Grower Summary

TF225

Developing Practical Strategies to Improve Quality and Storage Potential of UK Apples

Annual report 2020

Project title:	Developing Practical Strategies to Improve Quality and Storage Potential of UK Apples
Project number:	TF225
Project leader:	Dr Richard Colgan - Natural Resources Institute, University of Greenwich
Report:	Annual Report November 2020 (for 2019)
Previous reports:	Annual Report October 2019 (for 2018) Annual Report October 2018 (for 2017) Annual Report October 2017 (for 2016)
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Location of project:	NIAB/EMR, FAST LLP, Selected Gala orchards in Kent
Industry Representatives:	Nigel Jenner, Paul Smith and Nigel Stewart
Date project commenced:	1 April 2016
Date project completed (or expected completion date):	31 March 2021

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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.

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GROWER SUMMARY

Headline

- Centrifugal pruning combined with positioning of reflective mulches in alleyways may increase Fruit Dry Matter content in lower canopy fruit.

Background and expected deliverables

Fruit dry matter (FDM) content is considered a good indicator of high sugar and acid content (% Brixº) and eating quality of apples at harvest. Apples high in FDM tend to retain quality attributes over extended periods of storage. The extent to which orchard management practices during flower bud and fruit development affects FDM at harvest requires further attention. Moreover, the relationship between FDM and the quality of fruit coming out of store throughout the storage season is of interest to the UK apple industry and may afford the opportunity to identify orchard consignments that can be stored for longer.

Several research groups, including the work of Palmer (1999) in New Zealand have linked high FDM at harvest to good quality and good storage potential. These studies were reviewed in AHDB Horticulture Project TF 222 and although previous research highlights the potential to use FDM as a proxy measure of fruit quality, much of this work was correlative.

The underlying basis of this relationship needs to be better understood so that it can be manipulated to deliver premium fruit quality. At the outset of this project, we aimed to achieve this through a combination of the following activities in orchards using Gala apples as a test cultivar:

- A meta-analysis of existing data sets to obtain a greater understanding of the factors controlling both FDM and quality.
- A comparison of different pruning strategies and their effect on FDM.
- A study of the use of reflective mulches and their impact on FDM.
- Manipulation of crop load using bud and fruit thinning to assess their impact on FDM.

The meta-analysis work was undertaken in the early years of this project and is reported on in previous project reports.

Summary of the project and main conclusions

Pruning systems and reflective mulch

At the outset of the project in the Autumn of 2016, innovative centrifugal pruning and training systems were initiated and compared with a standard tall spindle tree within a 4-year old Gala/M9 orchard at NIAB EMR. Within the orchard, reflective mulches were laid on either side of the tree rows between the period of cell division stage (April/May) and two weeks before harvest, to determine the effects of improved light penetration and effects on Class 1 yields, FDM and components of fruit quality (TSS, colour).

In 2019, the Gala orchard used at NIAB EMR was severely affected by apple scab which would have influenced fruit quality and yield at harvest. Therefore, results in 2019 from this section need to be interpreted with caution.

In 2019, the centrifugal training system combined with reflective covers in the alleyways increased % FDM in fruit (Table 1.1) harvested from the lower parts of the canopy (15.6% FDM) and in addition produced fruit with higher firmness (86.6 N= 8.8 kg). The combined treatment delayed fruit maturity, which may be the result of fewer fruits per tree as the trees return to full crop load following their conversion to a centrifugal training system in 2016. Despite manipulation of dry matter content in the lower canopy fruit there was no corresponding increase in % Brix in fruit at harvest.

Table 1.1 Fruit maturity and Fruit Dry Matter (FDM) Content of Gala Apples Subject to Centrifugal Training and the Presence of Reflective Covers

		Int. Eth. Conc. ppb		*Starch CTIFL*		% FDM		*% Brix*		*Firmness (N)*	
	Reflective Covers	Top	Bottom	*Top*	*Bottom*	Top	Bottom	*Top*	*Bottom*	*Top*	*Bottom*
Tall Spindle	*Yes*	385	366	6.8	**8.1**	14.8	14.6	11.9	11.8	79.6	77
	No	348	377	6.2	6.5	14.4	14.6	12.1	11.8	83	81.3
Centrifugal	*Yes*	**153**	**204**	**5.8**	6.1	14.8	**15.6**	11.7	12	83.6	**86.6**
	No	**179**	330	6.7	6.8	14.6	14.9	12	12.1	82.5	82.7
F.prob		0.545		0.349		6.42		0.419		0.327	
$LSD_{0.05}$		80.5		0.35		0.3867		0.54		3.97	

N.B. numbers in bold are significantly different ($p<0.05$) from the control treatment (Tall Spindle No Covers). To convert fruit firmness from Newtons (N) to kg divide values by 9.8

Fruit thinning

The work on the effects of fruit thinning in 2019 were carried out by FAST in a Gala orchard at their Brogdale Farm, near Faversham in Kent.

Treatments 2019

NO	DESCRIPTION	RATE & WATER VOLUME	EVENTS / APPLICATIONS	BBCH STAGE	DETAILS
1.	Control	Na	Na	Na	Na
2.	Singles	Na	1	71-72	Fruit size 10-20mm before fruit fall
3.	Single (>.1.5 M) Doubles (< 1.5 M)	Na	1	71-72	Fruit size 10-20mm before fruit fall
4.	Chemical Exilis & Fixor*	Exilis 3.5 L/ha to **7.5 L/ha** in 100 L water Fixor **100ml/ha**	1 per year maximum application	70 -72	8 to 10mm Exilis + Fixor (no treatment > 10mm) 7 to 15mm Exilis alone KING FRUIT SIZE >15ºC & increasing temperatures 3 to 4 days after
5.	Chemical Brevis*	1.1kg/ha to **1.65g/ha** (2.2kg/ha max) in 1000L water	2 NB minimum 5 days between applications	1 = 70-71 2 = 71-72	Application 1 8-10mm Application 2 12-14mm KING FRUIT SIZE 9-11mm (8-14mm max window) lower water volumes (min 350L/ha no tank mix
6.	Hand Thinning Standard	Na	1	71-73	15mm to 25mm Pre/up to 2nd fruit fall (50 days post full bloom)
7.	Hand Thinning Size	Na	2	1 = 73 2 = 74	Event 1 from 25mm-30mm (at fruit fall) Event 2 at 40mm (late, after fruit fall)
8.	Doubles		1	71-72	Fruit size 10-20mm before fruit all

* Chemical thinners were applied using manufacturers' recommendations and adapted according to conditions before, during and after applications (see product label, SDS and guidelines (Appendix 1)).

Fruit thinning practices reduced overall yield per tree but increased the percentage of Class I fruit (Table 1.2). While no single thinning treatment stood out as a preferred treatment in terms of overall yield of class I improvement, there were differences associated with size distribution of fruit and the sources of rejection (Table 1.3, Figure 1.1, Table 1.4).

Table 1.2 Grade out of Gala apples at harvest subject to thinning regimes during fruitlet development

	Control	*Singles*	*Singles/ Doubles*	*Exilis*	*Brevis*	*Standard*	*Size*	*Doubles*	*F.prob*	*$LSD_{0.05}$*
%Class1	50.6	**63.1**	**59.5**	**61.8**	48.1	**61.9**	**61.6**	**58**	0.525	17.38
Yield/Tree (kg)	**37.1**	25.0	30.8	30.3	23.0	28.3	29.1	25.4	0.002	5.93

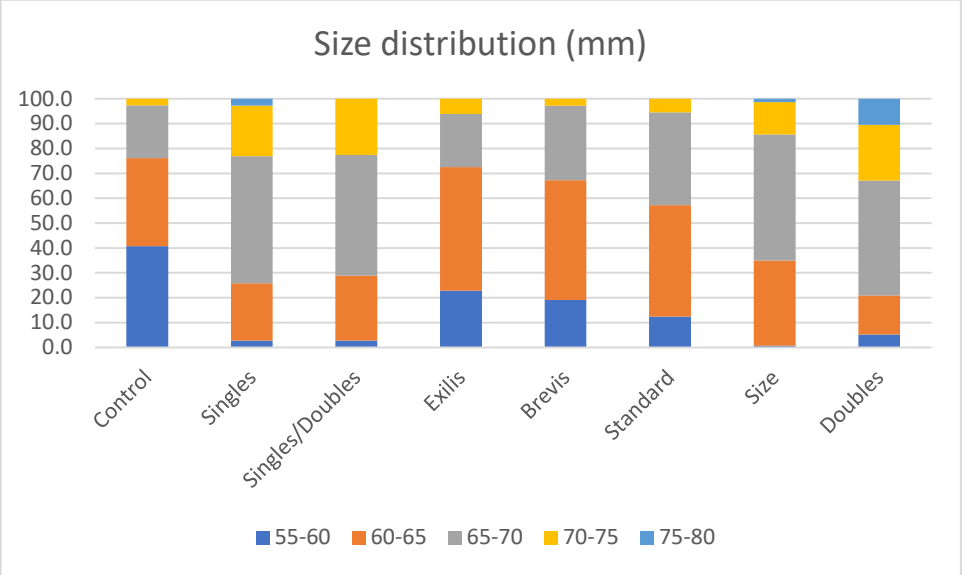

Figure 1.1 Size distribution of Gala apples subject to different thinning regimes during fruitlet development

Table 1.3 Size distribution of Gala apples subject to different thinning regimes during fruitlet development

Size Class (mm)	*Control*	*Singles*	*Singles/Doubles*	*Exilis*	*Brevis*	*Standard*	*Size*	*Doubles*
55-60	40.7	2.7	2.8	22.9	19.1	12.4	0.7	5.2
60-65	35.4	23.1	26.1	49.6	48.2	44.8	34.2	15.7
65-70	21.2	51.0	48.6	21.4	30.0	37.2	50.7	46.3
70-75	2.7	20.4	22.5	6.1	2.7	5.5	13.0	22.4
75-80	0.0	2.7	0.0	0.0	0.0	0.0	1.4	10.4

However, both spray treatments (Exilis and Brevis) shifted the majority of fruit to the 60-65 mm category. This was observed in trees subject to standard thinning practices, while as expected, un-thinned trees produced the largest proportion of 55-60 mm sized fruit.

Thinning to size, singles, singles/doubles or doubles across the tree shifted size category of the Gala with a greater proportion of 65-70 mm fruit. Thinning to singles, singles/doubles or doubles across the tree produced the smallest proportion of 60-65 mm fruit. Thinning to singles, singles/doubles, doubles or to size, minimised fruit size below 60 mm. Thinning to doubles across the tree had the unexpected result of shifting fruit size towards larger fruit with over 10% of the size classes in the 75-80 mm category (Table 1.3).The effect of thinning strategies on weight of fruit from each size class can be seen in Table 1.4; thinning to singles, singles/doubles or doubles when fruitlets were between 10-20 mm had the effect of increasing the yield of fruits in the 65-70 mm category and was equal to the thinning to size strategy. Early thinning (10-20 mm) increased the yield of class1 as did thinning to size (Table 1.4).

Table 1.4 The weight (g) of Class 1 Gala apples in each size category as a result of fruitlet thinning strategies. Figures in parenthesis represent average fruit numbers making up the yield in each size category averaged across four replicate plots.

Treatment	55-60 mm	60-65 mm	65-70 mm	70-75 mm	75-80 mm	Total wt
Unthinned	908 (11.5)	1032 (10)	751 (6)	110 (0.8)	0	560
Singles	40 (1)	933 (8.5)	2464 (18.8)	1207 (7.5)	187 (1.0)	**966**
Singles/Doubles	62 (1.0)	960 (9.3)	2264 (17.3)	1259 (8)	0	**909**
Exilis	568 (7.5)	1716 (16.3)	908 (7)	306 (2)	0	699
Brevis	402 (5.3)	1377 (13.3)	1052 (8.3)	108 (0.8)	0	588
Standard	346 (4.5)	1734 (16.3)	1747 (13.5)	297 (2.0)	0	825
Size	12 (0.3)	1344 (12.5)	2402 (18.5)	746 (4.8)	86 (0.5)	**918**
Doubles	94 (1.8)	559 (5.3)	2000 (15.5)	1190 (7.5)	654 (3.5)	**899**
$LSD_{0.05}$ 663.2 Treatment x Size class $LSD_{0.05}$ 296.6 Treatment (Total weight)			F.prob <0.001 F.prob <0.035			

A more detailed analysis of grade-out data taken from a nominal 60 fruit sample per plot found that lower grade out figures for Gala treated with Brevis were associated with a higher proportion of diseased fruits and a higher numbers of small fruits <55 mm (Table 1.5). Un-thinned trees produced a significant number of small undersized fruits.

Table 1.5. Types of Fruit Deformities Resulting in Rejection during Grading

Grade out-Numbers of fruit	***Control***	***Singles***	***Singles/Doubles***	***Exilis***	***Brevis***	***Standard***	***Size***	***Doubles***
Scarring/Russet	1.5	2.8	2.0	1.5	0.8	0.8	1.0	2.0
Damage - pest/physical	7.5	5.5	8.5	6.5	9.3	8.0	9.0	9.3
Misshapen	1.5	2.0	2.3	2.8	1.8	0.8	1.0	2.3
Small	12.5	1.3	2.3	4.3	7.3	1.0	0.8	1.5
Diseased	9.8	10.5	7.3	7.8	12.3	11.8	11.5	9.5
Lack % Red	0.5	1.0	3.0	0.8	1.5	1.5	0.5	2.0
Unmarketable	33.3	23.0	25.3	23.5	32.8	23.8	23.8	26.5
Marketable	28.3	36.8	35.5	32.8	27.5	36.3	37.0	33.5

Total (n=60)	61.5	59.8	60.8	56.3	60.3	60.0	60.8	60.0

Thinning practices that raised FDM were restricted to trees where fruitlets were thinned to singles across the tree, or subject to standard thinning or thinning to size. This only translated to increase % Brix in fruit where thinning to size had been practiced (Fig 1.6). In general, %FDM in the 2019 season was low, partly due to the cooler summer compared to 2018 and previous years. Brevis and Exilis applied at BBCH 70-71 & 71-72 failed to significantly increase %FDM.

Thinning generally improved fruit firmness across the treatments raising firmness by 4-5 N (0.4-0.5 kg). Thinning to single fruitlets per cluster across the tree produced the firmest fruit at 92.6 N (9.2 kg) at harvest. Individual sugar concentrations more clearly reflect changes in maturation.

Table 1.6 Overall fruit maturity, %FDM and sugar content of Gala apples at harvest grown under different fruitlet thinning regimes (average of apples from the top and bottom canopy)

Thinning	***Control***	***Singles***	***Singles/ Doubles***	***Exilis***	***Brevis***	***Standard***	***Size***	***Doubles***	***F.prob***	***$LSD_{0.05}$***
I.E.C ppb	193.2	**289.8**	**341.3**	**282.3**	**328.3**	**384.1**	**401.1**	**342.7**	<.001	52.57
Starch	5.3	**4.08**	**4.08**	**3.95**	**4.2**	4.58	4.47	4.88	0.051	0.98
% Brix	12.0	12.4	11.4	11.8	12.1	12.2	**12.8**	**12.6**	<.001	0.61
% DM	15.4	**16.4**	15.7	15.7	16.1	**16.5**	**16.5**	16.1	0.127	0.87
Fructose	123.7	**103.0**	**105.8**	114.8	119.0	**110.5**	123.9	**111.1**	<.001	9.23
Glucose	14.0	**9.8**	**9.7**	12.0	12.2	12.0	12.3	**11.3**	0.004	2.11
Sucrose	75.8	81.2	81.3	74.7	**83.1**	**82.7**	**85.0**	82.3	0.041	6.77
Firm (N)	84.5	**92.6**	**88.4**	**88.3**	87.2	**89.6**	**88.9**	**89.3**	0.003	3.40

Values in bold are significantly different ($p<0.05$) from fruit harvested from the control (un-thinned trees) in the same row. To convert fruit firmness from Newtons (N) to kg divide values by 9.8

Main conclusions drawn from the work in 2019

In the fourth year of this study, Fruit Dry Matter (FDM) content in Gala apples was increased by manipulating crop load through fruitlet thinning practices. However, neither the timing of thinning events, the final crop load achieved, nor the use of alternative chemical thinning agents, provided specific advantage in raising FDM in Gala.

Increasing light interception by the adoption of centrifugal training systems in conjunction with positioning of reflective mulches in alleyways raised FDM in apples harvested from the lower canopy.

The benefits of fruit thinning and centrifugal pruning combined with reflective mulches were seen in different parts of the canopy. Thinning treatments were most effective in raising FDM in the upper canopy, while centrifugal pruning/reflective covers raised FDM in the lower canopy by 0.7% to 15.6% FDM.

Hand thinning practices, where fruitlets were removed to single fruits per cluster across the tree, standard thinning or thinning to size were more effective in raising the FDM across the whole of the canopy.

Applying thinning treatments earlier at fruitlet size 10-20 mm (singles, single/doubles or doubles) led to increased fruit size at harvest, compared to implementing standard thinning practices single fruits per cluster > 1.5M and double fruitlets per cluster <1.5 M when fruits were at 15-25 mm in size.

As expected, fruit thinning raised firmness of fruit, improved the size grade out for class I and delayed fruit maturity.

Financial benefits

- No financial benefits from this work have been identified to date.

Action points for growers

- Harvesting fruits higher in the canopy separately will provide consignments with higher FDM.
- Centrifugal Pruning combined with reflective mulches can increase FDM in fruit from the lower canopy.
- Manipulating crop load through thinning, can increase %FDM. The timing of hand thinning or application of thinning agents has more influence on fruit size at harvest rather than specifically manipulating %FDM.
- Early thinning events (10-20 mm) may increase the number of fruits reaching the target 65-70 mm size and may be as effective as thinning to size strategy.
- In this study, application of Brevis or Exilis concentrated fruit size in the 60-65 mm category. Brevis treated trees had a poorer grade-out due to a higher number of smaller (< 55 mm) fruit, possibly due to poor uptake in the lower canopy.