# Research and Development Protocol for Grazed Orchards in Northern Ireland

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| **Project name** | AGFORWARD (613520) |
| **Work-package** | 3: Agroforestry for High Value Trees |
| **Specific group** | Grazed orchards in Northern Ireland, UK |
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**Contents**




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## 1 Context

The AGFORWARD research project (January 2014-December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to the second objective. It contributes to the initial research and development protocol for one of the ten stakeholder groups which are focused on the use of agroforestry in high value tree systems.

## 2 Background

Apples (*Malus domestica*), are the main fruit produced in Northern Ireland, with 99% being of the "Bramley" apple variety. The other 1% is made up of cider and dessert varieties. In March 2012, the Armagh Bramley Apple gained Protected Geographical Indication (PGI) Status. Currently 96% of production is in County Armagh which is also known as "The Orchard County". The annual rainfall is up to 2000 mm and the mean temperature is 3$^{o}$C in winter and 18$^{o}$C in summer. The soils in the area are highly fertile, silt-loam or clay-loam, high in calcium and essential nutrients with a pure and abundant supply of water.

The apple industry in Northern Ireland has 223 Independent growers farming 1506 ha of orchards, with a typical field size of 1.5 to 4 ha. The tree spacing varies with the rootstock used: the M9 dwarfing rootstocks are widely used with a typical spacing of 4 m between rows and 1.5 m between trees. The field boundaries are planted with windbreaks or hedgerows of mixed woody species. The area below the windbreaks is generally left unmown, producing a dense understorey. Grass strips between trees mowed regularly. Pruning is carried out manually in the summer and winter. To aid pollination, honey bees are brought into the orchards during the flowering period.

Across Northern Ireland, approximately 35 tonnes of pesticides are applied each year (2012 figure) primarily as fungicides to prevent the main disease apple scab (*Venturia inaequalis*). A typical spray regime involves fungicide applications every 10-14 days from May (flowering) to end of July. There will also typically be one application of an insecticide each year and two herbicide applications per year.

The industry employs directly about 300 full time workers and 450 casual staff. Other industries such as handling, packing, juicing and cider making also generate further employment. The apple industry in Northern Ireland produces an average 30-45,000 t/year. Of this about 12-15% is sold fresh with a market value of £6.3 million, 60-70% to an added value market worth £7-8 million, and 25-30% to juice. In is estimated that 35% of fresh apples are exported to Republic of Ireland and the rest of the UK. It is estimated that the total annual value of the apple industry in Northern Ireland is £13.3-14.3 million.

The other component of the grazed orchard system is sheep management. There are about 1.9 million sheep in Northern Ireland. These are managed by about 20,000 beef and sheep farmers (no distinction is made) and the average farm size is 35.5 ha. More work is needed to find which of these might be suitable for silvopastoral systems, but there is a large potential.

Livestock incur costs and add additional complexity to the system, and an administrative burden. However, these orchards can be mown about eight times a year, and may require herbicide application to control weeds, which have an additional expense, environmental impact, amongst other disadvantages Therefore, if the complexity and additional administrative burden can be overcome, there exist opportunities for using grazing as a tool to manage the grass understory whilst providing grazing for sheep, and potentially other beneficial synergies. For example, it has been postulated by farmers that better control of apple scab might be achieved by grazing, since sheep will eat apple leaves immediately as they fall to the ground, and help to decompose old leaves by trampling, thus reducing harbourage for the organism responsible (Corroyer 2014; McAdam 2014).

A meeting of the 'Grazed Orchards in Northern Ireland' stakeholder group was held on 4 December 2014, at which it was decided that a key area of interest was to study sheep grazing (mixed breed) in dessert and cider orchards.

## 3 Objective of experiment

The aim of the experiment is to produce quantitative information about the use of sheep (mixed breeds) to graze Cider and Dessert orchards in comparison to normal management, mechanical mowing and similar sized grazing plots without trees.

Key questions include:

- What are the financial and labour impacts of grazing?
- Is there any damage to trees caused either by mechanical mowing or grazing?
- What is the impact of grazing on the bottom of tree canopies?
- What is the impact of grazing in the orchard on weight and condition of sheep?
- Develop a better understanding of the constraints imposed in normal orchard operations, such as spraying, of grazing with sheep.
- Is grazing a problem for the fruit quality, do the animals or competition with weeds impact fruit yield?

Alongside these questions, a number of hypotheses can be developed:

- Savings will be made on the cost of mowing as a result of the introduction of sheep into the orchards, although these may be offset by the additional labour related costs associated with handling the sheep.
- The sheep will browse the lower branches of the trees, thereby raising the lower limit of the canopy. This damage will be light.
- Sheep live weight gain will be similar to the live weight gain expected on a similar area of pure pasture for a similar time period.

# 4 System description

Figure 1. Stakeholder group in Northern Ireland discussing sheep grazing in orchards

The experimental orchard is located in the Agri-Food and Biosciences Institute (AFBI) research station, Loughgall Co. Armagh Northern Ireland. The orchard was planted in 1998 and consists of wo apple varieties: 1) dessert – Jonagold, tree spacing 4 m between rows x 1.5 m between trees, 1485 trees/ha, rootstock M9. 2) cider – Coet-de-linge tree spacing 5 m between rows x 2 m between trees, 1485 trees/ha, rootstock MM106.

Each variety has four blocks surrounded by an Alder windbreak. Each of these blocks is further divided into two plots. During 2014 all necessary fencing was carried out to allow sheep to run safely in the orchard. At present the bottom of the canopy is about 75 to 80 cm from the ground. The grass sward is suitable for sheep, whilst a water trough will be accessible to the sheep. All harvesting will be carried out by hand picking or gathering of windfalls. Further details are given in Table 1.


Figure 2. Location of AFBI, Northern Ireland.

Figure 3. Overview of the AFBI trial plots (2014)

Figure 4. A trial plot area

Table 1. Description of the site, with soil, tree, understorey, livestock, and climate characteristics.

| Site characteristics | |
|---|---|
| Area (ha): | |
| Co-ordinates: | 54.412075°North; -65.81690°West |
| Site contact: | Jim Mc Adam |
| Site contact email address | jimmcadam@afbini.gov.uk |

| Soil characteristics | |
|---|---|
| Soil type (WRB classification) | Eutric rhodic cambisol<br>Calcareous brown earth on carboniferous limestone red till |
| Soil depth | 30 cm |
| Soil texture (sand%, silt%, clay%) | Clay loam and clay, Clay-rich red soil |
| Horizon | sand%, silt%, clay% |
| Ap | 50.6 25.1 24.3 |
| Bw | 42.4 14.4 43.2 |
| C | 43.3 26.5 30.1 |
| Aspect | Easterly aspect, tending slightly to the South East |
| Landscape | This unusual clay-rich red soil is found in the drumlins of Co. Armagh from Loughgall to Armagh City and Navan. |
| Soil Series Area | Red limestone (Carboniferous) till covers 3,005 ha, or 0.22% Northern Ireland area.<br><br>Available P is adequate in the Ap, but K and Mg are low. pH is extremely high in B and C horizons, reflecting the high Ex. Calcium values and high total of exchangeable bases. CEC is base saturated. High per cent LOI reflects presence of carbonates. The strong red colour of the soil is not reflected in total iron values. Soil textures are clay loam and clay (clay is 43.2%) in the B horizon. The soil may be classed possibly as a PELOSOL.<br>Munsell colour of B horizon is 2.5YR 4/4 Reddish Brown |

| Climate data | |
|---|---|
| Mean monthly temperature | 13.3°C |
| Mean annual precipitation | 812 mm Reference Climatic data 1981 – 2010 for Ardress House, reference UK Meteorological Office Web Site (2015). |
| Additional details | Chances of spring frosts average of 16.5 days frost over the past 30 years from March to May |
| Details of weather station | Data can be accessed from 2 weather stations both within 2 miles for the trial site. Weather station 1 is used to feed data to the national met station. Number 2 is used to record data for the prediction of Apple Scab infection periods. |

Table 1 continued

| Tree characteristics | | | | | | |
|---|---|---|---|---|---|---|
| Experimental design: factorial 3 crop areas (2 apple varieties + 1 grass) x 2 management (mow or sheep) x 4 replications = 24 plots | | | | | | |
| | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 | Treatment 5 | Treatment 6 |
| Tree species | Cider apple | Dessert apple | No trees, grass paddock | Cider apple | Dessert apple | No trees, grass Paddock |
| Variety<br><br>Rootstock | Coet-de-linge<br><br>MM106 | Jonagold<br><br>MM106 | Similar sized grass plots | Coet-de-linge<br><br>MM106 | Jonagold<br><br>MM106 | Similar sized grass plots |
| Tree density (spacing)<br>Between rows<br>Between trees<br>Trees per ha<br>Approximate experimental plot size | <br>5 m<br>2 m<br>900<br>10 m x 33 m (0.033 ha) | <br>4 m<br>1.5 m<br>1485<br>Either 10 m x 33 m (0.033 ha) or 14.5 m x 33 m (0.048 ha) | <br><br><br><br>10 m x 33 m (0.033 ha) | <br>5 m<br>2 m<br>900<br>10 m x 33 m (0.033 ha) | <br>4 m<br>1.5 m<br>1485<br>Either 10 m x 33 m (0.033 ha) or 14.5 m x 33 m (0.048 ha) | <br><br><br><br>10 m x 33 m (0.033 ha) |
| Tree protection | Hare guards | Hare guards | | Hare guards | Hare guards | |
| Management | Mow April to harvest | Mow April to harvest | Mow April to harvest | Sheep | Sheep | Sheep |
| Under Story Management | Herbicide strip (2m wide TBC) | Herbicide strip (2m wide TBC) | No trees Grass paddock | Herbicide strip (2 m wide TBC) | Herbicide strip (2 m wide TBC) | No trees Grass paddock |
| coverage | Some weeds | Some weeds | Complete | Some weeds | Some weeds | Complete |
| Sheep breed<br>Stock rate | None | None | None | Mixed<br>3 per plot | Mixed<br>3 per plot | Mixed<br>3 per plot |

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# 5 Experimental design

## 5.1 Conceptual design

This experiment follows a replicated split-plot design. Classically these experiments are used in agricultural research for testing interactions between a number of different factors for example irrigation, plant hybrid, or fertiliser rate. In these experiments, every combination of each of the factors is tested in a number of 'sub-plots'. Every field is unique, with its own slope, aspect, soil, local micro-climate, but uncertainty caused by these so-called 'site effects' can be reduced by replicating the experiment several times in several fields, or more commonly, in several adjacent blocks. Split plot experiments are considered to be robust and produce a high quality of information for scientists.

## 5.2 Description of design

This experiment combines four replicates of three crops: Dessert apples, Cider apples, and a grass control, with a management treatment: grazing or mowing (Table 2).

Table 2. Experimental treatments (with 4 replicates = 24 plots).

| Treatment and variety | Management | Animal density | Grazing/mowing |
|---|---|---|---|
| 1. Coet-de-linge (Cider) | Mow | 0 | Mow April to before harvest |
| 2. Jonagold (Dessert) | Mow | 0 | Mow April to before harvest |
| 3. Grass (Control) | Mow | 0 | Mow April to before harvest |
| 4. Coet-de-linge (Cider) | Graze | 6 per plot | Sheep June to before harvest<br>Sheep after harvest |
| 5. Jonagold (Dessert) | Graze | 6 per plot | Sheep June to before harvest<br>Sheep After Harvest |
| 6. Grass (Control) | Graze | 6 per plot | Sheep June to before harvest<br>Sheep after Harvest |

**Orchard details:**

**Site** Dessert: Jonagold; cider:- Coet-de linge and plots in Bettycooks

**Rootstock MM106**

**Jonagold**

Tree spacing 5 rows x 16 trees (4 m between rows x 1.5 m between trees) = 1485 trees per ha
Main plots = 80 trees x 4
Spilt the main plots to give 4 mowed and 4 grazed treatments = 8 plots

**Coet-de-linge**

Tree spacing 4 rows x 10 trees (5 m between rows x 2 m between trees) = 900 trees per ha
Main plots = 40 trees x 4
Spilt the main plots to give 4 mowed and 4 grazed treatments = 8 plots

**Grass plot areas**

4 mowed and 4 grazed = 8 plots

**Livestock details**

3 dry sheep per grazed plot to be rotated between treatments 3 and 6

## 6 Crop management and husbandry

Table 3. Crop management

| Time | Crop management/Husbandry |
|---|---|
| | • Before carrying out any husbandry activity in this orchard please discuss with Fran or Jim Mc Adam. |
| Early season[1] | • All plots to receive fungicide applications up to end of flowering.<br>• Mowing is to be maintained in all plots up until 10 days before sheep application (Start of May).- record mowing dates<br>• Spring herbicide application on all plots, pre sheep application.<br>• This area had fertilisers applied Spring 2014. No further fertilisers to be applied for the trial period. |
| End of flowering (May) | • Sheep to be applied from end of flowering<br>• Once sheep are on mowing is carried out only in the Mowing plots.<br>• Pruning and water shots to be removed as normal. Record dates of activities. |
| Late Aug to Harvest | • Sheep removed. To provide a 56 day harvest interval<br>• Normal orchard husbandry to continue. |
| Post-harvest | • Apply the sheep to treatments plots as soon as possible.<br>• Sheep do not eat brown leaves so sheep are to be applied to plots as soon as possible after harvest to consume the leaves as they fall. The sheep are to stay on the plots as long as possible to clean up the site; this will be weather and amount of grass dependant. |

[1]**:** Until end of flowering this orchard is to receive the same husbandry as the other orchards on the estate

## 7 Scientific management

Table 4. Timing of scientific management

| Time | Scientific management |
|---|---|
| Pre June/stocking of trial | • Soil analysis x 18 samples<br>• Record distance from soil to lowest growth point before sheep<br>• Trial is stocked.<br>• Pre stocking – 18 grass samples cut and dried<br>• Soil compaction measurements<br>• Worms<br>• Sward heights |
| Sheep records when on the orchards | • Monitor the height of the grass in the sheep plots, when it reaches 4 cm rotate the sheep to the next plot in the treatment (treatments 4, 5 or 6). From 2014 experience this could be as little as 3 days stocking for each plot. Let the plot rest for 10 days before restocking. If necessary remove the sheep from the trial for 10 days.<br>• Record the weight of each sheep as it is put into and taken from a treatment plot.<br>• Record the number of days a sheep stays in a plot<br>• Sheep grazing days – number of sheep x days in the plot |
| June | • Leaf scab assessments (on 4 central trees per plot)<br>• Damage caused by sheep each time sheep are removed from a plot |
| July | • Leaf scab assessments (on 4 central trees per plot)<br>• Damage caused by sheep each time sheep are removed from a plot |
| August | • Leaf scab assessments (on 4 central trees per plot)<br>• Damage caused by sheep each time sheep are removed from a plot<br>• When sheep removed before harvest 18 grass samples cut and dried (1 per plot) (?digestibility required)<br>• Height soil to lowest branch (on 4 central trees per plot) (4 sides per tree)<br>• Soil compaction<br>• Worm assessment<br>• Soil analysis<br>• Record distance from soil to lowest growth point before and after sheep |
| September | • Harvest weights from the full plot<br>• Plot Weights: picked and drops; grades<br>• Fruit scab, and fruit pest (Blastobasis)<br>• Fruit diseases,<br>• Fruit damage from sheep. |
| Oct – Autumn clean up and treatments | Before restocking treatment 3 and 6 with sheep:<br>• 18 plots visual assessments % of leaves<br>i) under the trees and ii) on the grass strips<br>Treatment application<br>• Mow/pulverise leaves in treatments 1, 2 and 3<br>• Restock treatments 4, 5 and 6 until all the fallen leaves are eaten. Again rotate sheep when grass is down to 4 cm as for initial application of sheep<br>Post re stocking and autumn treatments<br>• 18 plots visual assessments % of leaves<br>i) under the trees and ii) on the grass strips<br>• Record damage caused by sheep if any and the number of trees in the plot affected |

## 8 Statistical analysis

Table 5. Description of the data for statistical analysis

| Measurement | Analysis |
|---|---|
| Soil Samples nutrient analysis (1 per plot, 18 plots) | a. June Pre stocking<br>b. Aug Post stocking |
| Distance from soil to lowest branch (1 per plot, 18 plots) | a. June Pre stocking<br>b. Aug Post stocking |
| Grass Samples mineral analysis and dry matters (?digestibility) (1 per plot, 18 plots) | a. June Pre stocking<br>b. Aug Post stocking |
| Soil Compaction Measurements (1 per plot, 18 plots) | a. June Pre stocking<br>b. Aug Post stocking |
| Worm analysis per plot (1 per plot, 18 plots) | a. June Pre stocking<br>b. Aug Post stocking |
| Mean Sward Heights (1 per plot, 18 plots) | a. June Pre stocking Sward heights |
| Sheep Weights | a. Sheep weights when put on to a plot various dates<br>b. Sheep weights when taken out of a plot |
| Sheep grazing days | Number of sheep x days in the plot. |
| % Leaf Scab analysis | a. June<br>b. July<br>c. Aug |
| Leaf % cover | a. Autumn/Oct Pre re stocking<br>b. Autumn/Nov Post re stocking |
| Sheep damage to trees | |
| Harvest Data | A Wt of 100 apples kg<br>B Plot Wt picked kg<br>C Plot Wt drops kg<br>D Total Yield of no trees kg<br>E Number of cropping trees per plot<br>F Av Yield per tree Kg<br>G % <70 mm<br>H % 70 – 80 mm<br>I % 80 – 90 mm<br>J % 90 – 100 mm<br>K % >100 mm<br>L % Fruit > 70 mm<br>M Penetrometer<br>N Fruit No Scab seen <70 mm<br>O Fruit No Scab seen >70 mm<br>P % Marketable fruit<br>Q % Unmarketable Fruit<br>R % Blastobasis<br>S Wt of Marketable fruit per plot<br>T Wt of Unmarketable fruit per plot kg<br>U Plot Yield tonne per ha |


Figure 4. Schematic diagram of the experiment.

## 9 Acknowledgements

The AGFORWARD project (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD, Theme 2 - Biotechnologies, Agriculture & Food. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission. We acknowledge the support of the Soil Association and the Bulmer Foundation in organising the meetings.

## 10 References

Mcadam, J.H. (2014). Initial Stakeholder Meeting Report Grazed orchards in Northern Ireland, UK, Loughall, Northern Ireland. Available at: http://www.agforward.eu/index.php/en/grazed-orchards-in-northern-ireland-uk.html?file=files/agforward/documents/WP3_NI_grazed_orchards.pdf [Accessed January 15, 2015].

UK Meteorological Office (2015). Met Office. http://www.metoffice.gov.uk/public/weather

## Appendix A. Example recording sheets

Table A.1. Tree canopy recording

| | Bottom heights in centimetres | | | | | |
|---|---|---|---|---|---|---|
| Tree number | 1 | 2 | 3 | 4 | 5 | Average |
| 1. | | | | | | |
| 2. | | | | | | |
| 3. etc | | | | | | |

Table A.2 Sheep weight

| Date in | Number of sheep | Sheep type* | Average weight | Average condition score | Date Out | Number of sheep | Sheep type | Av weight | Av condition score |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

*ewe, lamb, ewe lamb, in-lamb ewe, ewes with lambs at foot

Table A.3. Field operations

| Date | Type of operation* | Inputs used~ | Cost of inputs | Time taken |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

*Topping, spraying, etc ~sprays, lime, etc

Table A.4. Minerals

| Mineral type/description | Date | Quantity |
|---|---|---|
| | | |
| | | |

Table A.5. Labour

| Date | Job description | Time taken |
|---|---|---|
| | | |
| | | |
| | | |

Table A.6. Tree damage

| Date | Treatment 1 or 2 | Short Description | Damage scale 1-5 |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

## Appendix B. Climatic data 1981 – 2010

for Ardress House, reference UK Meteorological Office Web Site (2015).

| Month | Max. temp (°C) | Min. temp (°C) | Days of air frost (days) | Sunshine (hours) | Rainfall (mm) | Days of rainfall >= 1 mm (days) | Monthly mean wind speed at 10 m (knots) |
|---|---|---|---|---|---|---|---|
| Jan | 7.4 | 1.9 | 8.6 | 46.4 | 74.5 | 14.3 | n/a |
| Feb | 8.1 | 1.6 | 8.8 | 69 | 54 | 11 | n/a |
| Mar | 10.2 | 3.1 | 4.8 | 96.6 | 65.6 | 13.3 | n/a |
| Apr | 12.6 | 4.3 | 2.9 | 142.6 | 57.6 | 11.6 | n/a |
| May | 15.6 | 6.7 | 0.3 | 173.5 | 57.8 | 11.8 | n/a |
| Jun | 18.0 | 9.6 | 0 | 144.2 | 58.4 | 10.9 | n/a |
| Jul | 19.7 | 11.7 | 0 | 137 | 62.7 | 11.7 | n/a |
| Aug | 19.3 | 11.4 | 0 | 133.3 | 76.3 | 13 | n/a |
| Sep | 16.9 | 9.5 | 0 | 113.9 | 68.1 | 12.2 | n/a |
| Oct | 13.4 | 6.8 | 0.9 | 90.2 | 85.5 | 13.7 | n/a |
| Nov | 10.0 | 3.9 | 4.4 | 58.5 | 74.6 | 13.6 | n/a |
| Dec | 7.7 | 2.1 | 8.5 | 40.3 | 77.1 | 13.3 | n/a |
| Annual | 13.3 | 6.1 | 39.2 | 1245.5 | 812.3 | 150.3 | n/a |

Ardress House (NT) site information:
Location: 54.442, -6.584
Altitude: 18 m above mean sea level