Project Number:	TF 206
Project Title:	Comparison of Different Planting Material for Fruit Wall Orchard Systems for Apple
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Tim Biddlecombe

Chairman

Fruit Advisory Services Team LLP

Signature ..... Date .....

Report authorised by:

Dr William E Parker

Director of Horticulture

The Agriculture and Horticulture Development Board

Signature ..... Date .....

CONTENTS

GROWER SUMMARY

Headline

- Early results suggest that 2 Year Old, Standard Knip and 1 Year 5+ Branche trees are offering the most suitable planting material for Fruit Walls, in terms of early yield build-up, class 1 fruit and optimum returns.

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 8 month tree at a close planting distance can give better results. This project will provide 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 3.5m by 0.8m (except Twin Stem at 1.6m).

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. 1 Year 5 + Branches
2. 1 Year Unfeathered
3. 2 Year Old (grow through)
4. Standard Knip
5. Twin Stem

The trial area consists of a randomized complete block with each of the 5 growing systems replicated in 6 blocks (rows):

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**

Each row has 1 plot of 10 trees of each tree type (except for twin stems which have 5 trees but 10 stems), making 300 trees in total on an area approximately 0.09 ha. The middle 8 trees (3 trees for twin stems) were used for recording and sampling and the end 2 trees (1 for Twin Stems) in each plot were guards.

Table 2. Plot layout – except Twin Stems:

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

Table 3. Plot layout – Twin Stems:

	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 during early 2016 and shoot growth assessments commenced in May, to establish when to prune at the 9 leaf stage which occurred on 24 June.

Photographs of trees before and after the 9 leaf cut in 2016 cut are included in Appendix 1 at the end of the Science Section of the report.

In July 2016 (after the fruit wall cut), all trees were thinned to 2 fruit per cluster on branches below 1.5m and 1 fruit per cluster on branches above 1.5m. A further quality / crop load thin was also carried out.

Fruit was harvested commencing 12 October 2016 following maturity testing to determine the optimum harvest date, placed into cold store and assessed later for quality and size.

Key results in 2016

- There were statistically significant results in yields – 2 Year Old tree types yielded the most fruit and 1 Year Unfeathered yielded the least fruit.
- Fruit quality in 2016 was good – all tree types achieved over 80% Class 1 except 1 Year 5 + 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 2 Year Old trees continue to have the highest volume.

Financial benefits

The trees have now carried three crops, two of which have been heavy. It is too early to determine conclusive financial benefits but some treatments are approaching commercially acceptable Class 1 yields and have the potential for increased returns compared to non Fruit Wall managed systems.

There is potential for reducing pruning costs and skilled pruning labour requirements.

The trial is responding to industry requirements to investigate shortening payback periods and to produce guidance on the cropping potential of different tree types in the early years.

The cost of successfully establishing an intensive orchard is currently up to £28k per hectare (FAST 2017). In particular:

a. The differences in costs of the various tree types available are variable depending on type selected and quantity (from an extra £0.70 to £2.50 per tree or from an extra £1,600 to £4,100 per hectare (FAST 2017)). Some tree types have the potential to increase in volume, vertically and horizontally, much more quickly, leading to increases in early yields.
b. A reduction in yield from a Fruit Wall system of 5% in each of the first 4 cropping years can reduce net returns by around £2,100 per ha.
c. New intensive orchard systems are simpler and easier to prune than lower density traditional orchards. Depending upon planting distance, it takes approximately 34 hours (4.5 days) to hand prune 1 hectare of orchard (FAST 2017) compared to 3 hours for mechanical pruning or a difference of £420 per hectare (Adrian Scripps Ltd 2017). Some hand pruning will be needed (eg inter pruning) even where mechanical pruning is used but net savings of around £6,300 per ha over a 15 year orchard life are envisaged (excluding machinery costs).
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.
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 £16,750 (Seymour 2017), but the machine could also be used for other operations on the farm (eg. hedge and windbreak cutting) and could also be rented out.

f. Continued good technology and knowledge transfer will be needed and possibly further adapted developmental work. This is because 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 well 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.

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 need to regularly make random leaf counts to establish the growth stage before making the cut.
- Inter tree pruning requirements should be considered and will need to be done regularly once the orchard reaches maturity. Only one or two cuts per tree may be required.
- 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 areas.
- Fruit Wall managed trees have a narrow profile and may be suited to narrower alleyways - 3.0m rather than 3.5m as in this trial. Growers may consider increasing the density for newly planted orchards which would increase trees per hectare (from 3,571 to 4,167) and maximise the yield efficiency of orchards managed under the Fruit Wall system.
- Other actions points will be determined in future years when it is concluded which tree type may be most suitable to Fruit Wall management in terms of early yield build up, highest yield of Class 1 fruit and optimum returns. Early results suggest that 2 Year Old, Standard Knip and 1 Year 5 + Branch trees are leading in this regard.

SCIENCE SECTION

Introduction

Growers in many countries are actively looking for ways to reduce labour inputs and increase mechanisation in a range of fruit crops. The Fruit Wall concept originated in France in 1986 when CTIFL began a project which aimed to reduce growing costs in top fruit production. Around the same time a harvesting robot, known as the Magali, was developed and CTIFL adapted an orchard to create a narrow tall hedgerow (the 'Fruit Wall') to accommodate the robot and maximise the use of automation at harvest. As a result, the work by CTIFL demonstrated the potential of the Fruit Wall growing system in reducing the costs associated with hand pruning and increasing Class 1 yields. However, differences in cropping were shown between the south and north of France with the trial plots in the north performing less well than in the south.

The Fruit Wall system and the mechanisation of pruning are now considered as options in commercial practice in the UK but they require a modified tree architecture to be successful. Results from the original work by CTIFL in France can be applied to growing areas further north, but only by adapting the methods, particularly the time of pruning, to the local growing conditions.

Three key factors influence total productivity from a Fruit Wall orchard:

- Planting density
- Tree architecture
- The timing of pruning

These factors all have an effect on extension growth, flower initiation and yield by influencing light interception and distribution by and through the canopy and the total amount of fruiting wood in the orchard. The management of these factors determines whether the Fruit Wall is able to provide increased and sustainable yields throughout the life of the orchard.

Hampson *et al* (2002) demonstrated that planting density can have a greater influence on productivity than the training system (tree height and shape). Trees planted at a lower density were more productive per tree than at a higher planting density due to reduced competition for resources. However, higher planting densities tend to be more productive per hectare. Palmer *et al* (1992) suggest that Leaf Area Index (LAI) increases with increased planting density with greater light interception as a result. Higher planting density systems tend to increase yields per unit area through more efficient use of ground area until

a natural limit is reached (Weber, 2001). For the Fruit Wall system to achieve greater productivity it should make improved use of the unit ground area than traditional orchard system designs.

Hampson *et al* (2004) demonstrate in their study that the percentage of fruit with acceptable colour was reduced with increased planting densities. Red colouration is an indicator of fruit quality and, therefore, as planting density increases the percentage of Class 1 fruit may become compromised. The tree architecture of the Fruit Wall system has the potential to overcome issues such as reduced red colouration, as the trees tend to be narrower than in traditional orchards and result in less shading of the fruit. It will be essential to maintain the narrow shape and size of the trees composing the Fruit Wall to maximise the light distribution throughout the tree. In the Fruit Wall system a pruning cut is made by a tractor mounted mechanical cutter bar during the summer rather than in the winter to create an A shaped tree which is 40cm wide at the top and 80cm wide at the base.

However, the aim of pruning is not only to achieve the narrow A shape trees but also to encourage flower bud formation. Flower bud formation usually occurs during August (Abbot, 1974; cited in Dennis, 2003) and so conditions prior to this are important in determining both the quality and the quantity. There tends to be negative correlation between vegetative growth and flower bud formation and so nitrogen applications which favour vegetative growth tend to reduce flower bud formation, whereas Plant Growth Regulators (PGRs) which retard vegetative growth tend to improve flower bud formation. In the Fruit Wall system, the pruning cut is made during the summer and the timing of the cut is critical in determining the amount of vegetative re growth and flower bud formation. This is also true for other crops such as cherry - Guimond *et al* (1998) showed that flower initiation was stimulated by summer pruning and vegetative growth also increased due to the removal of apical dominance along the shoot. If the Fruit Wall cut is made too early then the bud behind the cut will form a shoot, reducing flower bud formation. However, if the cut is made too late the buds do not have enough time and resources to form a fruit bud and will then remain vegetative. The optimal date for the Fruit Wall cut to be made may vary between varieties and between different seasons. Therefore, it is essential to relate the time of the cuts to an easily identified growth stage.

The aim of the trial is to compare different planting material for Fruit Wall orchard systems for Apple by assessing performance (yield and grade out) and tree volume.

Materials and methods

The six year trial was established in 2013. The trees were planted in March 2013 at Brogdale Farm, Faversham.

Gala trees (clone Royal Beaut) were sourced from specialist nurseries.

The site, soil type clay loam with flint, had been fallow for at least 10 years.

The trees were planted at a distance of 3.5m by 0.8m (except Twin Stem at 1.6m).

A post and wire system with bamboo was installed to support the trees.

Gala trees (clone Royal Beaut) were sourced from specialist nurseries.

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.

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6. 1 Year 5 + Branches
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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
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Fruit was harvested commencing 12 October 2016 following maturity testing to determine the optimum harvest date, placed into cold store and assessed later for quality and size.

Assessments

In order to determine the correct date to carry out the Fruit Wall cut at the 9 leaf stage initial assessments of extension growth were made at the beginning of May 2016. Detailed leaf counts commenced on 17 May. One shoot on both sides of each tree or stem was assessed (20 shoots per plot). Average numbers of leaves were calculated and are shown in Table 4.

Table 4. Leaf counts 2016.

Date	1 Year 5 +	1 Year Unfeathered	2 Year Old	Standard Knip	Twin Stem	Overall
17-May	3.6	3.4	3.9	3.7	3.6	3.6
24-May	4.0	3.9	4.1	4.1	4.0	4.0
02-Jun	5.0	5.0	5.3	5.0	5.1	5.1
09-Jun	6.1	6.0	6.2	6.2	6.2	6.1
17-Jun	7.7	7.1	7.9	7.3	7.8	7.6
24-Jun	9.4	8.4	9.8	9.3	9.0	9.2

The Fruit Wall cut was made after the shoot extension growth had reached a mean of 9.2 leaves. The branches were cut back by hand (simulating a mechanical cut) to a maximum length of 40cm each side at the base of the tree and 20cm at the apex (giving a total width per tree of 80cm and 40cm respectively).

The total yield (kg) was recorded in each plot at harvest commencing 12 October 2016. Average yield per tree and average yield per stem were calculated. A random sample of 100 fruits from each plot was collected at harvest, placed in cold storage and measured during the autumn for fruit size and quality (Class 1; Class 2 and Waste). The average fruit weight (g) was calculated. The percentage of total yield by size category was calculated together with percentages of fruit within each class category (weight (g)).

Height and spread were measured during the autumn of 2016 and tree volume calculated. NB – each twin stem tree was treated as 2 trees and height and spread for each stem measured separately (making 6 in total rather than 8 for the other tree types).

Statistical Analysis

Statistical analysis was carried out using Analysis of Variance (ANOVA) and multiple range tests (MRTs) used to determine whether the differences between individual treatments were statistically significant. Charts are shown with standard error bars (where applicable) and the results of the MRTs are indicated by letters (homogenous groups) where statistically significant effects were shown (and where the P value = < 0.05).

Results

Yield

Yield data was recorded following harvest commencing 12 October 2016.

Table 5. Total yield per tree type, average yield per tree and per stem (kg) 2016:

Tree Type/kg	Total Yield Per Tree Type kg	Average Yield per Tree kg	Average Yield per Stem kg
1 Year 5 + Branches	440.6	9.8	9.8
1 Year unfeathered	338.0	7.2	7.2
2 Year old	484.6	10.8	10.8
Standard Knip	421.4	10.0	10.0
Twin Stem	269.9	15.0	7.9

Table 6. Tonnes per hectare by year:

Tree type/year	t/ha 2014	t/ha 2015	t/ha 2016
1 Year 5 + Branches	14.0	35.9	35.0
1 Year unfeathered	5.3	26.1	25.7
2 Year old	19.0	37.4	38.5
Standard Knip	11.9	36.1	35.8
Twin Stem	8.1	29.0	28.4

Total yields for all plots for each tree type was between 484.6kg (2 Year Old) and 269.9kg (Twin Stem). 2 Year Old trees had significantly higher total yields than all other treatments except 1 Year 5 +. Twin Stem trees had significantly lower total yields than all other treatments. See Figure 1.

Per tree, however, the Twin Stem trees had the highest average yield of 15.0kg (since they have two stems instead of one). The lowest average yield per tree was 7.2kg for 1 Year Unfeathered trees. Differences were statistically significant. See Figure 2.

Per stem the highest yields were for 2 Year Old trees (10.8kg) and the lowest for 1 Year Unfeathered trees (7.2kg). 1 Year Unfeathered and Twin Stem had significantly lower yields per stem than the other treatments. See Figure 3.

There were significant differences in total yields (t/ha) between tree types in 2016 where 2 Year Old trees yielded 38 t/ha and 1 Year Unfeathered only 26 t/ha. See Figure 4.

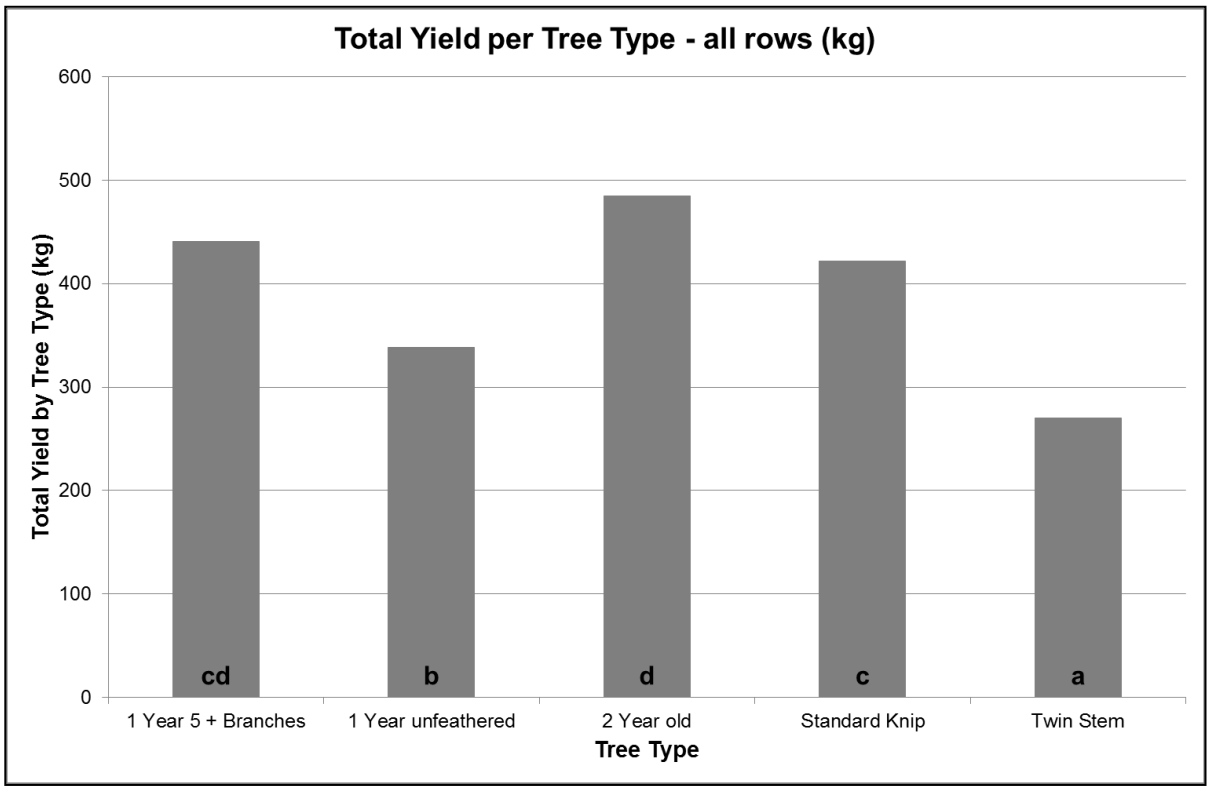

Figure 1. Total Yield per Tree Type (kg). Results with different letters are significantly different from one another (P=<0.000).

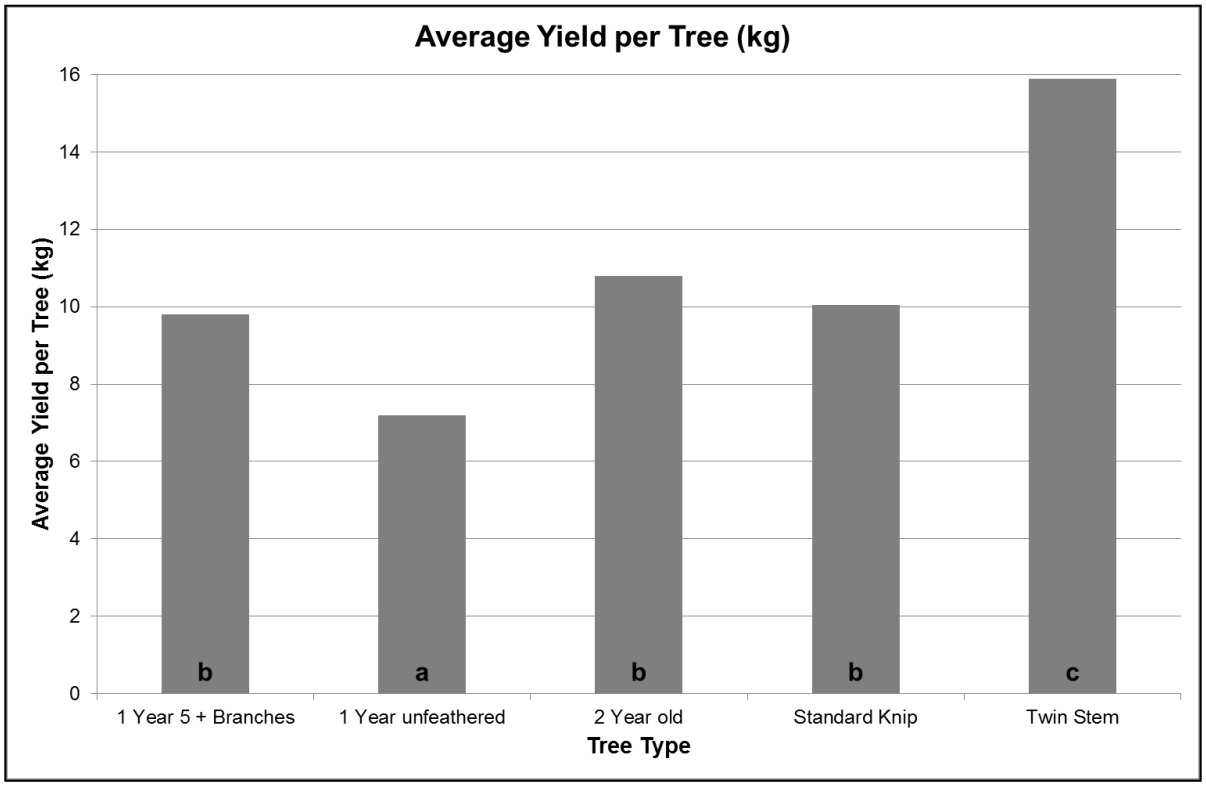

Figure 2. Average Yield per Tree (kg). Results with different letters are significantly different from one another (P=0.000).

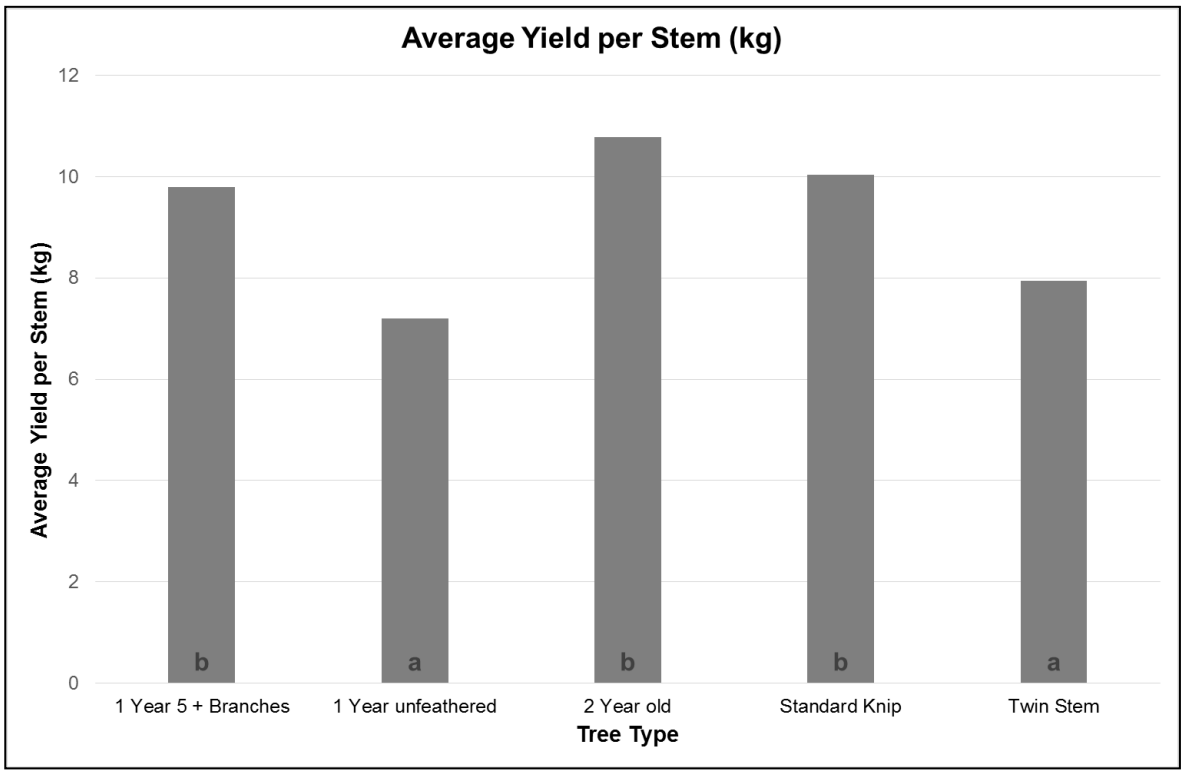

Figure 3. Average Yield per Stem (kg). Results with different letters are significantly different from one another (P<0.000).

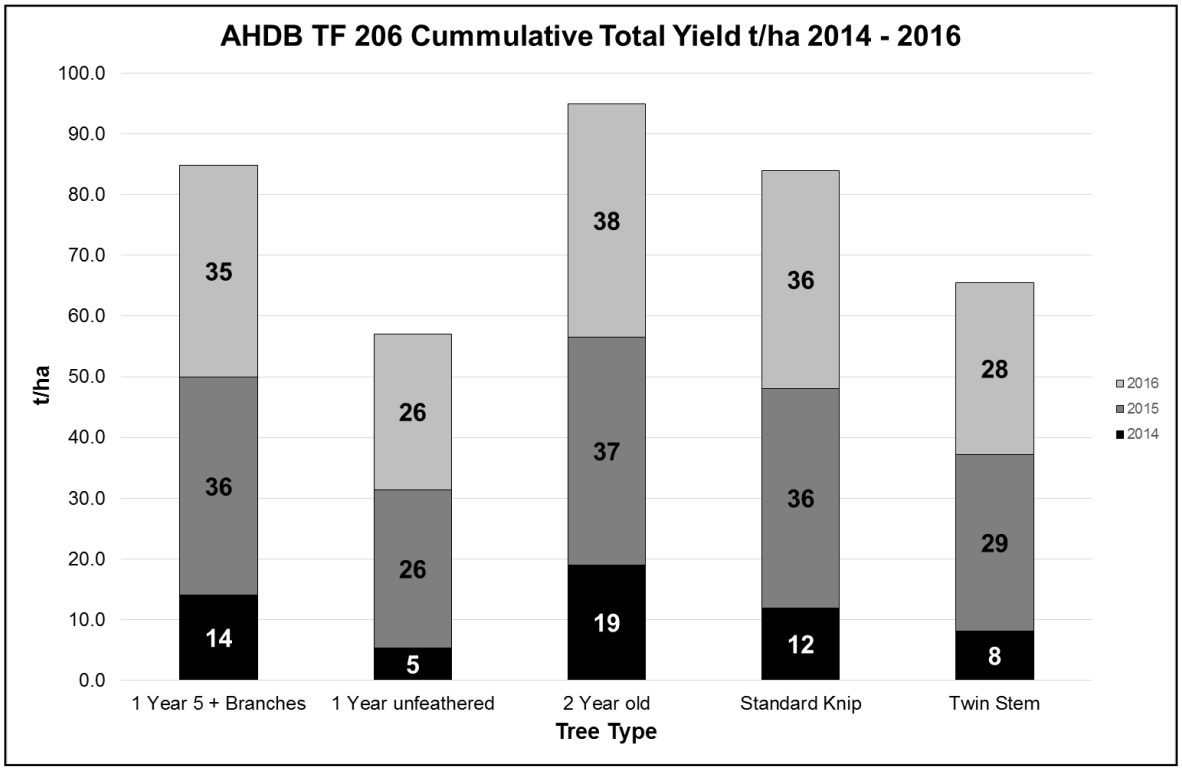

Figure 4. Cumulative Yield tonnes per hectare 2014 to 2016. Results (2016, light grey) with different letters are significantly different from one another (P<0.000).

Quality (class)

Quality assessments were made after harvest during the autumn of 2016.

Table 7. % Class 1, Class 2 & Waste by Fruit Weight.

Class/Type	1 Year 5+ branches	1 Year Unfeathered	2 Year Old	Standard Knip	Twin Stem
Class 1	74.4	82.7	81.2	81.9	82.2
Class 2	15.3	7.5	10.8	12.2	10.5
Waste	10.4	9.9	7.9	5.9	7.3

Class 1 fruit was highest for 1 Year Unfeathered (82.7%) and lowest for 1 Year 5 + branches (74.4%). See figure 5.

Class 2 fruit was highest for 1 Year 5 + branches (15.3%) and lowest for 1 Year Unfeathered (7.5%). Most fruit was downgraded to Class 2 due to russet.

Percentage Waste fruit was highest for 1 Year 5 + branches (10.4%) and lowest for Standard Knip (5.9%). Most fruit was downgraded to Waste due to scab and misshapes.

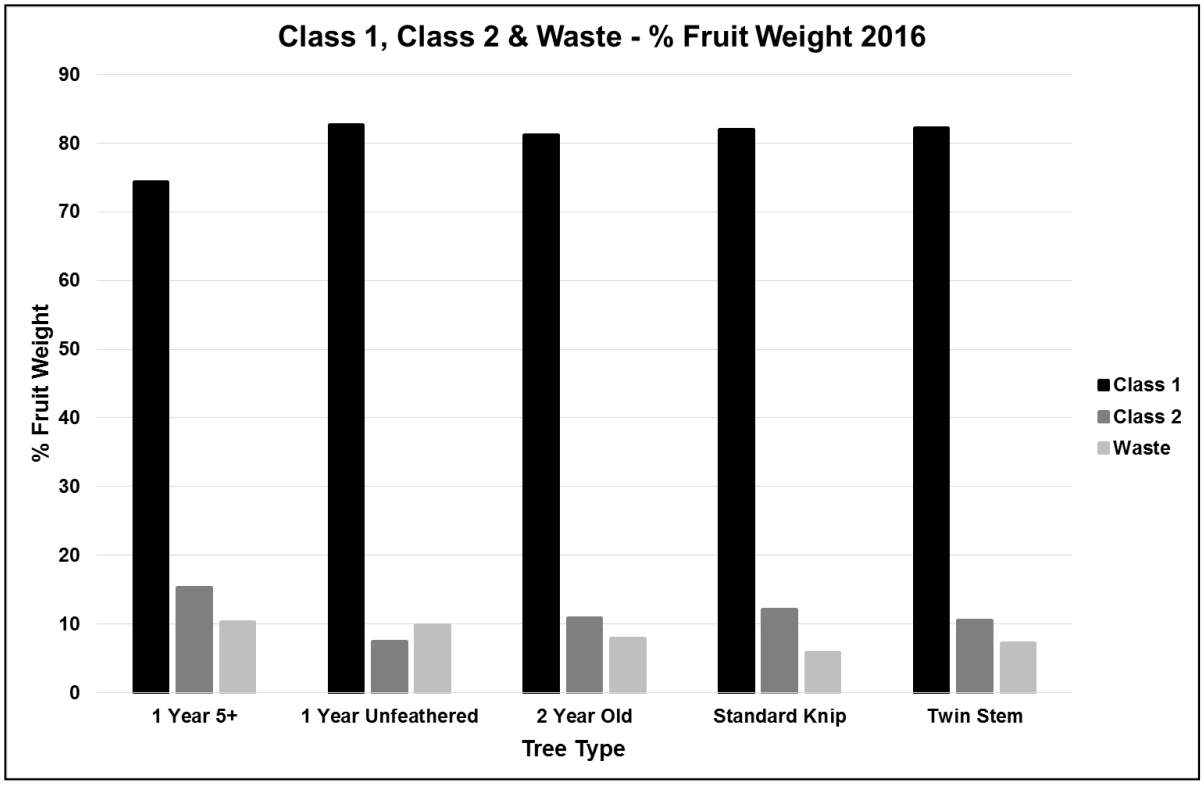

Figure 5. Class 1, Class 2 & Waste - % Fruit Weight.

Fruit weight

Average fruit weight was calculated from 100 fruit randomly sampled at harvest.

Table 8. Average Fruit Weight:

Tree Type / Parameter & Year	Average fruit weight (g) 2016	Average fruit weight (g) 2015	Average fruit weight (g) 2014
1 year 5 + branches	96.5	107	132.8
1 year unfeathered	100.7	115.1	130.3
2 year old	94.5	108.7	135.1
Standard knip	103.7	111.9	128.5
Twin stem	100	119.8	147.7

Average fruit weight in 2016 was between 94.5g (2 Year Old) and 103.7 (Standard Knip). There were statistically significant differences in fruit weight between treatments namely 1 Year 5 + was lower than Standard Knip, 1 Year Unfeathered was lower than 2 Year Old and 2 Year Old was lower than Standard Knip. See Figure 6.

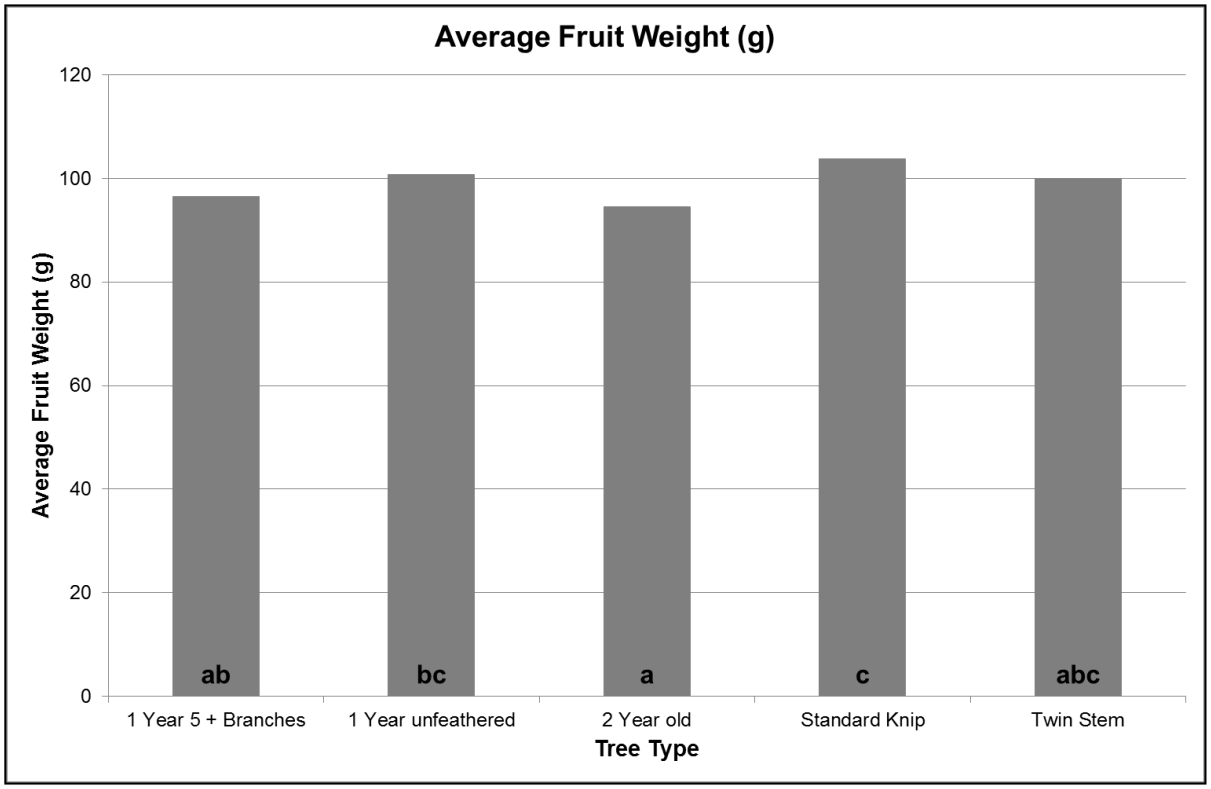

Figure 6. Average Fruit Weight (g). Results with different letters are significantly different from one another (P=0.03).

Fruit Size

Fruit was assessed for size after harvest during the autumn of 2016.

Table 9. Class 1 - % fruit by weight within size categories:

Size/tree type	1 Year 5+	1 Year Unfeathered	2 Year Old	Standard Knip	Twin Stem
<60 mm	37.5	34.7	42.1	25.0	30.6
60-65mm	40.4	42.8	41.7	41.7	42.8
65-70mm	20.0	19.1	16.2	29.6	22.4
70-75	2.1	3.4	0.0	3.7	4.2
>75mm	0.0	0.0	0.0	0.0	0.0

Standard Knip had the highest combined percentage of C1 fruit sized 60mm to 70mm (71.3%) and 2 Year Old the lowest (57.9%).

2 Year Old trees had the highest percentage of fruit under 60mm (42.1%) and Standard Knip had the lowest (25.0%).

None of the tree types had fruit over 75mm in 2016.

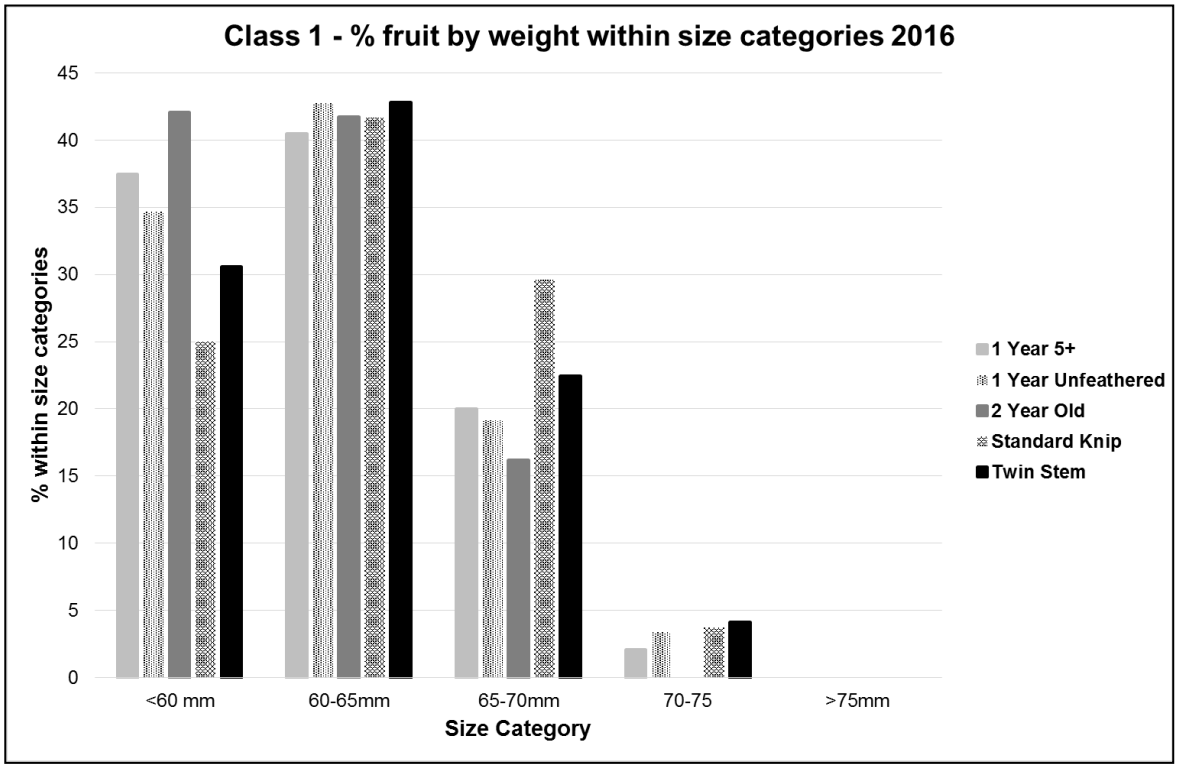

Figure 7. Class 1 - % fruit by weight within size categories.

Tree height, spread and volume

Tree height and spread were measured during the autumn 2016 and the volume calculated.

Table 10. Tree height, spread and volume:

Treatment	Height cm	Average Spread cm	Average Volume m^3
1 year 5 + branches	265.3	118.6	1.0
1 year unfeathered	250.1	102.1	0.7
2 year old	284.4	128.4	1.3
Standard knip	267.1	122.1	1.1
Twin stem	229.3	103.4	0.7

The average tree height varied between 284.4cm for 2 Year Old trees and 229.3cm for Twin Stems. Differences in the average tree height were statistically significant between all treatments except 1 Year 5 + Branches and Standard Knip – see Figure 8.

The average spread varied between 128.4cm for 2 Year Old trees and 102.1cm for 1 Year Unfeathered. Statistically significant differences between spread for tree types were noted – see Figure 9.

The average tree volume varied between 1.3m^3 for 2 Year Old trees and 0.7m^3 for 1 Year Unfeathered and Twin Stem trees. Differences in the average tree volume were statistically significant between all treatments except 1 Year 5 + Branches and Standard Knip plus 1 Year Unfeathered and Twin Stem– see Figure 10.

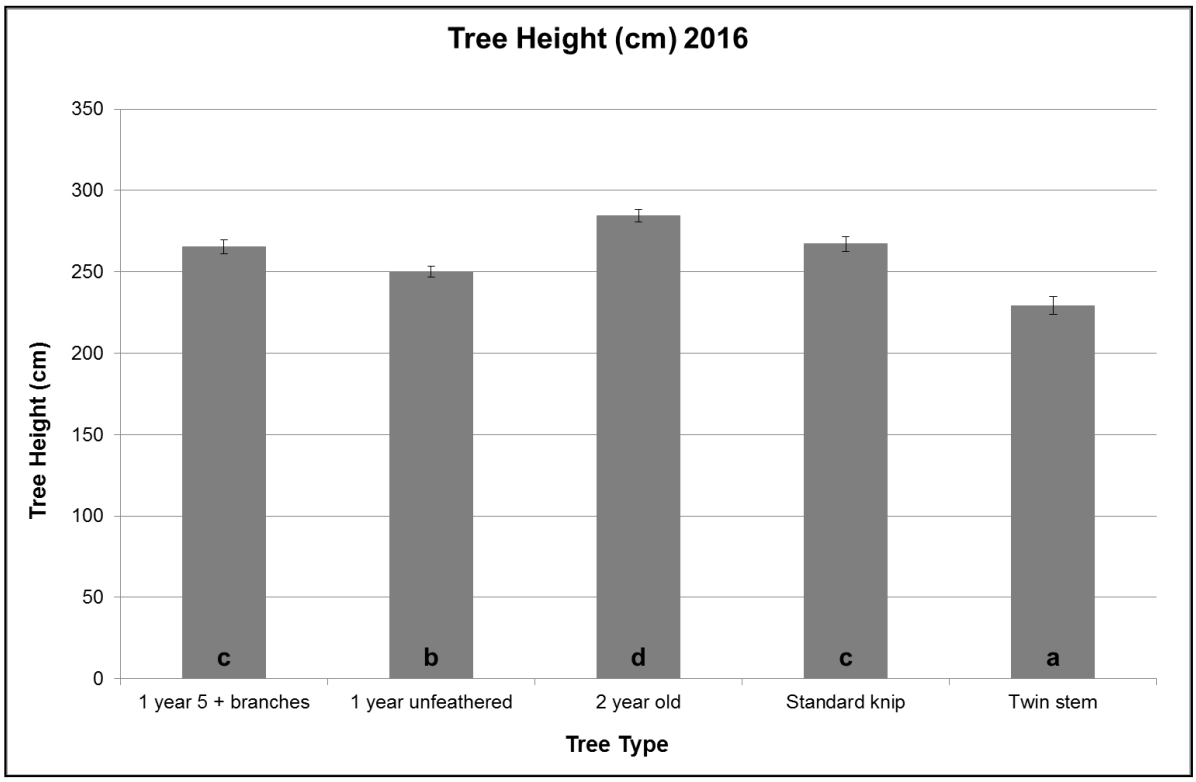

Figure 8. Tree Height (cm). Results with different letters are significantly different from one another (P = <0.0000).

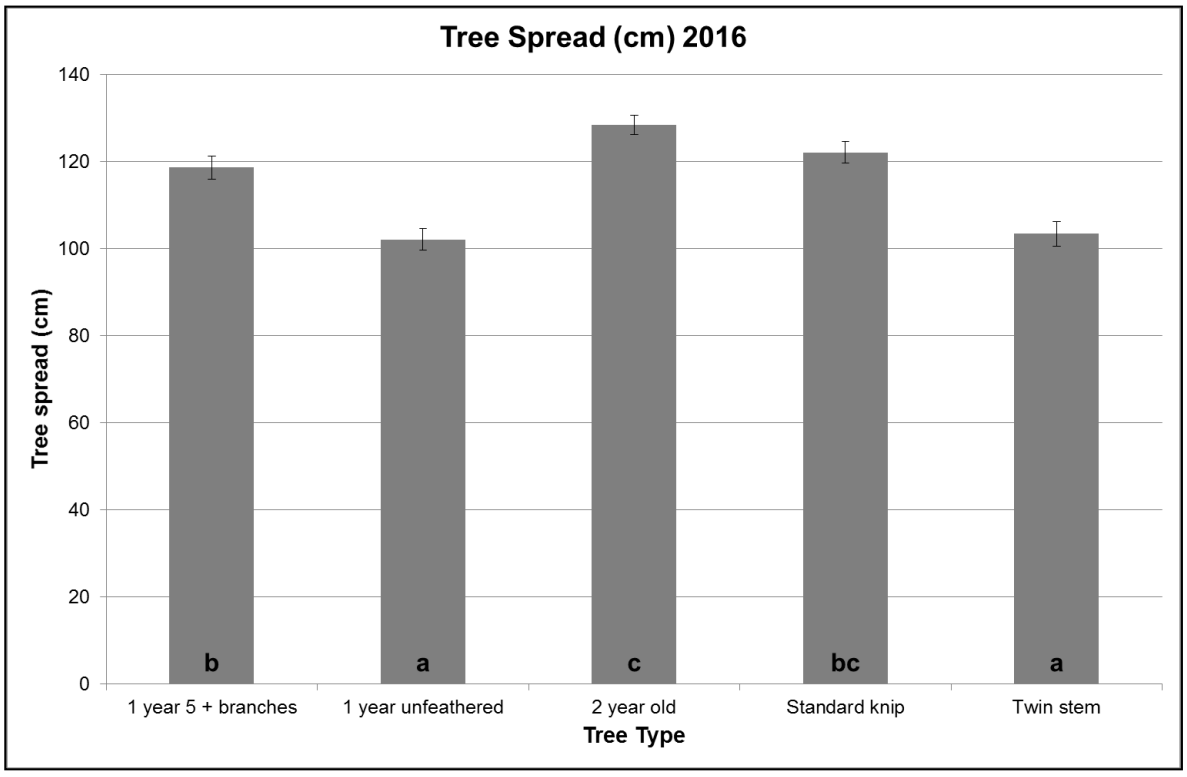

Figure 9. Tree Spread (cm). Results with different letters are significantly different from one another (P = <0.0000).

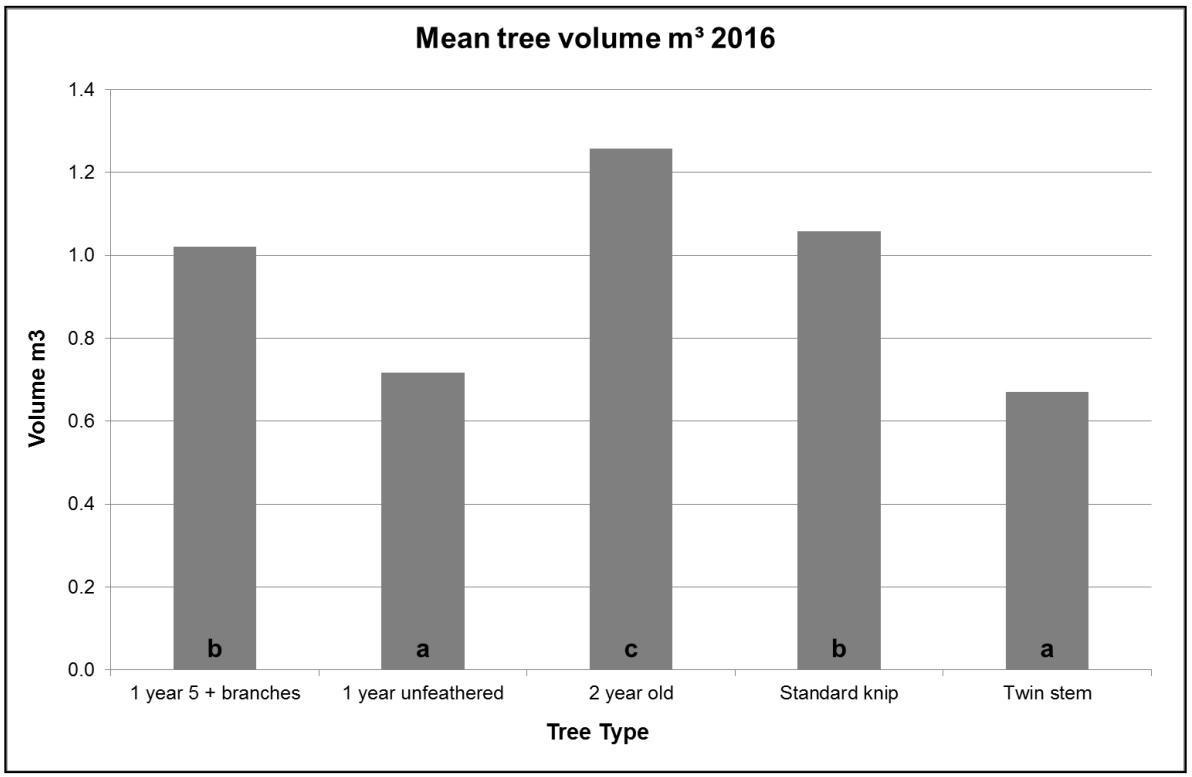

Figure 10. Tree Volume (m³). Results with different letters are significantly different from one another (P = <0.0000).

Discussion

There were statistically significantly differences for all yield assessments in 2016.

Total yields between tree types during 2016 were again variable. This is to be expected with trees of different ages and growing methods in the nursery.

1 Year Unfeathered trees remain the lowest yielding treatment per stem since they have a lower volume of fruiting wood and because they were the least developed trees out of nursery. Whilst 2 Year Old trees remain the highest yielding tree type, Standard Knip and 1 Year 5 + Branches yields were statistically similar in 2016. These three tree types are close to producing the expected 30 + t/ha of a commercially pruned Standard Knip tree in its third fruiting year.

Unlike 2014 to 2015, there was very little or no increase in yields between 2015 and 2016 for any tree type. The generally smaller fruit size in 2016 was a contributory factor. Smaller fruit size was common across the industry in 2016.

The cumulative total yields profile remains similar between tree types.

Numerical differences between the highest and lowest yielding tree type in 2016 2015 also remain similar.

Despite the moderate disease pressure in 2016, average Class 1 percentages were higher than in 2015 when disease pressure was low. All tree types achieved over 80% Class 1 fruit except 1 Year 5 + Branches. Marketable fruit (Class 1 and 2) percentages were above 90% as in 2015 but in 2015 Class 2 averages were higher. Average waste percentages were similar in 2016 compared to 2015 (8% versus 7%). Most Class 2 fruit was due to russet and the low percentages of waste fruit were due to scab and misshapes.

Average fruit weight in 2016 was around 100g, smaller than 2015 but as trees continue to develop, differences in average fruit weight between tree types again decreased. Unlike 2015, Twin Stem fruit weight was statistically similar to all other treatments influenced by climatic conditions but also due to development of laterals within the tree structure.

The maturing trees are increasing in volume, filling the available space and have more cropping wood. 2016 was a heavy cropping year with a very high percentage of fruit under 60mm – 25% to 42%. The orchard is not irrigated and the below average rain fall from July to October (Southern Water 2016) combined with the higher than average temperatures in August and September (FAST & Met Office 2016) were contributing factors.

All tree types increased in height between 2015 and 2016 but decreased in spread and volume indicating regrowth was reduced due to a combination of higher temperatures and low rainfall. Tree heights for Twin Stems remain significantly less than all other tree types possibly due to advancement of lateral growth. Tree spread and volume remain significantly lower for Twin Stem and 1 Year Unfeathered due to delayed overall development of cropping wood. A standard feed programme has been applied to the whole orchard plot which may be more suited to the more fully developed trees.

Objectives

The objectives have been achieved by following the programme of work and specifically:

A. To select 5 different tree types with potential for use in the Fruit Wall System.
   Achieved during 2012/2013 when trees were planted.
B. To measure the performance of each tree type under the same Fruit Wall management technique over 5 cropping years by recording yield and grade out.
   Partially achieved through assessments and records between 2014 and 2016 and continuing.
C. To measure tree volume by recording height and spread each year.
   Partially achieved through assessments and records between 2014 and 2016 and continuing.

D. To provide growers with guidance on the attributes including cost of establishment and of the different tree types, so that they can make informed decisions with establishing new orchards.
   Partially achieved through assessments and records between 2014 and 2016, reports for 2013 to 2016 and continuing.
E. To communicate the results of the trial via grower meetings, AHDB Horticulture News articles and open day(s) at the trial site.
   Achieved via AHDB Horticulture news articles in 2014, 2015, 2016 and 2017, at the FAST Members Conferences in 2015, 2016 and 2017 plus at AHDB Tree Fruit Technical Days in 2016 and 2017. Continues.

Conclusions

- The speed at which newly planted trees increase in volume and achieve good yields in the first years after planting are crucial to the success of new orchards.
- The rate at which the trees in the Fruit Wall system increased in volume was checked in 2016 due to climatic conditions.
- Whilst statistically significant results of various assessments were again observed in 2016 yields did not increase in this unirrigated orchard.
- However, yield and volume differences were similar to 2015 indicating differences between tree types may no longer be diminishing.
- It is not yet clear whether the responses are due to establishment of the different tree types or the pruning effects.
- Despite low tree costs per hectare for 1 Year Unfeathered and predicted higher returns for Twin Stem trees, early results in this trial suggest that they are the least suitable for growing in a Fruit Wall system because of their slow establishment and lower yields compared to other tree types in the trial and conventionally pruned trees of the same type and age.
- Based on early yields compared with predicted returns and taking into account the tree costs, 2 Year Old, Standard Knip 2 and 1 Year 5 + Branches may be more suitable for growing in a Fruit Wall system but results are not yet conclusive.

Knowledge and Technology Transfer

Results from 2016 have been presented at the:

- FAST LLP growers' conference on 2 February 2017 (Abi Dalton, Trials Manager).
- AHDB Tree Fruit Day for Agronomists on 28 February 2018 (Abi Dalton, Trials Manager).

- An article for the AHDB Grower magazine was submitted in February 2017 for publication.

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Appendix 1 – Photographs 2016

Photograph series 1. 1 year 5 + Branches – before 9 leaf cut and at harvest.

Photograph series 2. 1 Year Unfeathered – before and after 9 leaf cut and at harvest.

Photograph series 3. 2 Year Old – before 9 leaf cut and at harvest.

Photograph series 4. Standard Knip – before and after 9 leaf cut and at harvest.

Photograph series 5. Twin Stem – before 9 leaf cut and at harvest.