Grower Summary

TF 206

Comparison of Different Planting Material for Fruit Wall Orchard Systems for Apple

Final 2019

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GROWER SUMMARY

Headline

- Based on this six year trial of five different apple Gala tree planting types, Two-Year-Old, Standard Knip and One-Year Five-plus-Branches tree types would be more profitable than One-Year Unfeathered and Twin Stem for growing in a Fruit Wall system

Background and expected deliverables

Growers in many countries are actively looking for ways to reduce labour inputs and increase the use of mechanical aids in a range of fruit crops. With a general decline in skilled labour, ease of management is another requirement, but in all these developments it is essential that there is no loss of yield or quality. In fact, an increase in yields will be required to enable growers to maintain profitability.

Following the successful development and commercial uptake of the Concept Orchard (AHDB Horticulture Project TF 151) by many UK growers, further evolution and development of more intensive planting systems is being considered. In TF 151, reference was made to 'Le Mur Fruitier', a newly developed orchard system in France. Further developments of this system have been carried out privately and at the PC Fruit Research Station in Sint Truiden, Belgium. Generally this work has been done in existing orchards that have been adapted to the new pruning regime and generally on varieties not grown in the UK. Results have shown that the principles developed in the work by CTIFL in France can apply in more northern growing areas. However, they need to be adapted to local growing conditions and varieties, as the timing of pruning is critical and specific to individual varieties, whilst the length of the growing season varies in different geographical areas.

Little work has been done on ways of establishing Fruit Wall orchards and which type of tree gives the best results. Conventionally produced trees have a form and structure ideally suited to wider spacings, where a branch framework is necessary, but they can be adapted to be managed in a Fruit Wall planting. However, other tree types may be more suitable, either because they are cheaper and can be planted more intensively at the same cost per hectare, or because they have been specifically grown in the nursery to form a narrow, tall tree potentially giving higher, early yields.

Several specialist nurseries are developing tree types designed and grown especially for Fruit Wall orchards. These include 'grow through trees' from several nurseries, and Bibaum® trees from Mazzoni nurseries. Other nurseries recommend that using a maiden tree or an eight month tree at a close planting distance can give better results. This project has provided a comparison of five different tree types using a standard variety/rootstock and spacing, and provide growers with comparable data to allow them to make informed decisions about the best tree type to use for their own situation.

Summary of the project and main conclusions

Trees were planted and established during 2013. Gala trees (clone Royal Beaut) were sourced from specialist nurseries. The trees were planted in March 2013 at Brogdale Farm, Faversham. The site (soil type: clay loam with flint) had been fallow for at least 10 years. The trees were planted at a distance of 3.5 m by 0.8 m (density of 3571 trees/ha) except Twin Stem at 3.5 m by 1.6 m.

The trees were not irrigated during establishment and have not been irrigated during the trial. A standard commercial programme for management of pest and disease, nutrient requirements and foliar feed sprays plus herbicides has been applied since establishment.

The five different tree types selected were:

1. One-Year Five-plus-Branches
2. One-Year Unfeathered
3. Two-Year-Old (grow through)
4. Standard Knip
5. Twin Stem

The trial area consists of a randomized complete block with each of the five growing systems replicated in six blocks (rows) (Table 1).

Table 1. Trial plan

Twin Stem	2 Year Old grow through	1 Year 5 + Branches	1 Year Unfeathered	Standard Knip	1 Year Unfeathered
2 Year Old grow through	1 Year 5 + Branches	Standard Knip	2 Year Old grow through	1 year Unfeathered	Twin Stem
1 Year Unfeathered	Twin Stem	2 Year Old grow through	Standard Knip	1 Year 5 + Branches	Standard Knip
1 Year 5 + Branches	Standard Knip	1 Year Unfeathered	Twin Stem	2 Year Old grow through	1 Year 5 + Branches

Standard Knip	1 Year Unfeathered	Twin Stem	1 Year 5 + Branches	Twin Stem	2 Year Old grow through
Block 1	**Block 2**	**Block 3**	**Block 4**	**Block 5**	**Block 6**

All of the trees were supplied by specialist nurseries in the Netherlands except for the Twin Stem trees, which came from a nursery in Italy. The Dutch trees were grafted onto the dwarfing rootstock M9 (Clone 337), with an equivalent dwarfing rootstock used for the Italian Twin Stem trees.

Each row has one plot of 10 trees of each tree type (except for Twin Stems which have five trees, but two stems each), making 270 trees (300 stems) in total, on an area approximately 0.09 ha. The middle 8 trees (three trees for Twin Stems) were used for recording and sampling and the end two trees in each plot were guards (Tables 2 and 3).

Table 2. Plot layout of each row for all tree-types except Twin Stems

	1 guard tree	**8 trees used for recording**	**1 guard tree**	

Table 3. Plot layout for rows of Twin Stem trees

	1 guard tree	**3 trees used for recording (6 stems)**	**1 guard tree**	

During 2013 the trees received minimal pruning by hand to remove excess branches (any that were too strong or too weak) and all fruit was removed in order to ensure that the trees established well.

Growth stages were monitored regularly and shoot growth was assessed, to establish when to prune at the nine leaf stage. Photographs of trees before and after cuts are included in Appendix 1 at the end of the Science Section of this report.

Key results in 2016

In July 2016 (after the fruit wall cut), all trees were thinned to two fruit per cluster on branches below 1.5 m and one fruit per cluster on branches above 1.5 m. A further quality / crop load thin was also carried out.

- There were statistically significant results in yields per hectare – Two-Year-Old tree types yielded the most fruit and One-Year Unfeathered yielded the least fruit
- Fruit quality in 2016 was good – all tree types achieved over 80% Class 1 except One-Year Five-plus-Branches

- Fruit size in the trial and across the industry in general was small in 2016 due to climatic conditions during fruit development
- Tree volume decreased for all tree types in 2016. The Two-Year-Old trees continued to have the highest volume

Key results in 2017

2017 was the fourth and penultimate fruiting year.

- There were statistically significant results in yields per hectare – Two-Year-Old tree types yielded the most fruit and Twin Stem yielded the least fruit
- Fruit quality in 2017 was again reasonable but affected by frost events at vulnerable growth stages – One-Year Unfeathered and Standard Knip achieved over 80% Class 1 fruit whilst all other tree types were under 80% and Twin Stem had the lowest (76.4%)
- Average fruit weight was acceptable in 2017 with all tree types having average single fruit weights of >120g except Two-Year-Old (116.5 g). One-Year Five-plus-Branches had the heaviest average fruit weight of 131.4 g
- Percentage fruit size was acceptable with all tree types having 60% fruit between 60 mm and 70 mm and <10% fruit under 60 mm
- Tree volume decreased for all tree types in 2017 compared to 2016. The Two-Year-Old trees continue to have the highest volume

Key results in 2018

- There were statistically significant effects of tree type on yield per hectare in 2018 - Standard Knip trees had higher Class 1 yields than other tree types
- Twin Stem had the lowest Class 1 yields, which were statistically not different to One-Year Unfeathered
- Two-Year-Old trees had the highest cumulative yields per hectare and Twin Stem and One-Year Unfeathered the lowest
- Twin Stem had the highest yield efficiency of all tree types and Two-Year-Old the lowest
- Fruit quality in 2018 appeared unaffected by climatic conditions and was commercially acceptable at >80% Class 1. Twin Stem had the highest Class 1 fruit (84.1%) and One-Year Unfeathered the lowest (81.7%). Marketable (Class 1 and 2) fruit percentages were >90% for all tree types

- There were no significant effects of tree type on average fruit weight in 2018. Acceptable average single fruit weights of >120g were achieved for all tree types except One-Year Five-plus-Branches, which had the lowest (118.5 g), whereas in 2017 it had the highest. Twin Stem had the highest average fruit weight of 127.5 g
- Percentage fruit size in 2018 was acceptable with all tree types having >60% fruit sized between 60 mm and 70 mm. There were low percentages of small fruit (<60mm) and very low percentages of fruit >75mm
- All tree types increased in volume in 2018 or were static except for Twin Stem which decreased. The Two-Year-Old trees continue to have the highest volume

Main conclusions from the trial

Statistically significant differences in yields were due initially to tree type, but latterly responses have diminished as trees matured and fruiting wood increased.

The Fruit Wall cut was carried out when nine new leaves had emerged in the 2018 season's growth. To determine this, growers regularly need to make random leaf counts to establish the growth stage before carrying out mechanical pruning.

Pruning was delayed in some years of the trial and growers may be faced with a similar logistical problem in commercial practice. Sub optimal pruning (timing and quantity) could negatively affect bud initiation and careful consideration of when and where to make the Fruit Wall cut is required. Growers must robustly monitor crop growth stage and assess bud formation. They should not cut at exactly the same point each year.

A different assessment of tree volume such as Leaf Wall Area or Porosity may be a more accurate method for estimating and revealing differences between tree types in the development of fruit bud/cropping wood.

An assessment of fruit set, bud number and quality can help thinning and crop load management decisions.

Minimal inter tree pruning was carried out on the trial trees for the second time in spring 2018. Requirements must be considered and trees will need pruning regularly once commercial orchards reach maturity. Only one or two cuts per tree per season should be required.

Fruit size in irrigated orchards will be easier to maintain. Irrigation is critical at high planting densities otherwise fruit size and quality may deteriorate. Growers will need to ensure adequate irrigation, especially during low rainfall / higher than average temperature seasons, to ensure adequate fruit size and maintain sufficient regrowth. Extra fertigation and mulching should also be considered in particular for any weak orchard areas.

Fruit Wall managed trees have a narrow profile and may be suited to growing in narrower alleyways (2.5 m) rather than 3.5 m used in this trial. Growers may consider increasing the density in this way for newly planted orchards, which would increase trees per hectare from 3,571 to 6,667 if trees were planted within row at 0.6 m and to maximise the yield efficiency of orchards managed under the Fruit Wall system.

Based on early yields in this trial compared with predicted returns and considering tree costs, Two-Year-Old, Standard Knip and One-Year Five-plus-Branches would be more profitable than One-Year Unfeathered and Twin Stem for growing in a Fruit Wall system at the same tree height and alley width as in the trial.

However, whilst Twin Stem and One-Year Unfeathered trees in this trial had statistically lower volumes and yields than the other tree types, were slower to establish and had higher incidences of disease, their higher yield efficiency suggests that they could be grown at reduced inter-row and alley widths and lower canopy height without yield reductions.

Mechanical pruning could be used to convert existing orchards or as part of a husbandry management programme. Mechanically pruned orchard systems grown with a significantly further reduced profile and reduced alley width could be beneficial with the introduction of mechanised harvesting.

Financial Benefits

- The trial has attempted to support industry requirements of shortening payback periods and to produce guidance on the cropping potential of different tree types in the early years
- The trees have carried five crops, four of which have been heavy. Tree types yielded commercially acceptable marketable quantities in 2017, but not in 2018
- Based on results from this trial, there would be minimal value to the grower until the fourth or fifth fruiting year of a similarly established new Fruit Wall managed orchard
- Increased long term returns are unlikely based on results from this trial and predicted potential yield increases from the best tree type for Fruit Wall systems may be unrealistic
- However, yield responses in more vigorous orchards may be different and should be higher than the trial orchard

- Twin Stems or One-Year Unfeathered may be viable profitable options given their enhanced yield efficiency and if planted at higher densities (despite increased tree and planting costs for Twin Stems and assuming they will be disease free) (e.g. 6,667 trees/ha – 0.6 m planting distance within row and a reduced row width of 2.5 m plus low canopy height <2.0m). This type of management could assist growers with the development of mechanical picking
- Alternatively, growers should be able to reduce pruning costs from the reduced labour input required if mechanical pruning is used as part of an orchard management programme

The cost of successfully establishing an intensive orchard is approximately £32,000 per hectare (depending on price variation of materials and exchange rates) (FAST 2019). In particular:

a. The differences in costs of the various tree types available vary depending on type selected and quantity (up to an extra £3.02 per tree or from an extra £174 to £3465 per hectare (FAST 2019)). Some tree types (e.g. Two-Year-Old) have the potential to increase in volume much more quickly. However, this would be unnecessary if planting at narrow alley widths and maintaining a reduced canopy spread. Therefore, considering the least expensive tree (e.g. One-Year Unfeathered / Whip) for Fruit Wall management may be beneficial.

b. An estimated reduction in yield from a Fruit Wall system of 5% in each of the first five cropping years can reduce net returns by around £3000 per ha (FAST 2018). However, the real percentage reduction for all tree types in the first five cropping years of this Fruit Wall trial has been much greater. The One-Year Unfeathered trees had the highest percentage reduction from 2014 to 2016 (87.1%, 32.6% and 48.5%) and Twin Stem the highest in 2017 and 2018 (19.1% and 34.9%). However, some of this reduction is likely to have been caused by diseases (like scab and canker) in these tree types. Only One-Year Five-plus-Branches, Two-Year-Old and Standard Knip had equal to or less than 5% percentage reductions in 2015 and 2017 (Table 1). Based on cumulative marketable yields the overall reduction for the duration of the trial still falls below the estimated reduction of 5% (between -14.1% for Two-Year-Old and -36.4% for Twin Stem) (Table 2). Some differences could be attributable to the tree types, orchard and climate conditions. Results from AHDB TF 207 (Determination of the optimum pruning time for fruit wall orchard systems for Gala apple) also demonstrated lower yields in mechanically pruned trees than from hand pruned treatments.

c. Intensive orchard systems are simpler and easier to prune than lower density

traditional orchards. Depending upon planting distance and hand pruning equipment used, it takes approximately 34 hours (4.5 days) to hand prune one hectare of mature orchard (FAST 2017) compared to three hours for mechanical pruning or a difference of £420 per hectare (SCRIPPS 2017). Hand pruning speed is improved if electronic secateurs are used, but these cost around £1500 each. Younger trees such as those in this trial would take less time to hand prune, e.g. three days. Some hand pruning will be needed (e.g. inter pruning) even where mechanical pruning is used, but net savings of around £6,300/ha over a 15 year orchard life are envisaged (excluding machinery costs).

Table 1. Percentage difference of yearly Fruit Wall marketable yields (Class 1 and 2) compared to commercial expected yields for five years, from 2014 to 2018 (25, 35, 45, 45 & 50 t/ha respectively) – shaded cells indicate similar to or greater than estimated Fruit Wall reduction of 5%

TREE TYPE / YEAR	2014	2015	2016	2017	2018
1 Year 5 + Branches (maiden)	-75.0	-4.4	-30.3	12.5	-10.1
1 Year Unfeathered (whip)	-87.1	-32.6	-48.5	-10.2	-23.1
2 Year Old	-67.9	0.5	-21.4	11.1	-13.5
Standard Knip	-77.5	-5.3	-25.1	5.8	-9.1
Twin Stem	-82.4	-21.4	-41.6	-19.1	-34.9

Table 2. Percentage difference of cumulative Fruit Wall marketable yields (Class 1 and 2) compared to commercial expected cumulative yields for five years, from 2014 to 2018 (25, 60, 105, 150 & 200 t/ha respectively)

TREE TYPE / YEAR	2014	2015	2016	2017	2018
1 Year 5 + Branches (maiden)	-75.0	-33.8	-32.3	-18.9	-16.7
1 Year Unfeathered (whip)	-87.1	-55.3	-52.4	-39.7	-35.6
2 Year Old	-67.9	-28.0	-25.2	-14.3	-14.1
Standard Knip	-77.5	-35.4	-31.0	-19.9	-17.2
Twin Stem	-82.4	-46.8	-44.6	-36.9	-36.4

d. Anecdotal evidence from experimental plots in Northern Europe suggests that annual yields from Fruit Wall plantings can be around 20 t/ha greater than orchards of a similar density managed conventionally. Mika *et al.* (2016) have recorded an 11.5% increase in yields from mechanically pruned compared to hand pruned trees which would equate to 50 t/ha versus 45 t/ha respectively. The value to the grower of a 5 t/ha increase would be approximately £31,000 net of all post-harvest costs over 15 years. In 2017

tree types One-Year Five-plus-Branches, Two-Year-Old and Standard Knip achieved marketable t/ha of 50.6, 50.0 and 47.6 respectively (Table 3). This equals up to between 12.5%, 11.0% and 5.8% yield increases compared to commercial standard trees of the same age (Table 1). However, this yield increase was not seen in 2018 when only Standard Knip trees yielded above the estimated percentage reduction of 5% (48.4 t/ha) and no tree type yielded above standard commercial expectations of 50 t/ha.

Table 3. Marketable yields (Class 1 and 2) t/ha per year including standard commercial expectations and 5% expected reduction for Fruit Wall management – shaded cells indicate where Fruit Wall yields have equalled or exceeded standard commercial expectations

TREE TYPE / YEAR	2014	2015	2016	2017	2018
1 Year 5 + Branches (maiden)	6.2	33.5	31.4	50.6	45.0
1 Year Unfeathered (whip)	3.2	23.6	23.2	40.4	38.4
2 Year Old	8.0	35.2	35.4	50.0	43.2
Standard Knip	5.6	33.1	33.7	47.6	45.5
Twin Stem	4.4	27.5	26.3	36.4	32.5
Standard commercial	25.0	35.0	45.0	45.0	50.0
Standard commercial - 5%	23.8	33.3	42.8	42.8	47.5

e. For growers to implement the system they would have to rent or buy specialist pruning equipment. Current costs for this type of equipment are approximately £18,500 per machine (Seymour 2017), but this could also be used for other operations on the farm e.g. hedge and windbreak cutting and could also be rented out.

f. The interaction between the Fruit Wall growing system and other orchard management operations (such as use of growth regulators for fruit setting and thinning) could be different (possibly due to the effects of late pruning on leaf metabolism at a critical time of year during the early fruit development phase). As the leaf-to-fruit ratio is altered in the Fruit Wall more attention to crop nutrition and leaf health will be necessary.

g. Continued adaptation of this trial's developmental work would be beneficial including investigating the best yield efficiency tree types at even higher density plantings (e.g. 0.6 m x 2.5 m, creating 6,667 trees per hectare). This work could contribute to the current trend for creating orchards ready to utilise mechanical harvesters.

Action points for growers

- The Fruit Wall cut was carried out when 9 new leaves had emerged on the current season's growth. To determine this, growers regularly need to make random leaf counts to establish the growth stage before carrying out mechanical pruning
- Growers must robustly monitor crop growth stage and assess bud formation. They should not cut at exactly the same point each year
- An assessment of fruit set, bud number and quality can help thinning and crop load management decisions
- Requirements must be considered and trees will need pruning regularly once commercial orchards reach maturity. Only one or two cuts per tree per season should be required
- Growers will need to ensure adequate irrigation, especially during low rainfall / higher than average temperature seasons, to ensure adequate fruit size and maintain sufficient regrowth. Extra fertigation and mulching should also be considered in particular for any weak orchard areas