Field lab: Growing Flax for Regenerative Textiles

Final report

November 2023

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Summary

The project is coordinated by facilitator Colleen McCulloch in collaboration with the James Hutton Institute and Edinburgh College of Art at the University of Edinburgh; with support from Fantasy Fibre Mill and Heriot Watt University, and trial seeds provided by seed specialists Elsoms Seeds.

Take home messages

Fibre flax (*Linum usitatissimum*) has the potential to become an attractive addition to arable, horticultural and mixed rotations. There is a growing demand for UK-produced fibre crops, and a small but growing capacity for processing. Flax also grows well without chemical inputs and irrigation and is an attractive food source for pollinators. Although 'Tango' was shorter across the board, all three trial varieties performed well in terms of yield and straw height, which could likely be further improved with better weed control.

Context

Flax was once grown widely across the UK, before the advent of synthetic fibres and cheap overseas labour. A renewed appetite for more sustainable, natural textiles is driving a new wave of flax growing, to supply a sustainable and regenerative textile and fashion industry based on the principles of circularity and social and environmental responsibility. Since 80% of the world's flax is grown in Belgium, France, and the Netherlands, there is an opportunity to test new varieties in UK conditions and re-establish commercial production in the UK.

Trial design

Three new Dutch varieties of fibre flax (*Linum usitatissimum*) – Avian, Delta and Tango – were trialled at three Scottish sites to compare their straw height (cm) and yield (t/ha).

Each site grew 3 replicates of each variety in 10m^2 strips, sown in rows (8 rows per metre) either by hand or with a Jang seeder. The crop was harvested before it was fully ripe to obtain the best fibre quality, at which point crop density, height, and weight were measured.

Findings

When compared by variety, both the average height (cm) and average weight (t/ha) were similar for the Avian and Delta varieties, and lower for Tango. However, variation between sites was high, particularly for yield (weight).

Weed pressure will account for some of this variation; Site 1 was weed-free and recorded consistently taller crop heights, and most of the biggest weights. However, the crop of Avian at Site 3, which was weedy across all plots, returned the highest yield - 13t/ha compared to 9t/ha at (weed-free) Site 1 and 8t/ha at (weedy) Site 2.

Harvesting was done by hand with teams of volunteers due to lack of access to specialist machinery – fibre flax needs to be pulled rather than cut. This worked well on a small scale

and was a great way to engage people with the idea of regenerative fibre production, but harvesting on a commercial scale will require access to specialist equipment.

Recommendations & next steps

In the short term, the retted crop has been sent to project partners to be processed over the winter. Samples will also be lab-tested by colleagues at Herriot Watt University for fibre length, strength and quality.

Beyond this, plans are underway to refine the trial for 2024, and expand it to six sites, testing the same three varieties.

Useful resources

- Project Summary Sheet (https://www.soilassociation.org/media/26249/flax-fl-info-board-landscape-28_6.pdf)
- Flax: Bringing back the historic crop which could make fashion greener - BBC News (https://www.bbc.co.uk/news/uk-scotland-66593992.amp)

Farmer comment

Jossie Ellis, Market Gardener at Lauriston Farm, Edinburgh
"The trial has prompted conversations about sustainable fibre, regenerative farming and clothing, and the impacts of food and fibre production on the environment. Finding the seeds that work here will help contribute to the wider aim of bringing this industry back to the local area. We are also interested to see how it could fit within our vegetable rotations, given its short growing season."

Image 1: Grower Jossie Ellis being interviewed for BBC Farming Today while harvesting flax at Lauriston Farm

Main report

1) Field lab aims

The trial's main aim was to compare the performance of 3 new Dutch-bred varieties – Avian, Delta and Tango - in Scottish growing conditions.

Two secondary objectives were to gain and share experience of the hand-harvesting and retting process, and to compare the fibre quality of the three varieties.

2) Background

Once the foundation of Scotland's booming linen industry in the 18th and 19th centuries, flax (*Linum usitatissimum*) has not been commercially grown for fibre in Scotland since at least the 1950s – due in part to cheaper imports and the relocation of manufacturing.

However, increasing awareness of the negative environmental (and human) impacts of 'fast fashion' has led the textile and fashion industries in Scotland to actively seek more sustainable alternatives, which embed agroecological production and circular economy principles.

For farmers interested in diversifying their rotations with crops which are good for biodiversity, and which suit a regenerative or organic approach, fibre flax fits very well. There is a ready demand for farmers interested in providing the crop for a UK-grown, biodegradable textile; something which is not currently being produced on a commercial scale in the UK.

The field lab started as a one-year trial, but the growers are keen to scale up and collaborate with a growing network of other businesses and organisations to establish a commercially viable Scottish linen processing and supply chain in the longer term. And since the Delta and Tango varieties are not yet commercially available in the UK, this trial will inform wider industry knowledge on their performance in Scottish soils and climate.

There is also a parallel citizen science project with more than 30 growers and groups across 25 community sites across Scotland, trialling the Avian variety to complement the growers' findings by broadening the range of growing conditions being tested. These range from Orkney to Lismore to the Borders, and comprise home gardens, crofts, allotments, schools and community gardens.

3) Methodology and data collection

Three new varieties of flax (*Linum usitatissimum*) were trialled – Avian, Delta, and Tango - bred by Dutch flax specialist Van Der Bilt, and supplied by independent seed specialist Elsoms Seeds.

Plot Layout

Trials were carried out at three sites, near Dundee, Edinburgh, and Oban. Each site grew three replicates of each variety in $10m^2$ plots, totalling 9 plots per site. To fit in with existing crop beds, plots were arranged in strips [Fig. 1], and sown in rows 125mm apart (8 rows per

metre) at a rate of ~10g/m^2 [Table 1]; and sown by hand or with a Jang-type seeder between late April and early May.

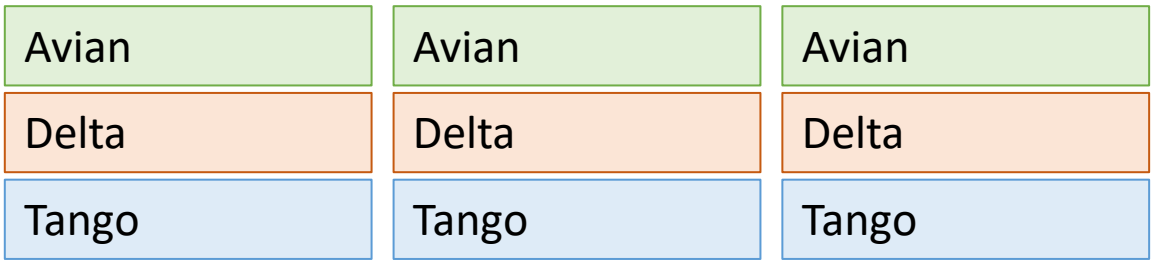

Figure 1: Trial plot layout

Variety	*TSW*	*Germination*	*Seed/m*	*Plot area*	***Amount / Plot (g)***
Avian	5.7	97	1600	10	**98.97**
Delta	5.5	97	1600	10	**95.50**
Tango	5.9	97	1600	10	**102.44**

Table 1: Sowing rates were recommended by Elsoms Seeds. TSW = Thousand Seed Weight (g)

Weeding

Weeding practice varied between sites. Site 1 applied glyphosate to all plots at the pre-sowing stage; site 2 used no chemicals and did not carry out weeding after the initial pre-sowing cultivation; and site 3 also avoided chemicals but carried out mechanical weeding until the crop was established. The decision not to weed at Site 2 was deliberate, in order to assess how the crop would perform without intervention.

Soil testing

Soil type, texture (visual assessment using AHDB flow chart) and structure (VESS scoring) was recorded at each site at harvest.

Harvesting

Fibre flax (which differs from shorter oilseed varieties in height and the amount of seed produced), is typically ready to pull after 100-120 days of growth, and around 40 days after flowering; when the seed pods have changed from pale to brown and the stem has started to yellow. Recommendations from other growers were to harvest at ~100 days; however, all three sites found that the crop was not quite ready at this stage so waited an additional 10-17 days before harvesting. At this stage, the seed heads are not yet fully ripe, but the fibre in the stem is at its strongest and most flexible for processing into textiles. If over-ripe, the inner fibres start to become brittle, break easily and become more difficult to process.

Because there is no commercial flax industry in the UK, there is currently no specialist harvesting equipment available, so the crop was hand-harvested by groups of volunteers with support from the field lab coordinator.

Plants were pulled up by the root to ensure maximum fibre length, and to prevent the fibres deteriorating at the cut end. Pulled bundles were then laid out on bare soil or grass in strips, to begin the retting process. The harvested crops from Site 1 and Site 3 were transported to Site 2 for retting, to make retting and handling logistics easier.

Retting

The process of 'dew-retting' involves the pulled crop being lain flat on the soil in rows, with roots at one end and seed pods at the other, for ~3 weeks, and turned halfway through. This is the process by which rainwater and soil microbes in the damp ground break down the lignins and pectins in the woody stem, allowing the flexible fibres to be extracted more easily during processing. Once retting is complete, the crop is dried and stored for at least two months before it can be processed into yarn. It is also possible to rett the flax in tanks of water, ('tank retting') but the group decided against this method, as the resultant liquid would be difficult to dispose of safely without causing diffuse pollution.

Yield

Weight: The main measure of yield was straw weight at harvest; measured using scales and totalled as weight per plot (kg/m^2).
Height: Crop height was measured in centimetres, using 6 heights per plot to calculate an average per plot for each variety.
Density: This was measured by counting the number of plants in three 0.5m strips per plot and calculating plants per square metre for each plot.

Citizen science community plots

The community plots all grew the Avian variety, sown in rows as described above, in plots ranging from 1m^2 to 20m^2. They recorded data on crop weight and height, measured as above.

Image 2: Visual Evaluation of Soil Structure (VESS)

4) Results and discussions

All sites were hand-harvested with volunteers in early August.

Crop Yield - **Weight**

The main measure of a fibre flax crop is straw weight – measured in kilos per square metre (kg/m2) which we converted to tonnes per hectare (t/ha).

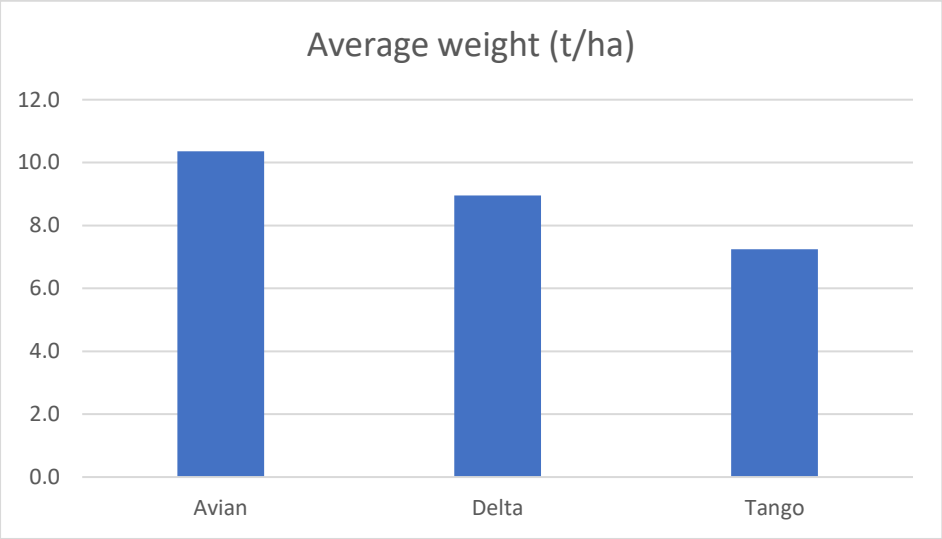

Figure 2: Average yield per variety (crop weight)

On the face of it, the Avian variety returned the best average weight. However, this is a misleading figure due to a high level of variation between sites, for all varieties [see Figure 3]. Avian produced the highest yield at two sites, but there was a difference of 4t/ha between these; and only 1t/ha difference between the middle and lowest weights. Delta was likewise variable, with a 6t/ha difference between the highest and lowest yields. Tango had a yield variation of 7t/ha between the highest and lowest yields, and 2t/ha between the top two.

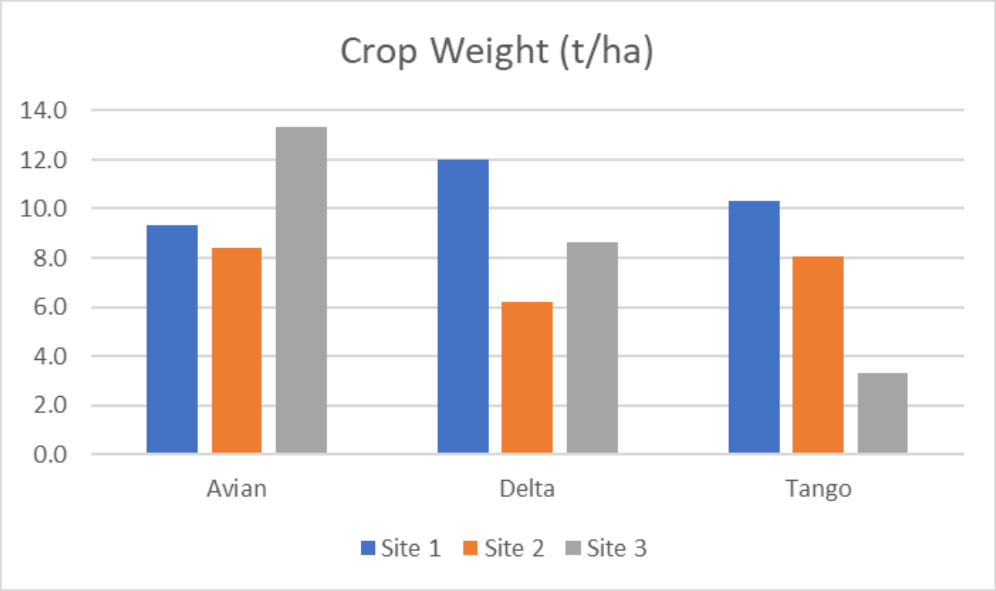

Figure 3: Crop weight broken down by variety and site

Height

The financial value of the crop is informed by the combination of total crop weight, and crop height. The ideal scenario would be a large volume of long fibres, as longer fibres can produce higher quality yarn, textile and linen.

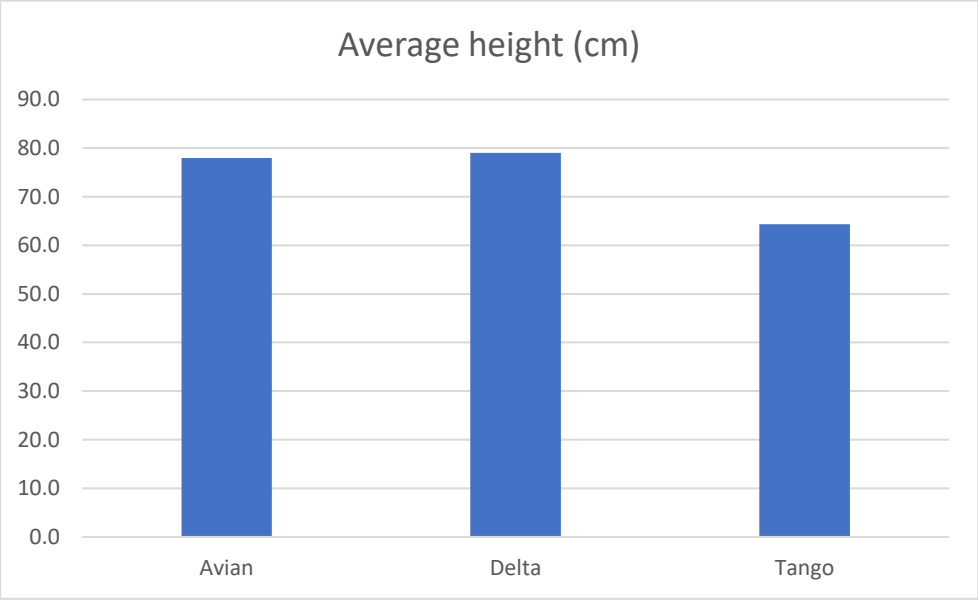

Figure 4: Average crop height per variety

Average height of Avian and Delta were very similar – 78cm and 79cm respectively – although again there was a lot of variation between sites. Tango was consistently shortest at all three sites however, with an average height of just 64cm. By comparison, the average height of community plots was 100cm.

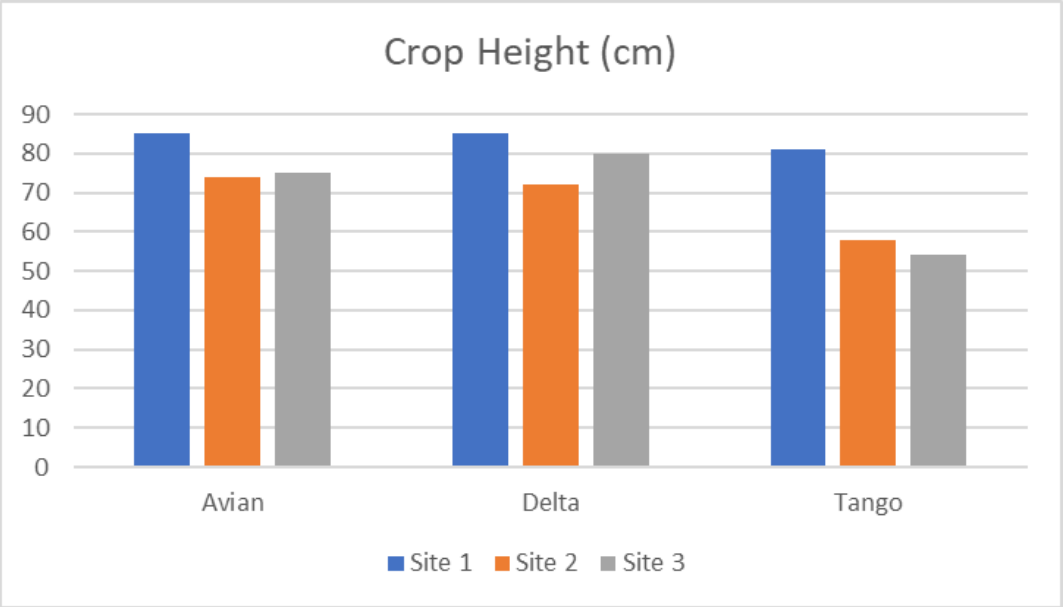

Figure 5: Crop height broken down by variety and site

Density

The crop density data do not appear correlate to yield, particularly in Site 2 which shows the highest densities despite both yield and height being mostly lower at that site. Sowing rate was the same at all sites, so this is something we will look at more closely in 2024.

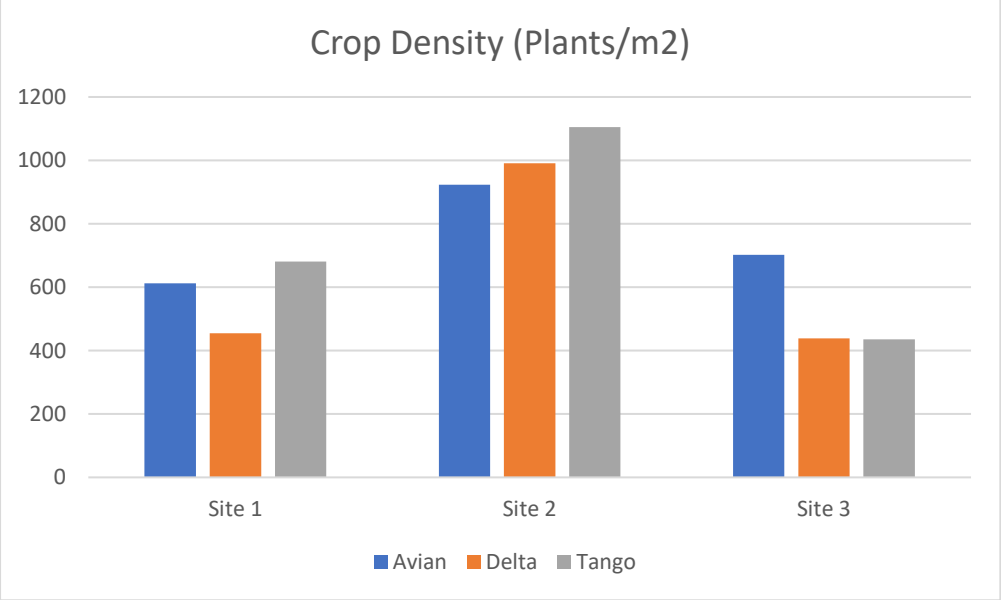

Figure 6: Crop density broken down by variety and site

Individual site findings

Site 1 is an established conventional arable site near Dundee. Soils are Brown earth, sandy loam, and trial plots were given a VESS score of 2. VESS - 'Visual Evaluation of Soil Structure' - assesses soil structure based on the appearance and feel of soil dug out with a spade**,** and a score of 2 represents good, intact structure.

Other points to note include:

- Trial plots were set within an existing arable rotation
- Plots were sown with an 8 row, 1.55m wide custom-made drill using eight John Deere 750a direct drill disk / coulters
- One treatment of NPK fertiliser was applied
- A single treatment of glyphosate was used pre-sowing at the recommended rate
- Observation from adjacent plots with very high weed competition: flax plants were very short and thin, so strong weed competition was highly detrimental. This leads us to question the chosen flax sowing density and the possible effects on plant height and stem thickness due to self-competition. Plan to investigate this in 2024.

Site 2 is an organic stock-free horticulture enterprise near Edinburgh. Soils are also Brown earth, sandy loam, with a VESS score of 2 representing good intact structure.

Other points to note include:

- Beds were shaped into 1.2M wide with rakes however no amendments or compost were added prior to sowing.
- Sowing was done with a Jang LJ-24, (14F-9R) seeder. This wheel and gear combo gave 2-4 seeds every 2.7cm on row.
- Establishment was slower than expected, possibly due to drought conditions immediately after sowing.
- No weeding was carried out after the pre-sowing cultivation, in order to assess how the crop would perform without intervention.

Images 3-6: Establishment; Ready to harvest; Retting; Ready to dry for processing. Credit: Lauriston Farm (Site 2)

Site 3 is in an upland setting near Oban with surprisingly light sandy soil, and wetter weather compared to the other sites. It is a mixed enterprise with crops and livestock, and the trial plot was newly ploughed/rotovated from long term pasture. Soils are Brown earth, loamy sand, with a VESS score of 1. Mechanical weeding was carried out until the crop was established, and no chemical inputs were applied.

Community Plots

The 30 community plots growing Avian range from Orkney to Lismore to the Borders, and comprise home gardens, crofts, allotments, schools and community gardens. Trial plot size ranged from 1m^2 to 20m^2, in mostly loamy and clay-dominant soil types. Average weights were variable and ranged from 8-12t/ha; and height ranged from 68cm to 140cm (yes, we double-checked!), with most reaching around 100cm.

Image 7: One of the community garden plots

Discussion

Despite the variability between sites, it is fair to say that all three varieties performed well in this trial. Based on conversations with growers in the UK and Europe we used the threshold of 6t/ha as a benchmark for financial viability at a commercial scale, and only the Tango crop at site 3 (which was encroached by weeds) was below this.

Tango had the shortest average height overall, and although it also returned the lowest average yield across sites this was influenced by a poor crop at Site 3, which was encroached by dense weeds in the Tango strip.

The variability of weed pressure between sites is a likely factor in the high variability in weight and height data; and affects how well the data can be interpreted. Weeding practice – and subsequently weed burden – was different at each site. Site 1 applied glyphosate to all plots, while site 2 did no weeding after the pre-sowing cultivation, and site 3 carried out

mechanical weeding until the crop was established. Weed burden at Site 1 was zero, and high at sites 2 and 3.

It will be important therefore to trial the same varieties again next year, at more sites, with better weed control, to assess how much the results were influenced by weed pressure.

Another factor that we would change for next year is to arrange the plots in randomised blocks, rather than strips. At Site 3, weeds encroached into the Tango strip from an uncultivated area which ran down one side of the trial area; meaning that we cannot say by how much the lower weight and height of Tango compared to the other varieties was due to weed pressure, or to varietal difference.

Weeds also had an impact on harvesting, with weedy plots predictably taking much longer to harvest compared to the weed-free ones. Had we been mechanically harvesting, there may also have been an issue of equipment becoming tangled. It is also possible that a high level of weed contamination would hinder mechanical processing; particularly the breaking, hackling and scutching stages.

Next year the team at Site 2 plan to grow the flax in an area which is already part of the crop rotation, rather than newly taken out of long-term pasture, to reduce the pressure of what was a big weed seed bank this year. This will also be a consideration for the rest of the 2024 trial – whether to require all sites to allocate plots to ground already in cultivation, or to make this one of the factors that we explore further by having some in-rotation sites and some which are newly cultivated.

The following points are some further reflections from Site 2:

- Sowing: plan to use weed-free beds with compost amendment, and sow seeds at a higher density - both on the row and between the row. Interested to see how this might impact height and branching. Whilst crop fared admirably given its total neglect and weed competition, the flax we grew in the community plot, which had been sown in weed free/composted beds, was much taller (100cm).
- Growing: Probably still wouldn't spend time weeding this crop or irrigating it, but it would definitely be worth sowing it in better conditions in terms of weed pressure and water availability. Could also be interesting to include single beds within the Market Garden vegetable bed blocks which would enable it to receive some irrigation without extra work.
- Also be interesting to see how it could fit within vegetable rotations given its short growing season e.g. sown after overwintered/spring greens; followed by end of season salads/greens or transplanted winter brassicas. Could also be effectively followed by a late summer or overwinter cover crop.
- Harvest: Pull earlier - after retting there were clearly some viable seeds as they started to shoot. Don't underestimate the number of hands needed (and how much quicker it is without weeds)
- Retting: This takes time which needs to be factored in! Probably better to spread thinner and flip more for better standardisation of retting process - also aim to rett for less time. Some of the crop may be over retted which may negatively impact the quality of the fibres
- Drying: standardise stook sizes.

- Continue to develop understanding of the actual wholesale/retail value of this as a potential cash crop for fibre artists.

Another factor to explore further, is whether a short crop with a good yield is better than a tall crop with a lower yield. E.g. at Site 2 the Tango crop was shorter than Delta, but had a better yield. How do straw length and crop weight influence market price?

Finally, retting is a bit of an art. We are confident that most of the crop looks well retted but, with the changeable and often very wet weather in September, it is quite possible that some of the flax has been over-retted. When this is the case, the over-retted bits will be brittle, and break into short fibres during processing rather than staying long and flexible. These short fibres can still be utilised in other ways (e.g. as animal bedding), but are not suitable for textile production. The fibre quality will become apparent during the processing (and testing by project partners Heriot Watt University), allowing us to refine our processes for next year.

Community Flax Plots

Alongside the main trial, there has been a citizen science element to the project, involving over 30 growers and groups across 25 community sites across Scotland, ranging from Orkney to Lismore to the Borders, and comprising home gardens, crofts, allotments, schools and community gardens. The main aim of this element of the project was to increase awareness and engagement with the idea of flax as a sustainable fibre crop, and to initiate conversations about sustainable fibre, regenerative farming and clothing, and the impacts of food and fibre production on the environment.

Both the trial and citizen science project have been supported by Edinburgh College of Art's Textiles team, through their innovative Seed_Ed project. This has involved the team providing a series of practical hands-on workshops, demonstrating the various stages of processing flax from straw into fibre, spinning into yarn and weaving into cloth. It has been a valuable addition to the trial, and an effective way to engage a wider audience with our work, including prospective spinners, weavers, dyers, artisans and artists.



Images 8-10: Sowing, harvesting and 'scutching' flax with volunteers at Lauriston Farm Community Garden

Next steps in this field lab

Aspirations for 2024

Next year we plan to carry out a follow-on trial, testing the same varieties at up to 6 trial sites, with refined parameters based on what we learned this year. We also plan to continue the community flax network, and the knowledge exchange work on growing flax and processing it into fibre; and continue to collaborate to support the development of a Scottish flax processing and supply network.

Aspirations beyond 2024

This Innovative Farmers field lab is the first small step in a process that project participants and collaborators hope will be the start of the development and re-establishment of a thriving sustainable textile economy in Scotland (and the UK). Any reliable information we can share with the wider farming community on the performance of these new varieties, will be useful in supporting potential growers as well as the emerging flax and linen processing and supply chain.

There is a growing network of actors contributing to this work (e.g. the newly-established Fibreshed Scotland, Fantasy Fibre Mill, farmers who are interested in growing flax on a commercial scale, the Flax Futures project, spinners, weavers, dyers, educators, crafters and textile researchers); and we hope that by working together we can develop a sustainable Scottish textile industry which empowers everyone in the processing and supply network.

5) Conclusions

Due to the small number of replicates and sites, this trial should be treated primarily as a demonstration trial – but one which should be considered the first small step in exploring a resurgence in flax production and processing in Scotland. Fibre flax is not currently being produced or processed on a commercial scale at all in Scotland, and this represents an opportunity for growers interested in diversifying both crop rotations and income sources. While only 30-40% of the crop ends up as high-quality linen, there are a number of opportunities for the lower-quality and shorter fibres, including sustainable, breathable insulation for buildings, composite material for industrial use (e.g. there are already companies making chairs, tables and skis from flax bio resin) and animal bedding.

Lack of harvesting equipment is a barrier to larger scale uptake in the short term, as the labour cost of hand-harvesting is high, but from the increasing levels of engagement this year we know there is interest in running further trials on a larger scale. The results of these could be used to support supply chain and market feasibility studies; with an aim of making the case for industry investment in specialist harvest and processing equipment.

We know that flax grows well in Scotland, and that it fits well into regenerative, nature-friendly, low-input systems. We also know there is a growing demand for traceable, sustainably produced UK natural fibres. What is needed next is more information on and access to modern varieties, knowledge sharing between those growing the crop, further exploration of the commercial value and support to develop a localised processing and supply chain and routes to market.

Working in partnership with colleagues at Edinburgh College of Art at Edinburgh University, Fantasy Fibre Mill and Heriot Watt University, alongside the citizen science project, has also provided wider opportunities for knowledge exchange, demonstration and networking. The conversations about sustainable fibre, regenerative farming and clothing, and the impacts of food and fibre production on the environment are a valuable way to engage potential future consumers with this topic.

This trial is a small step towards exploring the potential of flax fibre production and processing in Scotland; and will contribute to the growing body of work being done by local growers, weavers, makers, artists and innovators to unlock Scotland's potential to produce regenerative textiles as part of a circular economy.

Innovative Farmers Manager Rebecca Swinn said:
"There is a growing interest in regenerative textiles and fashion – people are looking at linen and they can buy it in from Europe, but nobody grows it on a commercial scale here. So, there's a demand that farmers could meet, as well as flax fitting into low-input and regenerative rotations.

"This is an exciting trial that shows the potential of farmer-led research, with real-life trials on farms that are connected to their local communities and ready to collaborate. We are excited to see where these growers can take the regenerative textiles industry in Scotland and the wider UK."

Images 11-12: Bales of flax yarn; Bolt of linen fabric.

6 Tips and recommendations

Why grow flax?

• Flax fits well into low-input, regenerative and organic rotations. It can be direct drilled, doesn't need external inputs, is a food source for pollinators, and suits Scottish growing conditions (it was once widely grown across Scotland).
• Growing flax could meet a growing demand for UK-grown fibre crops to supply an emerging regenerative, sustainable UK textile economy.

• The longer-term aim is to collaborate across the sector to establish a sustainable UK flax processing and supply chain.

Benefits

The project is:

• Rediscovering lost knowledge on a crop which was an important part of Scotland's agricultural heritage.

• Increasing interest in Scottish and UK-produced sustainable and regenerative textiles.

• Engaging communities across Scotland in growing a novel crop, and processing it for fibre.

This is the first small step in a longer-term goal to bring commercial flax production back to Scotland, with plans to scale up cropping volumes next year and collaborate to develop a sustainable processing and supply chain.

The Field Lab Team would like to express our gratitude to all the community growers who took part in the project by sowing, growing, harvesting and measuring flax in the community plots; and to the volunteers who contributed by sowing, measuring and harvesting at the 3 main trial sites.

7 Further reading

www.innovativefarmers.org/field-labs/growing-flax-for-regenerative-textiles/

Innovative Farmers is part of the Duchy Future Farming Programme, funded by The Prince of Wales's Charitable Fund through the sales of Waitrose Duchy Organic products. The network is backed by a team from LEAF (Linking Environment and Farming), Innovation for Agriculture, the Organic Research Centre and the Soil Association