Agroforestry - a new approach to increasing farm production

As a grower at Radford Mill farm in Somerset in the 90s, I planted rows of cordon apples to demarcate the vegetable blocks in the rotation. It added an extra crop into the system and made the plots feel more manageable, a more human scale. I didn't think of it as agroforestry, but it seemed to make sense! The idea of cropping the third dimension, adding trees to the system to better exploit the available natural resources and get more than one crop from the space, is one that is starting to make sense to a lot of people. In September, at a workshop organised by IOTA (The Institute of Organic Trainers & Advisers), a large audience gathered in a packed back room of The Plough Inn on Farcet Fen, near Peterborough, to hear Stephen Briggs' experiences from his international study tour and to see how the embryonic system on his own farm is developing.

Agroforestry around the world

After establishing an apple agroforestry system on his tenant farm, designed 'on the back of an envelope,' Stephen was awarded a Nuffield scholarship in 2011. This enabled him to study commercial agroforestry in different countries to see how their experiences could be applied to UK farming and find out 'how it should be done'. His experiences included the discovery that the delicacy of Turkey Nuts were not an agroforestry crop; being escorted by black limousines in China and an encounter, in the USA, with an armed man from Monsanto, who was taking leaf samples on a farm to look for illegally planted crops.

North America

Agroforestry is being adopted in the 2012 US and Canadian Farm Bills and there are many examples of its successful adoption. In Canada, the use of agroforestry as riparian buffers for water protection to reduce sediment loadings into rivers is quite widespread. Stephen visited the University of Guelph which had established alley cropping research trials in 1993, comparing agroforestry to adjacent monoculture. The trials looked at productivity from the alley crops (arable), which showed no reduction in yields in the first seven years and cropped at near the monoculture norm until the trial ended in 2005. As trees have matured, crop yields have declined by 15%, but this doesn't take into account the yields and value of the timber element. They found a SE:NW orientation was best to avoid shading of alley crops. Annual pruning of trees improved timber quality and lifts the tree crowns for machinery access and also reduced crop shading. Stephen also visited a small-scale vegetable unit that had integrated agroforestry.

The Missouri Pecan Growers grow grass under the trees, which is grazed with bison and buffalo and then tightly mown to allow picking-up of the nuts, which are shaken from the trees. At the University of Missouri they discovered that trees not only stop nutrients being lost to the river but also that antibiotic and hormone pollutants were being taken up by the trees. Trials here were investigating the shade tolerance of different species of grass under trees, an important area in which little work has been done.

At the 12th North American Agroforestry Conference in Georgia in June 2012, a vast range of research was presented. Amongst the highlights was the concept of dwarf agroforestry, with examples including lucerne bushes and bush fruit crops. In contrast to the UK with very low percentage tree cover, in Pennsylvania where there is 38% tree cover, they are looking to introduce livestock into woodland.

Europe

In many parts of Europe agroforestry is a traditional approach with trees combined with grazing livestock. In the Spanish Dehesa there are three million hectares of under-grazed cork oak plantations. Post World War Two, the CAP has led to the eradication of many of these systems, especially in France, with grants for grubbing up trees. From 2001-2005 the EU funded a Silvoarable agroforestry for Europe (SAFE) research project, which was coordinated by INRA in France. The project studied 42 tree-crop combinations and found that they had Land Equivalent Ratios (LER) of between 1 and 1.4, suggesting that they are more productive than their corresponding monocrop systems. This means that with an LER1, agroforestry and monoculture are equally productive. However, with an LER of 1.4 you need 40% more land under monoculture to produce the same output as under an agroforestry system.

Photos: Stephen Briggs

Agroforestry system in SE France being used to support overhead irrigation pipes for vegetable alley crops underneath

Poplar is a widely adopted timber tree choice for agroforestry throughout Europe and black walnuts are the timber and nut crop of choice for many systems in France, where agroforestry is mostly found on conventional farms. One French farm had a 30 year old system with wild cherry. The standing volume of the timber is estimated to be €4000/Ha - which matches the value of the land. The future value will exceed €10,000/ha. Some of the photos showed the huge amount of leaf litter and thus organic matter being returned to the systems, with 5cm (2") of walnut leaf litter being evenly deposited.

Spacings of up to 52m between tree rows have been used with cereals grown between. It is clear that trees can make better use of the space above ground, in capturing energy through photosynthesis, but we don't always consider the below ground dimension.

Stephen visited a vegetable agroforestry system in which the trees were used as a structure to carry and hang the irrigation system. He also saw a system with vines, where the rational was to use the trees to stop or slow down disease spread across the vineyard (as it has been found to do with blight spread at Wakelyns).

In Germany most agroforestry systems are using alder or poplar mainly for woodchips for heating or energy generation, planted as shelterbelts or at 24-32 m spaced rows, with 6-9m in-row spacing, with arable crops or pasture in the alleys. Recent agroforestry research there has focused on optimisation of tree densities, the impact of trees on wind loading and evaporation and the shade tolerance of under-storey species such as clover, medic, rye grass etc.

China

Stephen Briggs and counterpart in Henan province China. Paulownia closely spaced at 5m between trees in the row. Wheat in alleys.

China proved a fascinating country to visit. China has 23% of the world's population, 80% of whom are farmers, (which means that around 18% of the world's population are Chinese farmers!). Agricultural policy reflects this. China integrated agroforestry into mainstream agricultural policy in the 1980s with over 3.2 million ha of agroforestry in Henan, Shanxi and Shangdong provinces alone. Although agroforestry is a traditional practice in China it was seen as a land use system, which could halt and reverse soil degradation whilst simultaneously allowing the production of food and timber crops. Although at least 120 tree species have been intercropped with agricultural crops, the paulownia trees/wheat combination is the most popular. Three million ha of paulownia intercropping systems were established in China in the 1980's and a serious impact has been made on reclaiming eroded barren land to productivity. Stephen visited Henan province where there are 1 million ha of this combination. The in-row spacing is always 5m, but the distance between rows can vary from 6- 50m depending on whether the farmer considers the alley crops or the timber to have priority. A density of 100 trees per ha in an agroforestry system has the potential to produce a significant 10t/ha/year of fresh forage from leaves, plus the timber. The trees also provide shade for the wheat crops in the hot summers. Paulownia is a native of China but may have potential for use in UK agroforestry. It is fast growing, nitrogen fixing, deep-rooting and drought tolerant, but it doesn't like waterlogged conditions...

Findings/reflections

- Modern agroforestry systems are compatible with modern mechanised agriculture with tree densities of around 100 trees/ha allowing alley crop productivity to be maintained.
- Agroforestry can be as, or more, productive than monoculture systems, achieving total productivity increases of up to 30% in biomass and 60% in final products.
- Agroforestry is as profitable as monoculture, and often more profitable when high value timber trees (such as walnut, poplar or paulownia) are included.
- Alleys have been widening as 12m and 18m was found to be too close, with productivity of the alley crop declining after a decade or so. Alleys of 24m and above work well. When the trees get as tall as the alley there is a crash of productivity in the alley crop. That is the case in latitudes further south than the UK so distances may need to be greater here.
- At our latitude it is a N:S row alignment that works best, as the alley crop is shaded too much otherwise.
- Fruit trees such as apple, pear, cherry and plum can be used as the tree species and provide income from fruit production 3-5 years after planting. A suitable harvest window for the fruit crop must be considered in relation to the alley crop. In general, the fruit crop needs to be harvested after the alley crop so as to facilitate access with harvesting machinery. For example, cherry trees with alley crops of wheat or maize in England may not work as the alley crop could prevent access to harvesting cherries in midsummer. However, if nuts and later maturing fruit like apples and pears follow the summer harvesting of cereals, this works satisfactorily.
- Squirrels are not as much of a problem as you might expect. They will go up and down the edge trees, and not venture into the middle as they want cover, being afraid of predators.
- Spacial and temporal partitioning: trees start and finish later and therefore are not competing for light and water with cereal crops. It is clear that trees can make better use of the space above ground, in capturing energy through photosynthesis.

Deep and expansive tree roots in agroforestry trees utilising soil underneath the alley crop - source A.Cannet - Arbe Pasage 32

- Rooting: resource partitioning. We don't always consider the below-ground dimension. Research has shown that trees in an agroforestry system put their roots down much deeper than they would in a forestry monocrop, due to cultivations in the alley and competition for nutrients in the spring. This means that not only do they not compete with the alley crop but they are better able to withstand drought and storm damage. They will also bring up minerals from parts of the soil profile the alley crops would not normally be able to access.
- Nutrient utilisation is more efficient in agroforestry systems, with farmland nitrogen losses reduced by 50% compared to monoculture.
- Temperature: agroforestry can increase the relative humidity of the air above the fields by 7-12%, reduce crop air temperature by 1-2^{o}C and reduce crop thermal stress during critical growing periods.
- Wind: agroforestry systems locally reduce wind speed by 30-50 % (depending on the spacing of the trees) having a horizontal effect ten times the height of the tree.
- Agroforestry can reduce evapotranspiration from alley crops by 30%, reducing irrigation requirements, and improving the growth and development of crops.
- Agroforestry systems have more earthworms with 60-70 earthworms per m^3 of soil under agroforestry compared to 20 earthworms per m^3 of soil under monoculture arable systems.
- Pest and disease levels are lower in agroforestry systems than in monoculture.
- There are significantly more beneficial insects, carabid beetles, syrphid wasps and other insectivores found in agroforestry systems compared to monoculture.
- Security of land tenure is a big issue for tree crops.
- Research funding is now more directed towards biomass production. Many research sites visited are no longer funded.

Agroforestry research and development networks

Jo Smith of the Organic Research Centre Elm Farm talked about the research currently being undertaken in the UK and Europe. A Silvo-pastoral national experimental network was set up in the 1980's, involving trials set up at six research stations around the UK and Northern Ireland. In 1992 a silvo-arable national experimental network was set up on three sites. Although the funding came to an end the systems are still in place and there is some ongoing research at North Wyke in Devon and Henfaes near Bangor. Perhaps the most interesting finding was that production from grassland in the plots with red alder was as high as in the control plots that received 160kg N ha^{-1} yr^{-1}, showing the value of nitrogen fixation. Silvo-arable agroforestry trials (poplar and arable) found that crop yields reduced by 4% in the first year but increased by 10% between years four and six. There was a higher insect abundance generally, with an increase in natural enemies and a decrease of crop pests, as compared to monocultures. Not all biodiversity is good however, and there was an increase in slug populations.

Both Whitehall Farm and Wakelyns Agroforestry (see OG5) are being used as case studies in the Innovative Strategies for Copper-free Low Input and Organic Farming Systems (Co-free) project, to establish whether planting apples in an agroforestry system can reduce the need for copper sprays. Reporting some of the results from studies at Wakelyns, the willow/wheat agroforestry system had an LER of 1.43, suggesting that 43% more land would be needed if the crops were grown as monocultures. Another study comparing occurrence of scab in the apple trees with a local organic orchard found less scab at Wakelyns where the apple trees are dispersed in the tree rows.

Research gaps identified were:

- Yields & economics.
- Management impacts.
- Suitable species and designs.
- Agroforestry and biofuels.
- Landscape effects.

Farm Woodland Forum – Formed in 1986 as the UK Agroforestry (Research) Forum it aims to facilitate the generation and exchange of information to support best practice in, and improve opportunities for farming with trees. www.agroforestry.ac.uk

Eco-Agroforestry Network www.organicresearchcentre.com Set up by the Organic Research Centre. Aims to promote organic and agro-ecological agroforestry approaches into the mainstream through research, dissemination and policy changes.

EURAF – European Agroforestry Federation www.agroforestry.eu This was formed in December 2011 with 250 members from 17 different European countries. If you join the Farm Woodland Forum, you can join EURAF for and extra £10.

Policy and support position

The current position is that agroforestry is not recognised as a land-use in the UK. Top fruit, nuts and vines and short-rotation coppice are eligible for Single Farm Payments but timber wood and fuel crops above 50 trees/ha are not eligible unless grazed. Agroforestry is not eligible for payments under agri-environment schemes, except in Northern Ireland. Traditional forms of agroforestry such as wood pasture, parklands and orchards are supported under Higher Level Stewardship for their landscape and biodiversity benefits. Agroforestry is not eligible for support under the Farm Woodland Scheme as the densities of trees required would be too high. In the UK there is a disconnect between Defra and the Forestry Commission, with neither party taking ownership of agroforestry.

EURAF is lobbying for:

- The inclusion of agroforestry as eligible land for Basic Farm System payments.
- Agroforestry as an option for the Ecological Focus Area.
- Conversion payments for agroforestry.
- Maintenance payments for agroforestry.

The new CAP reforms will be introduced in 2014. The biggest hurdle within the UK is the ignorance within Defra of agroforestry. There have been opportunities in the past to include it within support schemes, but they haven't been taken. It is the duty of all of us to lobby anyone in Natural England and Defra to look at the benefits of agroforestry and adopt it.

Whitehall Farm

Stephen Briggs has 50 ha (125 acres) of agroforestry at Whitehall Farm, which makes it the largest agroforestry system in the UK. In 2009, 4,500 apple trees were planted in rows 27m apart, an £85,000 investment. Good use of available grants facilitated the project, with Stephen using the conversion payment to top fruit production available under the Organic Entry Level Scheme, together with a 3m pollen and nectar strip amounting to four hectares in total ,where the trees are paid for under Higher Level Stewardship. The trees had established well, once tall posts had been installed for pigeons to perch on (rather than them snapping the branches), but pollination had been poor this year and there wasn't much fruit to pick. Cereal yields had also been disappointing this year, due to the wet summer. The rotation includes arable crops and leeks and other vegetable crops are also planned. When asked what he would have done differently if he had done his study tour first, he thought he wouldn't have changed much though if he owned the land rather than renting it he would have planted walnuts.

Photo: Phil Sumption

IOTA workshop delegates at Whitehall Farm in September 2012

Conclusions

If the EU and Defra/Natural England get it right, CAP reforms could herald a new age for agroforestry. It is time to stop thinking of forestry and agriculture separately. At present if a tenant plants trees he is seen as degrading agricultural land! In any case, the benefits of delivering multi-functional 'services' whilst increasing productivity from the land should make agroforestry an attractive option for growers. I would encourage you all to read Stephen's report and be inspired to think about how agroforestry could be incorporated into your own farming systems.

Phil Sumption

Stephen's report is at: http://www.nuffieldinternational.org/reports/report.php