Elm Farm silvopastoral trial

The first five years…..

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Elm Farm silvopastoral trial – the first five years…..

Agroforestry combines elements of agriculture and trees (and other woody elements such as hedgerows and shrubs) into production systems that can deliver a wide range of products including food, fuel, fodder and forage, fibre, timber, gums and resins and medicinal products, as well as a range of ecological services such as soil and water protection, biodiversity support and climate change mitigation. There is increasing evidence that supports the promotion of agroforestry in temperate developed countries as a sustainable alternative to -industrialised agriculture with high reliance on external inputs with its associated negative environmental externalities. However, evidence on the performance of such systems in the context of European low-input production systems (and the UK in particular) is still lacking.

A novel agroforestry system combining bioenergy production and livestock production was established on Elm Farm in 2011, as part of the European FP7 research project Sustainable Organic and Low Input Dairying Systems, with the aim of assessing the potential impacts of utilising an agroforestry system for low-input and organic dairy systems.

A replicated plot trial incorporating short rotation coppice (SRC) and pasture was planted in April 2011 using an alley-cropping design with tree rows running north/south. Willow was chosen as a SRC species as it has a dual value as both a bioenergy source and a livestock fodder; a mixture of five bioenergy varieties of *Salix viminalis* was planted. Common alder (*Alnus glutinosa*) was chosen as a second species to test; it's value as a fodder crop was unknown, and while it coppices well, it is not a common species for SRC bioenergy production. However, it is one of only a few temperate tree species that fixes nitrogen, and so is of interest in an organic system. A mixed species treatment combining both willow and alder was also trialled to test the hypothesis that combining the two species may result in higher productivity (N-fixation by alder enhancing growth of willow and pasture) and potentially decreasing pest and disease damage and increasing its value for biodiversity. Trees were planted in twin rows, 0.7m between twin rows and 1.0m between trees within rows. There is 24m of pasture between tree rows.

The research focused on five areas:

- establishment of the system;
- impact of establishment on pasture productivity and species composition in the agroforestry alleys;
- impacts on the microclimate;
- interactions between cattle and trees and the economics of establishing and managing a bioenergy/ livestock silvopastoral system.

Timeline

2011

April	Trial site marked out, tree row grass mown short, jute mulch installed and trees planted
June	Early silage cut
Sept	Boundary electric fence installed
Oct	Late silage cut

2012

March	Black fabric mulch installed, trees planted, woodchip mulch applied
July	Early silage cut
Oct	Late silage cut

2013

March	Beating up and cutting back. Every other tree row removed. Woodchip on all.
June	Silage cut
Sept	Pasture topped
Dec	12 Cattle grazed for 20 days

2014

March	Beating up gaps
June	Silage cut

2015

June	Silage cut
July	Electric fencing installed on tree rows
August	Cattle introduced

Summary of Key Conclusions

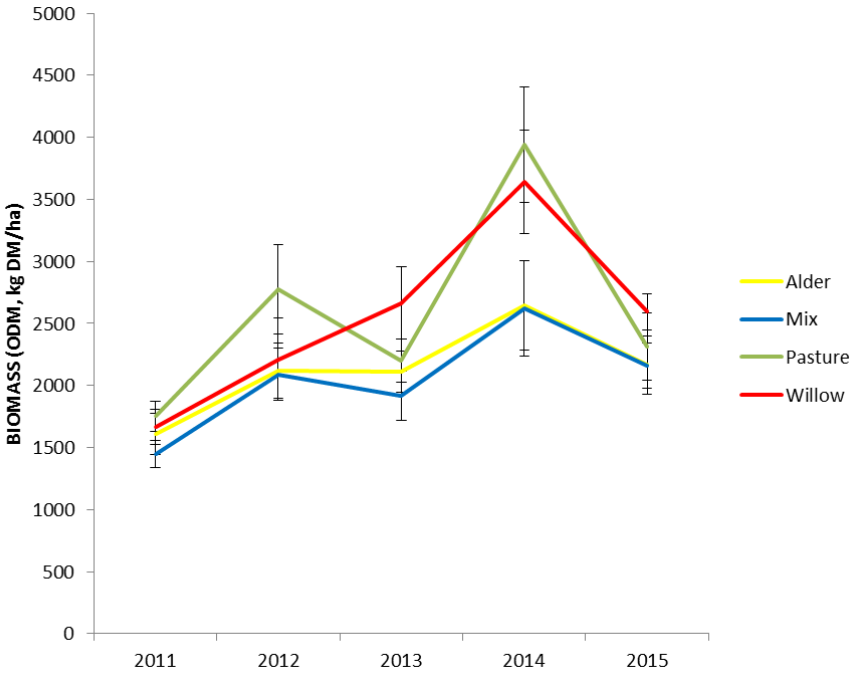
Establishing a bioenergy/livestock silvopastoral system

The establishment of coppice under organic conditions presents particular challenges with regards to weed and pest control. As chemical controls aren't allowed in organic systems, alternative methods of weed and pest control must be considered and the effectiveness and cost-benefit ratio investigated. This research compared three options available for organic farmers: direct planting into pasture (the cheapest option); woodchip mulch (using an on-farm or locally available resource) and a fabric mulch barrier (the most expensive option). Jute fabric mulch significantly increased survival rates of the newly planted trees compared with direct planting into the existing grass sward, with the bare-rooted alders establishing much better than the willow cuttings. Tree survival was similar within the woodchip and black propylene fabric mulch plots, although once again, willow establishment was significantly lower than the alders. However, by 2013 and through the following years to 2015, willow and alder rates of survival were not significantly different from each other, although by 2015, alders were significantly taller than the willows. As the woodchip was sourced for free from local tree surgeons, and tree survival rates were similar to those in the fabric mulch plots, we concluded that woodchip provides a good approach to weed control in newly planted agroforestry systems.

Clockwise from top left: direct planting; jute fabric; black propylene fabric; woodchip.

Impact of tree planting on pasture productivity and biodiversity

Agroforestry systems are usually considered as increasing overall productivity due to the complementarity of trees and agricultural component. However, there are concerns within the farming community that integrating trees within pasture will negatively impact on pasture productivity and quality. Within northern temperate regions, the main limiting resource for plants is usually light and studies have shown that shading has reduced yields in temperate silvopastoral systems in both deciduous and evergreen systems. However, during the early years following tree establishment, it has been shown that trees have few effects on pasture as tree crowns are small, although this will depend also on growth rates and spacing. Pasture productivity within the agroforestry trial site varied considerably from year to year with the highest production in 2014 following a wet winter and spring. There were no statistically significant differences in pasture productivity and species composition found between the different treatments, indicating that for the first five years, the impacts of tree planting on the pasture were minimal.



Pasture productivity from 2011 to 2015 (mean ± standard error)

Impacts of tree planting on the microclimate

One of the main perceived advantages of integrating trees into livestock production systems using an agroforestry approach is that trees modify microclimatic conditions including temperature, water vapour content or partial pressure, and wind speed, and these modifications can have beneficial effects on pasture growth and on animal welfare. As expected, we found no significant differences in air temperature, relative humidity, wind speed, wind chill or soil moisture between the different treatments, no effect of year, and no interactions between treatments and year, indicating that as the trees are still small, they are not yet having an impact on the microclimate.

Interactions between cattle and trees

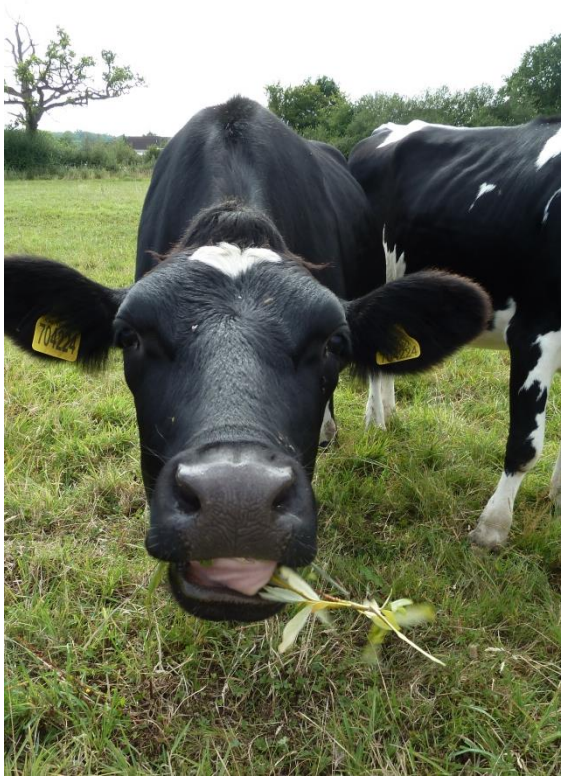
There is growing interest in exploiting tree fodder as an extra resource from trees planted for other purposes such as resource protection. For example, one dairy farmer in western England has planted trees for shelter, to improve soil conditions and help with water management, and is now managing them as a fodder system to provide nutritional and medicinal benefits. However, there is little scientific evidence available on the preference for browsing particular tree species or the impact of browsing on the trees. An on-line survey of 14 farmers found that browsing appeared to be a common behaviour in cattle, with most responses suggesting that cattle browsed most days, frequently, or at least once a week, and at any time of day, and a wide range of woody species were selected, including willow, hazel, oak, ash, sycamore, blackthorn and alder.

Cattle were introduced into the trial silvopastoral site in summer 2015, and browsing impacts on the trees monitored. Two levels of electric fencing (1 strand and 2 strands) were compared with a no-fencing control. It became clear that fencing is essential in order to protect the trees from damage caused by the cattle, and a single strand is sufficient to keep cattle away, whilst at the same time allowing them to reach grass in the understorey of the tree row. The cattle showed a preference for willow over alder, although after a few days, the cattle also started browsing the alder trees, suggesting that as they get more familiar with browsing tree leaves, their acceptability of different species increased. The use of trees to provide cattle fodder is likely to conflict with the production of woodchip for bioenergy, although one possibility would be to allow the cattle access to the trees in the months leading up to harvest in order to strip the leaves – they would also take branches up to 10mm in diameter but this is unlikely to make much difference to the woodchip yield. Otherwise, tree fodder may have a role to play when grass is in short supply, e.g. during summer droughts, when any loss in woodchip yield would be compensated by avoiding the expense of buying in forage.

Cow in alder tree row

Cow standing near damaged alder trees

Alder plot showing damage from cattle browsing and rubbing against trees.



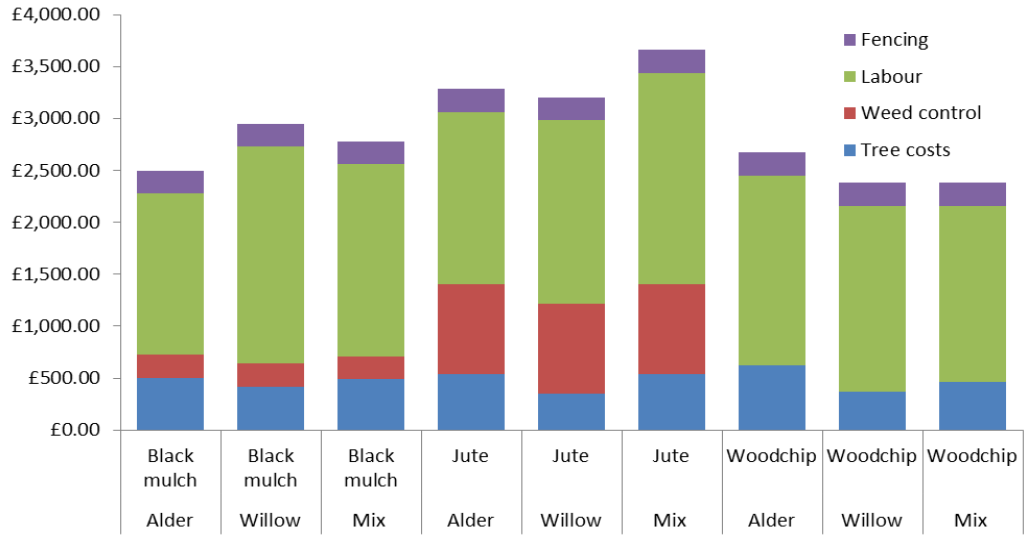
Cow eating willow branch

The economics of establishing and managing a bioenergy/livestock silvopastoral system

A study of the perceptions of organic dairy farmers in the UK (SOLID WP5 farmers survey) highlighted cost (especially cost of establishment and lack of financial/technical support during this phase), and increased workload, as two of the key barriers to adopting an agroforestry approach. Economic data on the costs of establishing the novel silvopastoral system at Elm Farm was collated, and the net present value approach was used to model on-going system performance.

The total costs (including tree costs, weed control, labour and fencing) for the first five years for each of the tree species and weed control combinations ranged between £2,380.37 and £3,660.20 per ha of agroforestry. The willow trees were cheaper than the alders as they were cuttings; while the jute mulch fabric was the most expensive of the weed control approaches. In all cases, labour accounted for over 50% of the total costs. The cheapest options over the first five years were the willow: woodchip and mixed species: woodchip combinations at £2,380.37 and £2,381.00 respectively. The most expensive combination was the jute: mixed species combination at £3,660.20.

Net present value (NPV) calculations of the most and least expensive weed control and tree species combinations (jute: mixed species and woodchip: mixed species respectively) over the 20 year lifetime of the system, gave positive values for both, with an annual income of £372/ha for the jute: mixed species combination and an annual income of £419/ha for the woodchip: mixed species combination. It was also noticeable from the cash flows that were used in the NPV calculation that the initial establishment is a large cash outflow that is not repaid, in this system, until 5 years after establishment. Despite the fact that the overall NPV is positive this may prove a barrier to many farmers contemplating agroforestry and suggests that support (e.g. from Rural Development Programmes, RDP) to cover establishment costs may be needed if uptake of agroforestry is to be encouraged.



Total costs per weed control per ha of agroforestry: species combination for Years 1-5

Conclusion

The research carried out at Elm Farm suggests that establishing trees within a pasture has negligible impact on pasture production and biodiversity and the microclimate within the first five years, although this may be due primarily to the low establishment rate and subsequent growth of the trees. Controlling competition from weeds and grasses is essential for promoting better tree establishment and using woodchip mulch from on-farm or a locally available resource was found to be the best option. Fencing is needed to protect the trees from livestock, and one strand of electric fencing was sufficient to keep cattle away, whilst at the same time allowing them to reach grass in the understory of the tree row. Cattle showed a preference for willow, but over time adapted to browsing alder trees too; controlled browsing of SRC at certain stages of the tree rotation, or when grass is in short supply, would be one way to balance production of bioenergy with livestock production. This trial also provided useful economic data on establishing a novel silvopastoral system, showing that labour costs account for over 50% of total costs. Net present value calculations (NPV) showed that while overall the NPV is positive, the initial establishment is a large cash outflow that is not repaid, in this system, until 5 years after establishment; this may prove a barrier to many farmers contemplating agroforestry and suggests that support (e.g. from RDP) to cover establishment costs may be needed if uptake of agroforestry is to be encouraged. There may be scope for including these types of novel systems in RDP agri-environment schemes in recognition of the benefits to wider ecosystem services such as water regulation, biodiversity and soil protection, which would enhance overall profitability.

Going forwards……

Following the browsing trial, those tree rows that were accessed by the cattle were coppiced back to the ground to initiate the harvest rotation (one row in three cut every year). In March 2016 the pasture alleys were ploughed with a three furrow plough ahead of manure application and re-seeding in autumn 2016. Assessments of tree and pasture productivity and microclimate will continue into the future with funding from European projects including Agforward (FP7) and SustainFARM (FACCE Surplus).

THE ORGANIC RESEARCH CENTRE

ELM FARM

Full report: Jo Smith, Catherine Gerrard, Kostas Zaralis and Susanne Padel (2016) **Assessment of an agroforestry system in terms of feed supply and multifunctionality. Part 2: Establishing a novel agroforestry system.** Deliverable for FP7 Project SOLID.

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Sustainable Organic and Low Input Dairying