Agroforestry for livestock systems

Photo: Jo Smith/ORC

Aberdeen Angus in among the trees, Fife, Scotland

Introduction

Agroforestry combines agriculture and trees, hedgerows or shrubs into production systems that can deliver, in addition to agriculture, a wide range of products including food, fuel, fodder and forage, fibre, timber, gums, resins and medicinal products. It also supports a range of ecological services such as soil and water protection, biodiversity support and climate change mitigation.

Silvopastoral systems that combine livestock and trees offer two main advantages for the animals. Trees modify temperature, water vapour content or partial pressure, and wind speed, which can have beneficial effects on pasture growth and animal welfare (Jose *et al*. 2004). Trees also provide alternative feed resources during periods of low forage availability, particularly in climates with seasonal droughts such as the Mediterranean (Papanastasis *et al*. 2008). This may become widely relevant in a changing climate.

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 is still lacking. This technical note highlights some of the potential benefits and impacts of utilising an agroforestry system for low-input and organic dairy systems.

Silvopastoral systems

Trees have traditionally been important elements of temperate agricultural systems around the world, evolving from systems of shifting cultivation towards more settled systems involving agriculture, woodland grazing and silvopasture (trees and livestock). Modern silvopastoral systems that cultivate trees specifically for fodder include fodder banks, where trees and shrubs are planted at high densities and pruned regularly to maximise productivity, and alley pasture systems with rows of trees and shrubs separated by alleys of pasture, with perceived benefits to enhanced nutrient cycling and improved animal welfare.

Agroforestry research at the Organic Research Centre

As part of the SOLID project, the Organic Research Centre evaluated an established willow agroforestry system (Wakelyns Agroforestry) in terms of productivity, microclimate modification and carbon storage, as well as investigating the establishment phase of a new organic agroforestry system at Elm Farm in Berkshire to provide economic and environmental (microclimate) data on establishing and managing a system.

In the Elm Farm trial, willow (*Salix viminalis*) was chosen as it has a dual value as both a bioenergy source and a livestock fodder. Common alder (*Alnus cordata*) was chosen as a second species to trial; its value as a fodder crop was unknown, and while it coppices well, it is not a common species for short rotation coppice (SRC). However, it fixes nitrogen, and so is of interest in an organic system. Trees were planted in double rows with a 24 m pasture alley between rows.

We have summarised some key results from this work on the following pages. Also see SOLID report (Smith et al., 2014).

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Tree fodder and browsing

Browse from trees and shrubs plays an important role in feeding ruminants in many parts of the world and there has been considerable research into the nutritional properties of many tropical fodder species. However, while there is growing interest in exploiting tree fodder as an extra resource from trees planted for other purposes, comparatively little is known about the potential of temperate browse species, the preference for browsing particular tree species or the impact of browsing on the trees.

As part of the SOLID project, an on-line survey of UK 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.

The composition of tree fodder varies depending on a range of factors including tree species and cultivars, season, age of growth, climate, and plant part utilized (leaf vs. stem). A literature review (Luske & Van Eekeren 2014) that collated nutritional information from a range of tree species into a database (Table 1) concluded that while the in-vitro organic matter digestibility of tree leaves is relatively low compared to grass, crude protein and mineral levels of some species are relatively high, showing the potential value of tree leaves as an additional feed source. There was a considerable range in feeding values for the same tree species, likely to be due to seasonal differences, local soil conditions and the ability of tree species to adapt to these. The presence of tannins and other phenolic compounds may reduce digestibility and availability of protein, and palatability and intake. However, at low concentrations, some condensed tannins (CT) can have a beneficial influence, by reducing protein degradation in the rumen and increasing the flow of protein and essential amino acids to the intestine (Rogosic *et al*. 2006).

Table 1. In vitro organic matter digestibility (OMD), crude protein (CP) and copper (Cu) levels in tree leaves, taken from a literature review (adapted from Luske & Van Eekeren 2014). Average (minimum – maximum) and number of records (n) found in the literature.

Species	OMD %	CP % of DM	Cu Mg kg^{-1} DM
Alnus glutinosa Alder	48.1 (10.4-69.1) n=6	19.2 (14.1-26.2) n=6	12.3 (6.0-20.0) n=4
Betulus pendula Birch	37.6 (5.9-63) n=3	17.5 (14.0-22.9) n=5	10.0 n=1
Corylus avellana Hazel	47.7 (46.4-50.0) n=3	16.1 (14.1-20.4) n=7	13.1 (8.5-18.0) n=4
Fagus sylvatica Beech	30.7 (7.4-59.0) n=5	18.0 (14.3-23.3) n=18	15.3 (6.5-24.0) n=2
Fraxinus excelsior Ash	34.1 (12.8-55.3) n=2	15.7 (5.9-26.8) n=8	10.0 n=1
Robinia pseudoacacia Robinia	56.7 (37.3-77.4) n=7	20.4 (11.6-27.0) n=16	7.7 (7.0-8.3) n=2
Salix spp. Willow	57.8 (4.5-70.5) n=5	15.9 (9.8-23.10) n=10	8.3 (5.5-12.9) n=5
Tilia platyphyllos Large-leaved Lime	30.6 (15-46.2) n=2	21.4 (15.3-28.0) n=13	8.0 n=1
Lolium perenne Perennial Rye Grass	79.0	16.5	8.9

Productivity

Agroforestry systems are usually considered as increasing overall productivity due to the complementarity of trees and the 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. 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.

Sward production within the newly established silvopastoral system at ORC was monitored over the first five years. There were no statistically significant differences in pasture productivity and species composition between the different treatments, indicating that for the first five years, the impacts of tree planting on the pasture were minimal.

At Wakelyns Agroforestry, a 15 year old SRC agroforestry system, we found evidence of competition between the trees and plants at the edge of the alleys, although the extent of this competition appeared to vary depending on weather conditions and stage of rotation of the tree component. This would suggest that wider alleys that minimise ‘edge’ would be better than the narrow alleys used in this system (10 m wide). The sward in the alley developed into a shade-tolerant grass-dominated community while the sward in the no-tree control field remained dominated by clovers. This shows that the selection of shade-tolerant species appropriate for agroforestry systems is important.

Microclimate

One of the main perceived advantages of integrating trees into livestock production systems is that trees modify microclimatic conditions including temperature, water vapour content or partial pressure, and wind speed. These modifications can have beneficial effects on pasture growth and on animal welfare. Studies have found that trees can reduce wind speeds in the protected area, with wind speed reductions extending up to 30 times the height of the windbreak on the leeward side, (Tamang *et al*. 2010). Providing shelter for livestock during the winter months has been found to lead to better survival rates, increased milk production and significant savings in feed costs (Brandle *et al*. 2004). In addition, the provision of shade in hot summers is an important factor for animal welfare.

At Wakelyns Agroforestry, the microclimate was significantly different in the agroforestry when compared with a neighbouring field without trees. Wind speeds recorded using a detector at a height of 1.5 m were significantly higher in the open field every month with speeds on average of 2.7 mph and up to 6.5 mph stronger than in the agroforestry. Combined with point measurements of air temperature at 1.5 m, the resulting wind chill was significantly greater in the control plots during the winter months with a noticeable difference of 1 to 4°C during the cooler months. In the newly-planted silvopastoral system at Elm Farm, there were no noticeable effects of trees on the microclimate in the first 5 years, and other studies have found a significant impact only when the trees reach a height of 3 m.

A browsing trial within the ORC bioenergy silvopastoral system also found increased acceptability of fodder, with cattle initially preferring willow, and then over time adapting to browsing alder trees too.

Establishing agroforestry

Silvopastoral systems that meet the farmer's objectives need careful planning. The selection of tree and livestock species for an agroforestry system is influenced by a number of factors, including the desired outputs (food, fuel, fibre), site conditions and climate, species properties (canopy size, root characteristics, shading tolerance etc.), species interactions, and agronomic factors such as harvest times and rotations. Government regulations regarding maximum tree densities and eligibility for basic farm payments and agri-environment schemes must also be considered.

The establishment of agroforestry under organic conditions presents particular challenges as regards weed and pest control. As chemical controls aren't allowed, alternative methods of weed and pest control must be considered and the effectiveness and cost-benefit ratio investigated.

Trials of different weed control approaches at Elm Farm showed that while tree survival rates in plots with fabric mulches were similar to those using woodchip mulch, as the woodchip was sourced for free from local tree surgeons, it provides a good approach to weed control in newly planted agroforestry systems.

Economic studies of agroforestry systems have shown that financial benefits are a consequence of increasing the diversity and productivity of the systems, influenced by market and price fluctuations of timber, livestock and crops. An assessment of establishment costs of forestry, agriculture and agroforestry found that establishing agroforestry required higher initial investment than the agricultural and forestry systems due to higher initial inputs, but over a 30 year period, profitability per hectare was higher in the agroforestry system than in the exclusively livestock (17%) or forestry (53%) systems (Rigueiro-Rodríguez et al. 2008). When environmental and ecological benefits were included in the evaluation, the profitability of the agroforestry system was even higher.

Establishment and maintenance costs of the new silvopastoral system at Elm Farm were collated, and showed 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 Rural Development programmes (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.

Conclusions and recommendations

- Agroforestry has been identified as a 'win-win' multifunctional land use approach that balances the production of commodities with non-commodity outputs such as environmental protection and cultural and landscape amenities.
- Designing a new system must consider the desired outputs (food, fuel, fibre), site conditions and climate, species properties (canopy size, root characteristics, shading tolerance etc.), species interactions, agronomic factors as well as government regulations.
- Controlling competition from weeds and grasses is essential for promoting better tree establishment.
- Tree fodder may offer nutritional benefits to livestock, although values vary depending on tree and animal species, as well as seasonal and bio-geographical factors. Fencing is essential to protect the trees from livestock and control the impact of browsing.
- Providing shelter for livestock during the winter months can lead to better survival rates, increased milk production and significant savings in feed costs. The provision of shade in hot summers is an important factor for animal welfare.

References

Brandle JR, Hodges L, Zhou XH (2004) Windbreaks in North American agricultural systems Agroforestry Systems 61:65-78

Jose S, Gillespie AR, Pallardy SG (2004) Interspecific interactions in temperate agroforestry Agroforestry Systems 61:237-255

Luske B, Van Eekeren N (2014) Renewed interest for silvopastoral systems in Europe – an inventory of the feeding value of fodder trees. In: Rahmann G, Aksoy U (eds) 'Building Organic Bridges', at the Organic World Congress 2014, Istanbul, Turkey, 2014. ISOFAR

Papanastasis VP, Yiakoulaki MD, Decandia M, Dini-Papanastasi O (2008) Integrating woody species into livestock feeding in the Mediterranean areas of Europe Animal Feed Science and Technology 140:1-17

Rigueiro-Rodríguez A, Fernández-Núnez E, Gonzalez-Hernandez MP, McAdam J, Mosquera-Losada MR (2008) Chapter 3 Agroforestry Systems in Europe: Productive, Ecological and Social Perspectives. In: Rigueiro-Rodríguez A, McAdam J, Mosquera-Losada MR, Rosa M (eds) Agroforestry in Europe: Current Status and Future Prospects, vol Advances in Agroforestry Volume 6. Springer, Belfast, UK, pp 43-65

Rogosic J, Pfister JA, Provenza FD, Grbesa D (2006) Sheep and goat preference for and nutritional value of Mediterranean maquis shrubs Small Ruminant Research 64:169-179

Smith J, Leach K, Gerrard C & Padel S (2014) Assessment of an agroforestry system in terms of feed supply and multifunctionality. Deliverable 3.2 for SOLID project www.solidairy.eu

Tamang B, Andreu MG, Rockwood DL (2010) Microclimate patterns on the leeside of single-row tree windbreaks during different weather conditions in Florida farms: implications for improved crop production Agroforestry Systems 79:111-122

Silvo-pastoral browsing trial at ORC, Elm Farm

Short rotation coppice willow agroforestry system at Wakelyns Agroforestry

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