexadione-Ca was very effective in reducing shoot extension, at least of Conference. For prohexadione-treated trees, the rate of shoot extension growth was reduced compared to untreated control trees, but apical buds appeared to remain active after control buds had become dormant. There is, however, no evidence that the fruit setting potential of trees treated with prohexadione-Ca of AVG is enhanced.

Sprays of a range of various plant growth regulating hormones have been applied to increase the fruit setting capacity of 'Conference' and 'Concorde' trees, with the exception of GA_3, no benefits have been evident.

Experiments with 'Comice' pear showed that branch orientation had no influence on the development of fruit buds or their ability to set and retain fruit.

Trees of 'Concorde' and 'Comice' have been grown in root-resticting membranes over several years, to enhance fruit bud production and cropping. For 'Comice' and 'Concorde' there was no evidence to show that root-restriction increased floral bud production or cropping, despite significant decline in annual shoot growth.

C. Improving precocity of cropping in pear trees

Background

Pears are subject to a number of problems, which have major effects on cropping. In the UK, crop yields, on a per hectare basis, are less than half of the EC average. Those pear varieties which predominate commercially (Conference, Comice and to some extent Concorde also) are considerably less precocious than is apparent with apple. The commercial profitability of pear production depends greatly on how quickly the trees come into full cropping. The reasons why precocity should be variable are some what unclear. This situation may have much to do with the limited extent to which attempts have been made to seek improvements in precocity by experimental husbandry and breeding.

Irregularity of cropping is a major problem facing the UK pear growing industry. The multiples demand a product which can be supplied consistently over a predictable time period and which is of large size and high quality. Recently, official government statistics (Basic Horticultural Statistics of the United Kingdom - MAFF) have indicated that UK pear production is failing to fulfil the UK market demands (East Malling Members Day 1997). This does not appear to be due to reduced consumer demand for the product, as imports of pears are increasing slowly. Without the support of further R&D to help pear growers overcome these inconsistency of supply problems, the multiples will continue to use imports, and the prospects for UK pear growers will continue to be uncertain.

Project aim

The aim of this programme is to adopt a co-ordinated approach to include three areas of work directed at the improvement of pear precocity. Field trials will be undertaken to assess the value of a range of material used as rootstocks. Attention will also be given to studying the methods by, which tree establishment in the orchard can be improved. Within this area opportunity exists for collaboration with the HRI-EM Crop Science Department Propagation Team in their APRC-funded work (project SP52) on maiden pear tree production. Material developed under this programme will provide trees, which can be used to study aspects of orchard establishment, as it relates to tree quality at planting. Studies of the influence of nursery tree quality will also include material brought in from commercial nurseries. The influence that shoot and root manipulation has on flower initiation and quality will also be examined. This area will include work on aspects of tree nutrition and the importance of the timing of irrigation events.

Project objectives

To improve tree establishment, precocity and cropping of pear varieties.

Project work plan

Work area 1. Factors Influencing Flower initiation

To study factors influencing initiation of flowers in young pear trees.

- What influence does branch orientation have on flower production and fertility and what is the best time to manipulate branches to achieve maximum beneficial effects?
- How important are foliar applications of nitrogen in influencing flower quality.
- Can restricting root development be beneficial?

Work area 2. Examine Ways of Improving Tree establishment

To study the means of achieving better tree establishment in the orchard.

- What is the optimum size of a nursery tree for good establishment and precocious cropping?
- Are there nursery treatments that can influence orchard establishment and precocity (examination of SP52 trees)?
- How important is irrigation during the first year of growth in the orchard, in influencing precocity?

Work area 3. Assess the Importance of Initial Tree quality

To study the ways in which tree quality at planting might influence precocity.

- The influence of nursery practice (time of heading back, number of feathers etc.) on tree quality will be assessed using material from SP53.
- Assessment with be made of commercial tree quality; equating tree feather number with precocity.

D. Improving the flower quality and fruit setting capacity of pears

Background

Pear production in the UK is frequently inconsistent from season to season and all the varieties planted commercially in the UK are slow to come into cropping following planting (i.e. exhibit poor yield precocity). Current work at HRI-East Malling (project SP73), is attempting to improve pear precocity by adopting and testing a number of orchard management techniques, which have previously been shown to increase speed of cropping in apple. This work has shown that several of these cultural operations can provide some benefit by enhancing pear precocity. Improvements to pear precocity were achieved by the use of high quality 2-year-old-trees (large size) at planting, the use of trickle irrigation and branch training (East Malling Members Day 1997). However, some of these improvements in precocity have not been achievable with all the cultivars tested, particularly with 'Comice' which has strong vegetative vigour, compared with 'Concorde' or 'Conference'. It was also apparent that with several of the other tree management treatments, flower bud number per tree increased, but in the absence of any increases in cropping.

The reasons why increasing the number of flower buds per tree often failed to produce an increased fruit yield is not entirely clear. It may be attributable to poor initial fruit set, or it may be attributable to excessive fruitlet abscission during fruitlet development. In the experiments above it was shown that initial fruit set was poor, suggesting that the most likely explanation for the failure of flowers to produce fruit is associated either with floral bud initiation and development or pollination and fertilization. Flower 'quality' has often been cited as a key determinant in fruit set and retention, although the term 'flower quality' is frequently ambiguous. What is known is that the unfertilized ovule within the flower has only a limited life-span, and if pollen transfer to the stigma is delayed or pollen tube growth down the style is slow, the ovule may have ceased to be receptive to fertilization by the time the pollen tube reaches it. It would appear that flowers which are of 'good quality', i.e., those which are large and well nourished, have a greater potential to maintain their ovules in a viable state for a longer period of time. This provides a buffer against poor weather conditions that may limit pollen transfer (pollination) and slow the rate of pollen tube growth prior to fertilization. Visual observations in pear orchards demonstrate a high degree of gross morphological variability in floral development, which can probably be related to their fruit setting capacity (East Malling Members Day 1997).

Project aim

The purpose of this study is to improve the economic performance of UK pear orchards by improving the precocity of young orchards.

Project objectives

This will be achieved firstly by identification of the reasons why pear flowers on young trees frequently fail to set fruit and the factors (genetic, climatic and cultural) which influence flower quality and fruit set and retention. Once this is achieved the aim will be to develop methods to produce flowers with high fruit set and retention. The new objectives of the study were as follows:

1. To describe and quantify 'flower quality' in 'Conference' and 'Comice' pear by comparison of poor and good quality flowers and linking this to easily measurable attributes.

2. To determine how differences in 'flower quality' influence fruit set, fruitlet retention and cropping potential.

3. To examine cultural and other ways of improving 'flower quality'.

4. To develop successful methods for increasing fruit setting and crop yields.

Work plan

The majority of the work described below will be conducted on the variety Conference, growing on Quince rootstocks

Work area 1. Investigation of Flower Quality

A study will be made of how flowers, which differ in their morphology, phenology, mineral status or location on the tree, differ in their fruit setting capacity. This will include examination of a number of floral attributes believed to be associated with flower quality, i.e. their mineral status, the age of wood on which flowers are produced, the location of spurs, the size of floral parts, the number of flowers per inflorescence, length of flower stalks, the presence or absence of supporting spur leaves and the presence of brindle shoots. Variation in these factors will be assessed in relation to the ability of flowers to set and retain fruit.

Flower initiation will be monitored, and the implications of this on the timing of remedial strategies to enhance flower quality and fruit setting capacity will be assessed. Flower quality will also be examined by determining the ability of flowers to set by measurement of the effective pollination period (EPP) of the appropriate cultivars (not self-pollinating).

Work area 2. Examine Ways of Promoting Flower Quality

A series of orchard management strategies to promote flower quality will be used. This will include the application of boron, zinc and/or nitrogen in the autumn to promote flower development and subsequent flower quality. Other experiments will examine the effects of shoot pruning and training strategies on the 'quality' of the flowers produced.

Work area 3. Determine Ways of Increasing Fruit Set

Preliminary evidence suggests that remedial treatments with hormones can improve the flower setting potential of pears. This approach will involve an evaluation of the effectiveness of various gibberellins (GA_3, or GA_{4+7}) and their commercial formulations ('Berelex' and 'Regulex') and/or benzyladenine (Axcel, Paturyl or Promalin) on fruit set and retention. The effectiveness of aminoxyvinyl-glycine (AVG - 'Retain') in preventing fruitlet abscission on young pear trees will also be studied.

Work area 4. Assess Improvements in Fruit Quality

The effects of flower bud quality on fruit size and grade out will be assessed in all of the experiments.

Part II

Final interim report for March 2000

Project SP73: **Improving precocity and cropping of pear varieties**

Project Staff: C.J. Atkinson L. Taylor and A.D. Webster

Date: Final Interim Report March 2000

Background

In this report data are presented and comments made on the conclusions that can be drawn from a number of experiments, which have attempted to enhance the fruit setting capacity of 'Conference' pear trees. This work also includes some results from experiments involving 'Concorde' and Comice pear. Attempts to increase the fruit setting and yield capacity of pear trees has been explored through; the application of plant growth regulators to increase set and reduce vegetative growth, the re-orientation of canopy branch angles and the restriction of root growth. The results within this report highlight the effects of these treatments on the 1999 cropping performance (yield and quality, i.e. fruit size) and the tree's vegetative growth and, in some cases, data is presented of tree grubbing weights (above ground tree fresh weights).

Methods

All of the experiments reported (applications of plant growth regulators, branch orientation and root-restriction) here were on-going and the details of the experimental set up, replication and treatments have been presented in earlier interim report (e.g. see SP73 September 1999 SP73 report). More detailed information in presented, in the figure legends, regarding the concentrations of the chemicals used.

Results

Effects of autumn spray of urea and 'Bortrac' on cropping and tree growth

Previous results had shown that neither autumn spray application of urea nor 'Bortrac' could be shown to significantly change flower bud number or final fruit set of 'Conference' of 'Concorde' pear (see September 1999 SP73 report). Measurements of crop from 'Conference' trees taken at harvest support this with no suggestion of any increase in cropping due to autumnal sprays of boron or nitrogen (Figure 1a). For 'Concorde', however, there was some suggestion of an increase in yield, in response to applied boron, through an increase in fruit number (Figure 1c). For both cultivars, there were no effects on total shoot growth per tree for 1999, or for any other parameter used to assess vegetative growth (Figure 1b and 1d).

Effects of shoot growth restricting chemicals on cropping and tree growth

Previous evidence obtained from experiments in 1998 showed that prohexadione-Ca, a GA biosynthesis inhibitor, restricted the extension growth of shoots. RETAIN^{TM}' (aminoethoxyvinyl-glycine, AVG), which is an inhibitor of ethylene production, was also applied to some trees to determine whether cropping could be enhanced. The aim of these experiments was to determine whether shoot growth could be controlled consistently from season to season and whether this reduction in shoot growth enhanced fruit production, through a change in the partitioning of resources into fruit growth. These treatments were applied to 'Conference', Concorde' and 'Comice' trees, but there was no evidence to suggest that reducing shoot growth produced any correlative increase in initial fruit setting potential (see September 1999 SP73 report). The crop yields recorded for 'Conference' and 'Comice' trees treated with, either AVG, or prohexadione-Ca and their combinations were no different than untreated trees (Figures 2a and 2e). There was some evidence that for 'Concorde' treated trees that the prohexadione-Ca treatment may have increased yield slightly (Figure 2c). The effects of prohexadione-Ca on vegetative shoot growth appeared to differ between cultivars, while AVG alone showed no response, irrespective of culitvar (Figures 2b, 2d and 2f). Prohexadione-Ca caused a small reduction in shoot growth for 'Concorde' (Figure 2d), a larger reduction for 'Conference' (Figure 2b) and was only effective in reducing shoot growth of 'Comice' in combination with AVG (Figure 2f).

Applications of other plant growth regulating hormones to cropping

Sprays of a range of various plant growth regulating hormones (GAs, Promalin and AVG) were applied to 'Conference' trees with the aim of enhancing fruit set. Sprays of GA had no effect on the numbers of final fruit, which set on 'Conference' trees (see September 1999 SP73 report). Crop yields for 'Conference' where unaffected by any of the remedial treatments (Figure 3a). The only obvious effect, on shoot growth, of these growth-regulating chemicals was that of the GA_{4+7} + GA_3 treatment, where total shoot length was reduced (Figure 3b). Trees treated with GA_{4+7} + GA_3 did have the highest mean number of fruits per tree and the lowest mean individual fruit weights. This result implies a possible crop load, tree growth interaction.

Sprays of a range of various plant growth regulating hormones (Ethrel and GA_3) were also applied to 'Concorde' there was a slight suggestion that GA_3 might have increased final fruit set slightly, but this has not been proved statistically (see September 1999 SP73 report). Trees of 'Concorde' treated with GA_3 did show higher yields than untreated control trees, which was reflection of a greater number of fruit per tree (Figure 4a). Despite some variability between treatments there was no significant treatment effect or interaction between shoot growth and Ethrel/GA_3 treatment and fruit number (Figure 4b).

Orientation of branches to reduce shoot growth and enhance cropping.

Experiments with 'Comice' pear have now finished; results from one final year have been taken to determine the influence of branch orientation on cropping. As recorded in previous years, the angle at which branches are re-orientated, either vertical or horizontal, had no significant influence on either the number of fruit buds produced (in the year before flowering) or in their subsequent capacity to set and retain fruit (see September 1999 SP73 report). Crop weights show that orientating branches from their upright habit to a more horizontal angle did not benefit yield (Figure 5a). Yields on horizontally and vertically orientated branches were very similar; however, spur pruning actually reduced the cropping potential of branches at both orientations. Measurements of shoot growth showed that there were no differences between vertically and horizontally orientated branches (Figure 5b). There was evidence to suggest that spur pruning increased shoot growth through an increase in shoot number, particularly for the horizontally orientated branches. The fresh weights of the above ground parts of these trees measured at grubbing, suggested that trees with vertically orientated branches had made more total growth, since planting in 1994, than horizontally orientated trees (Figure 5c).

Root restriction as a means of reducing shoot growth and enhancing cropping

Trees of ‘Concorde’ and ‘Comice’ have been grown in root-resticting membranes over several years (since 1994), in an attempt to enhance fruit bud production and cropping. The result obtained for ‘Concorde’ and ‘Comice’, showed that there was no evidence that root-restriction increased floral bud production, despite a significant decline in annual shoot growth (see March 1999 SP73 report). Fruit setting potential did, however, appear to be enhanced but only in the large rectangular root-restriction membrane. For root-restricted ‘Concorde’ trees this treatment showed a higher yield than the untreated control trees (Figure 6a). The yields obtained for the root-restricted ‘Comice’ trees were all lower than that those obtained from the unrestricted control trees (Figure 6c). For both the ‘Concorde’ and ‘Comice’ trees, root-restriction dramatically reduced shoot growth, principally by reducing the number of shoots on a per tree basis (Figure 6b and 6d). As expected from the annual measurements of shoot growth, tree size after 6 years of growth, was markedly reduced (>50% in the most restricting) in all treatments with restricted roots, irrespective of cultivar. The response was however, slightly greater for the more vegetatively vigorous ‘Comice’ (Figure 6e).

Figure legends for March 2000 report

Figure 1

The cropping and the end of season shoot growth of ‘Conference’ (a, b) and ‘Concorde’ (c, d) trees treated with autumn sprays of ‘Bortrac’ and urea.

The sprays were applied until run-off at the following concentrations; ‘Bortrac’ (14 ml per 3.5 litres), ‘Bortrac’ x2 (28 ml per 3.5 litres), and Urea (350g per 3.5 litres). The standard errors of the means are shown for comparison.

Figure 2

The cropping and the end of season shoot growth of ‘Conference’ (a, b), ‘Concorde’ (c, d) and ‘Comice’ (e, f) trees after treatment with either prohexadione-Ca or ‘ReTain’ (AVG) plus prohexadione-Ca).

The sprays were applied until run-off at the following concentrations; ‘ReTain’, (2.5g per 3 litres), ‘ReTain’ (2.5 g in 3 litres) and prohexadione-Ca (0.27 g per litre), prohexadione-Ca (0.27 g per litre). The standard errors of the means are shown for comparison.

Figure 3

The cropping (a) and the end of season shoot growth (b) of ‘Conference’ trees after treatment with GA_{4+7}, GA_{4+7} and GA_3, ‘Promalin’, ‘Promalin’ and GA_3, ‘ReTain’ (AVG) and ‘ReTain’ double dose.

The sprays were applied until run-off at the following concentrations; GA_{4+7} (12 ml per 3 litres), GA_{4+7} (6 ml per 3 litres) and GA_3 (0.03g per 3 litres), ‘Promalin’ (6 ml per 3 litres), ‘Promalin’ (3 ml per 3 litres) and GA_3 (0.03g per 3 litres), ‘ReTain’ (2.5g per 3 litres) and ‘ReTain’ (5.0g per 3 litres). The standard errors of the means are shown for comparison.

Figure 4

The cropping (a) and the end of season shoot growth (b) of ‘Concorde’ trees after treatment with, ‘Ethrel’, ‘Ethrel’ double dose, ‘Ethrel’ plus GA_3, ‘Ethrel’ double dose plus GA_3 and GA_3.

The sprays were applied until run-off at the following concentrations; ‘Ethrel’ (125 ppm or 0.65 ml in 2.5 litres), ‘Ethrel’ double dose (250 ppm or 1.3 ml in 2.5 litres), ‘Ethrel’ (125 ppm or 0.65 ml in 2.5 litres) plus GA_3 (50 ppm or 0.91g in 2.5 litres), ‘Ethrel’ double dose (250 ppm or 1.3 ml in 2.5 litres) plus GA_3 (50 ppm or 1.3 ml in 2.5 litres) and GA_3 (1.3 ml in 2.5 litres). The standard errors of the means are shown for comparison.

Figure 5

The cropping (a) and the end of season shoot growth (b) and grubbing weights (c) of ‘Comice’ trees with branches orientated to either the horizontal or the vertical and spur pruned.

Treatment codes are as follows: Horiz, horizontally orientated branches; Horiz + spur, horizontally orientated branches that were spur pruned; Vert, vertically orientated branches; Vert + spur, vertically orientated branches that were spur pruned. The standard errors of the means are shown for comparison.

Figure 6

The cropping (a, c) and the end of season shoot growth (b, d) and grubbing weights (e) ‘Concorde’ and ‘Comice’ trees subject to root-restriction by growing within membranes within the soil.

Treatment codes refer to the size of membrane used and its shape; Control, no membrane; Large V, the 187 litre V-shaped membrane; Small V, the 91 litre V-shaped membrane; Large R, the 187 litre rectangular shaped membrane; Small R, the 91 litre rectangular shaped membrane. The standard errors of the means are shown for comparison.