Guidelines for improved agroforestry systems for livestock production

Project name	AGFORWARD (613520)
Work-package	5: Agroforestry for Livestock Systems
Milestone	Deliverable 5.15 (5.3) Guidelines for improved agroforestry systems for livestock production
Date of report	20 December 2017
Authors	John E Hermansen, Monique Bestman, Sally Westaway, Anne Grete Kongsted, Valerio Bondesan, Rosa Mosquera Losada, Boki Luske, Sandra Novak and Jo Smith
Contact	john.hermansen@agro.au.dk
Reviewed	Paul Burgess (15 January 2018)

Contents

AGFORWARD (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD. 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.

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 Deliverable 5.15 (5.3) contributes to the second and fourth objectives. It contains a summary and copies of the guidelines (to industry) for improved agroforestry systems and practices for livestock production. The guidelines are in the form of eight agroforestry innovation leaflets, which were produced within a set of 46 leaflets which also covered agroforestry of high nature and cultural value, agroforestry with high value trees, and agroforestry for arable systems. The leaflets also support the dissemination activities covered by Objective 4.

2 Leaflets overview

Table 1 provides an overview of the eight innovation leaflets which were present in a folder (Balaguer et al. 2017) (Figure 1).

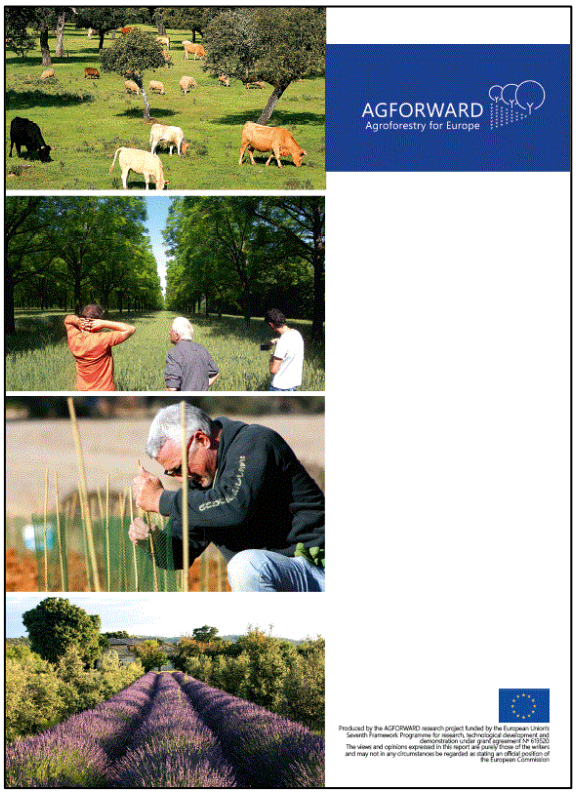


Figure 1. The eight innovation leaflets focused on agroforestry for livestock systems were included in a folder with a total of 46 innovation leaflets and 10 best practice leaflets (Balaguer et al. 2017)

Eight stakeholder groups each produced a leaflet focused on the combination of trees and poultry (two leaflets), pigs (three leaflets) and ruminants (three leaflets). Although other innovations leaflets also address livestock production, this report only focuses on those which were part of the original participative research and development network focused on agroforestry for livestock systems. The leaflets are presented in Appendix A.

Table 1. Overview of the innovation leaflets focused on agroforestry for livestock systems

Leaflet No	Title of leaflet	Authors	Organisation	Stakeholder group
39	Commercial apple orchards in poultry free-range areas	Monique Bestman and Bart Timmermans	Louis Bolk Institute, The Netherlands	Agroforestry for poultry systems, the Netherlands
40	Silvopoultry: establishing a sward under the trees	Sally Westaway	Organic Research Center, UK	Agroforestry for poultry systems, UK
41	Lactating sows integrated with energy crops	Anne Grete Kongsted, Heidi M-L Andersen, Malene Jakobsen and John E. Hermansen	Aarhus University, Denmark	Free-range pigs integrated in energy crops, Denmark
42	Pigs and poplars	Valerio Bondesan	Veneto Agricoltura, Italy	Free-range pigs integrated with energy crops, Italy
43	Mulberry (Morus spp.) for livestock feeding	María Rosa Mosquera-Losada, Juan Luis Fernandez-Lorenzo, Antonio Riguerio-Rodriguez and Nuria Ferreiro-Dominguez	University of Santiago de Compostela, Spain	Agroforestry for pigs, Galicia, Spain
44	Fodder trees for micronutrient supply in grass-based dairy systems	Boki Luske, Andreas Altinalmanzis Kondylis and Suzanne Roelen	Louis Bolk Institute, The Netherlands	Fodder trees for cattle and goats, the Netherlands
45	Fodder trees on dairy farms	Sandra Novak	French National Institute of Agronomic Research (INRA), France	Fodder trees for cattle, France
46	Combining organic livestock and bioenergy production	Jo Smith	Organic Research Centre, UK	Agroforestry with ruminants in UK

3 A brief description of the innovation leaflets

Table 2 gives an overview of livestock agroforestry systems covered by the eight innovation leaflets and the key characteristics of the systems.

Table 2. Overview of livestock agroforestry systems and their key characteristic

Case country	Tree Species	Ecosystem services		
		Provisioning		Regulating
		Livestock products	Tree products	
Poultry				
The Netherlands	Fruit trees	Eggs	Fruit (table and juice)	Shelter for hens, Reduced infection pressure for hens from wild birds, and reduced pest pressure in apples
UK	Mixed broadleaves trees	Eggs	Wood chips for bioenergy	Shade and shelter for hens Functional biodiversity Reduced soil erosion
Pigs				
Denmark	Poplar and willow	Pork meat	Woodchips for energy or for bedding-rooting material	Shade and shelter for pigs Reduce risk of nutrient leaching
Italy	Poplar	Pork meat	Timber, woodchips for energy	Shade and shelter for pigs Reduce risk of nutrient leaching,
Spain	Mulberry	Pork meat	Feed (proteins)	Carbon sequestration, biodiversity
Ruminants				
The Netherlands	Willow, alder	Milk	Feed (leaves), wood chips (bioenergy)	Drainage, shade, N-fixation, biodiversity
France	Ash, white mulberry, walnut, wild cherry	Milk, meat	Feed (leaves) , wood chips (bioenergy) timber	Shade and shelter for livestock, nutrient cycling, nitrogen- fixation
UK	Willow, poplar, hazel, alder	Meat, milk	Feed (leaves), wood chips (bioenergy)	Shade and shelter for livestock, nutrient cycling, nitrogen- fixation , functional biodiversity

3.1 Agroforestry for poultry systems

Two poultry agroforestry systems with laying hens were considered: one including apple trees in the Netherlands and one including broadleaves trees in the UK.

In combining hens with apple trees in an organic orchard, Leaflet 39 (Bestman and Timmermans 2017) describes synergies between the two businesses in terms of animal welfare and a possible reduction in apple scab because of introducing the hens in the orchard. Care needs to be taken to choice of trees near the hen house.

Trees compete with the understory of grasses and other ground vegetation that can minimise soil erosion and provides nutritional benefits for the hens both directly and in attracting insects. Leaflet 40 (Westaway 2017) gives guidance on the successful establishment of a sward under the trees.

3.2 Agroforestry for pig systems

Three pig systems were considered: including willow and poplar in paddocks for lactating sows in Denmark; including poplar in paddocks for growing pigs in Italy, and providing supplementary feed from forage trees for free-range pigs in areas with feed shortage in Spain.

Damage by pigs to young trees can be severe. Leaflet 41 by Kongsted et al. (2017) suggests that the poplar should be at least four years of age before sows get access to the trees. Leaflet 42 (Bondesan 2017) describes the effectiveness of different types of tree protection where a thin metal wire net cage stood out as being the most efficient. The welfare of the pigs is improved by the inclusion of trees providing shade, but in the systems tested the trees cannot completely prevent sunburn (Leaflet 41; Kongsted et al. 2017) and the use of mud baths for cooling is described by Bondesan (2017) in Leaflet 42. A simple layout of having trees at the one end of a paddock resulted in much of the defaecation occurring outside of the tree area, hence limiting the success of the trees in reducing nutrient leaching (Leaflet 41). Alternative tree layouts are probably needed to achieve maximise the reduction in leaching.

The prospects of growing different varieties of the forage tree Mulberry in relation to production of biomass and its protein content are described in Leaflet 43 (Mosquera-Losada et al. 2017). The varieties *Morus alba L* and *Morus nigra L* have proven to be a productive forage with high protein content in the temperate region of Spain.

3.3 Agroforestry for ruminant systems

Three aspects of agroforestry systems for ruminants were considered: fodder trees for feed supply in the Netherlands, France and the UK; spatial organization of trees in France; and woodchip production and biodiversity in UK.

Cattle seem to prefer willows over alder (Leaflet 44 by Luske et al. 2017; Leaflet 46 by Smith 2017) for browsing, and branched varieties of willow seem particularly attractive. Both willows and alder have a higher content of micro-nutrients than grass, but willow is in particular rich in Zinc and Selenium (Leaflet 44 by Luske et al. 2017). Leaves form white mulberry and common ash have a sufficiently high digestibility of organic matter to be included in the diets for lactating cows (Leaflet 45 by Novak 2017).

Three spatial distributions of trees were tested in France: single, double and three-row settings. Double and three-rows seem to be the most beneficial in terms of time needed to control vegetation and in terms of costs (Leaflet 45 by Novak 2017). Alder seems to provide the largest amount of biomass for woodchips (Leaflet 46 by Smith 2017) in organic systems.

4 Summary of the main advantages and challenges

- Across livestock species, including trees in the range areas benefits animal welfare by providing shade (Leaflets 41, 42, 44 and 45) which can, for example, support thermo-regulation and reduce sun-burn in pigs. In particular for hens, trees also provide protection against predators, stimulating the hens to use a larger proportion of the outdoor range and thereby minimize infection risk and hot spots with excessive nutrient load.

- In general, including trees in the range area is a means to obtain a higher production and income from the range area occupied. In addition for ruminants, tree leaves can provide fodder and especially micronutrients (Leaflets 44, 45 and 46).

- In addition, a number of environmental benefits might be achieved such as increased biodiversity (Leaflets 44, 45 and 46), soil carbon sequestration (Leaflets 43 and 44) and protection against soil erosion (Leaflet 44). Also, including poultry can diminish the need for chemical pest control in an apple orchard (Leaflet 39).

- A main challenge across the systems is the protection of the young trees against damage from the livestock. Practices to avoid this are described in Leaflets 39, 41, 42, 45 and 46.

5 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.

6 References

Balaguer F, Waldie K, Van Leberghe P, Liagre F, Girardin N, Pagella T, Burgess PJ (Eds) (2017). Folder for AGFORWARD Agroforestry Innovation and Best practice Leaflets. 8 November 2017. AGFORWARD project. www.agforward.eu

Bestman M, Timmermans B (2017). Agroforestry Innovation leaflet 39: Commercial apple orchards in poultry free-range areas. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/agroforestry-for-poultry-systems-in-the-netherlands.html

Bondesan V (2017). Agroforestry Innovation leaflet 42: Pigs and poplars. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/free-range-pigs-with-energy-crops-italy.html

Kongsted AG, Andersen ML, Jakobsen M, Hermansen JE (2017). Agroforestry Innovation leaflet 41: Lactating sows integrated with energy crops. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/free-range-pigs-integrated-with-energy-crops.html

Luske B, Altinalmazis Kondylis A, Roelen S (2017). Agroforestry Innovation leaflet 44: Fodder trees for micronutrient supply in grass-based dairy systems. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/fodder-trees-for-cattle-and-goats-in-the-netherlands.html

Mosquera-Losada MR, Fernandez-Lorenzo J. L, Rigueiro-Rodriguez A, Feirreiro-Dominguez N (2017). Agroforestry Innovation leaflet 43: Mulberry (*Morus* spp.) for livestock feeding. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/agroforestry-with-pigs-in-galicia-spain.html

Novak S (2017). Agroforestry Innovation leaflet 45: Fodder trees on dairy arms. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/agroforestry-with-ruminants-in-france.html

Smith J (2017). Agroforestry Innovation leaflet 46: Combining organic livestock and bioenergy production. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/agroforestry-with-ruminants-uk.html

Westaway S (2017). Agroforestry Innovation leaflet 40: Silvopoultry: establishing a sward under the trees. AGFORWARD project. 2 pp. http://www.agforward.eu/index.php/en/Poultry-systemUK.html

Appendix A: The innovation leaflets

Agroforestry Innovation leaflet 39: Commercial apple orchards in poultry free-range areas (Bestman and Timmermans 2017).

Agroforestry Innovation leaflet 40: Silvopoultry: establishing a sward under the trees (Westaway 2017).

Agroforestry Innovation leaflet 41: Lactating sows integrated with energy crops (Kongsted et al. 2017).

Agroforestry Innovation leaflet 42: Pigs and poplars (Bondesan 2017).

Agroforestry Innovation leaflet 43: Mulberry (*Morus* spp.) for livestock feeding (Mosquera-Losada et al. 2017).

Agroforestry Innovation leaflet 44: Fodder trees for micronutrient supply in grass-based dairy systems (Luske et al. 2017).

Agroforestry Innovation leaflet 45: Fodder trees on dairy arms (Novak 2017).

Agroforestry Innovation leaflet 46: Combining organic livestock and bioenergy production (Smith 2017).

Commercial apple orchards in poultry free-range areas

Increase revenues from your investment in animal welfare

www.agforward.eu

This 1.4 ha orchard in a 2.4 ha free range area provides enough shelter for chickens to travel up to 200m from their base (This picture was taken at 100m). *Ref: Louis Bolk Institute*

Why plant trees?

A free range area contributes to chicken welfare. However, chickens prefer range areas with shelter provided by trees, bushes or artificial structures. A farm with 10,000 chickens needs a range area of 4 hectares. Planting such a large area with trees is a big investment. Introducing commercial fruit trees is one way to add a valuable revenue stream. Every fruit species has particular needs and some will require additional investment. For example, cherry trees require netting for protection against birds. This leaflet explains the requirements of incorporating apple trees into a free range poultry system.

Two year old orchard in free range area
Ref: Louis Bolk Institute

Where, how and which trees to plant?

Planting and managing a commercially viable apple orchard demands special expertise. It is important to seek advice before planting: hire a fruit advisor or rent your land to a fruit farmer and let him/her advise or even decide which varieties and trees are suitable to your situation.

Apple trees need loose dry soil, therefore, conditions can be very challenging for apple trees growing near to the chicken house. In this area, it is more appropriate to plant cheaper and more robust species or rootstocks with more growth potential. In a range area, bigger and older trees, than those which would be suitable for an orchard without chickens, need to be planted. It is sensible to plant 2-3 apple varieties, since they may react differently to seasonal changes and the presence of the chickens.

Close to the chicken house the soil condition is compacted and wet due to chickens. Compaction of the soil by machinery will also impair tree growth and apple production. *Ref: Louis Bolk Institute*

AGFORWARD Agroforestry for Europe

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

- Chickens kept outside exhibit signs of reduced stress, as evidenced by less pecking damage. Chickens with full feather cover need less feed to maintain their body heat.
- Where there is more tree cover, fewer water birds will enter. This is critical as water birds can transmit avian influenza virus.
- Apple blossom provides feed for bees and other pollinators. So, fruit trees contribute to biodiversity.

Pests and diseases

- Apples are susceptible to harm from weather, animals and disease. Some pests, like scab, may increase over years.
- Chickens may have a negative impact on tree growth, the proportion of apples with sunburn damage and the proportion of rotten apples. This might be caused by chickens making the soil bare, compacted or, possibly, the high amounts of manure.
- Chickens may reduce scab and pest insects by eating leaves infected with scab and insects.
- In organic production, there are fewer conflicting interests because no chemicals are used in the orchard that could be harmful to the chickens.

Monique BESTMAN
Bart TIMMERMANS
m.bestman@louisbolk.nl
Louis Bolk Institute, Kosterijland 3-5, 3981 AJ Bunnik, The Netherlands
www.agforward.eu

November 2017

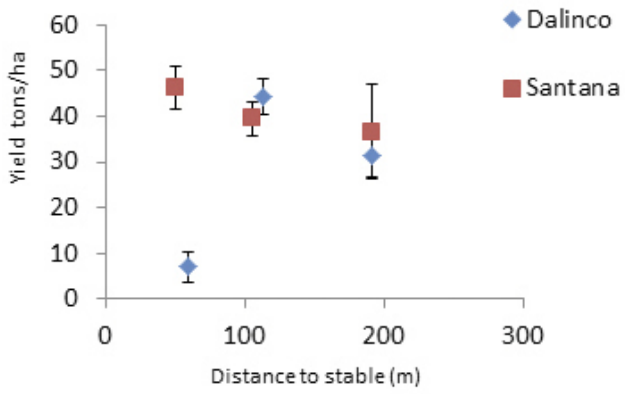
For food safety reasons neither the chickens nor their manure should have any contact with the fruit.
Ref: Louis Bolk Institute

Yields of apples

Investigations on a Dutch organic farm with 6,000 laying hens and 6,800 apple trees showed that a yield of 40-50 tonnes of apples/ha can be achieved. This good performing orchard is planted and managed by a fruit farmer who rents the range areas. The two apple varieties grown have to be harvested at different times. Planting several varieties also spreads the risks of diseases.

Tree management

The management of an orchard is seasonal. Pruning of trees is done in winter. Checking tree poles, thinning of blossoms and young fruits takes place in spring. In summer, tasks include checking for diseases and damage, organising material and labour for harvest, marketing, harvesting, sorting and delivering the apples. Sometimes the apples are processed into juice.



Yields of two varieties of 6-year-old apple trees on an organic egg production farm (2016)

Further information

Bestman M, de Jong W, Wagenaar J, Weerts T (2017). Presence of avian influenza risk birds in and around poultry free-range areas in relation to range vegetation and openness of surrounding landscape. Agroforestry Systems. Doi: 10.1007/s10457-017-0117-2

Timmermans B, Bestman M (2016). Quality of apple trees and apples in poultry free range areas. 3rd European Agroforestry Conference. May 23-25, Montpellier, France. pp. 420-423.

Timmermans B, Bestman M (2017). Quality of apple trees and apples in poultry free range areas. Season 2016. Report Louis Bolk Institute 2016-031 LbP.

Silvopoultry: establishing a sward under the trees

www.agforward.eu

Chickens under the trees in the silvopoultry system? *Ref : Organic Research Centre*

Why do chickens need a sward under trees?

Trees in the outdoor run are beneficial to the welfare of chickens. The ancestors of domestic chickens roost in trees, and hens are happier and use more of the range when it is enriched with trees. However, one problem with including trees in the range is the lack of ground vegetation under the trees, due to reduced light levels and increased competition. Further, where the tree canopy opens unpalatable weeds, rather than grasses, may grow.

European regulations for organic and free-range chickens state that the outdoor area should be mainly covered with vegetation. Establishing and maintaining a healthy sward under the trees has multiple benefits; it protects the soil, provides alternative food sources for the chickens and enhances biodiversity.

Preparing the ground for sward sowing using a pedestrian power harrow. *Ref : Organic Research Centre*

Establishing a sward in the understorey

The development of a sward mixture that can establish and survive under trees has been identified as a priority by a focus group of UK farmers producing woodland eggs. To address this issue, sward establishment trials were set up within an existing silvopoultry system at a commercial organic laying hen unit in southern England. Mixed broadleaved tree blocks of 144 trees were originally planted within the chicken enclosures in 2002 at 2 m x 2 m spacing. These blocks were selectively thinned to approximately 50% of planted density in February 2016 prior to sward establishment.

Three sward mixes were tested against a natural regeneration control to identify a mixture that performs well under trees. The trial mixes were: (1) a standard commercially available chicken sward mix; (2) a customised mix with shade tolerant grasses and (3) a diverse mix with grasses, legumes and forage herbs. The mixes were sown in four tree blocks in spring 2016 after a shallow cultivation using a pedestrian power harrow. Mixtures were sown by hand at a rate of 52 kg/ha, rolled and watered in. Chickens were excluded for the first three months to allow sward establishment and then introduced to two of the blocks for a ten week period from August to October 2016.

Growth and establishment of the mixtures was monitored weekly for the first six weeks, and environmental factors including soil moisture, canopy cover and temperature were also measured. Biomass cuts were taken after six weeks to measure sward productivity. After the chickens were introduced, biomass cuts and surveys of plant diversity were repeated every six weeks to identify the impact of the chickens on the different mixtures.

The sward six weeks after sowing (a) Mix 3 (b) The control. *Ref : Organic Research Centre*

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

The combination of trees, chickens and the presence of a healthy diverse sward throughout the range has multiple benefits.

- In addition to the animal welfare benefits associated with trees, a good quality sward has potential nutritional benefits for the hens, both directly from the plants and indirectly by increasing the number of insects.
- The presence of a diverse sward beneath the trees will enhance biodiversity, and weed suppression throughout the growing season, as well as protecting the soil by reducing soil erosion and building soil organic matter.
- There is also the potential for additional income from tree products. For example, material from tree thinning can be used as woodfuel for a farm biomass boiler.

The chickens checking up on the sward monitoring. *Ref : Kevin Waldie*

Sward establishment

All three mixtures established well under the trees. The commercially available standard sward mixture performed in a similar way as the other two customised mixtures. This has economic implications for poultry keepers, as the more specialised mixtures are likely to have higher seed prices as the seed is more expensive to source. Sward establishment rates increased one month after sowing for all mixtures, indicating higher weed suppression potential after four weeks and minimum growth time required for establishment.

Weed control

There was a clear trend of higher cover and biomass of weeds in the control than the mixtures. At the end of the growing season, in the absence of chickens, the cover of sown plants was still increasing and the cover of weeds had started to decline in all mixtures except the control; this suggests that the sowing of any mixture will help suppress weeds.

Introducing the chickens....

Once the chickens were introduced, the cover of all sown mixtures dropped significantly in the six week period they had access to the sward. This was especially evident where the house was close to the trees; here the sown sward species disappeared almost completely. Where the house was situated 25 m further away from the tree block, the sown sward appeared better able to withstand the presence of chickens.

This study highlights the need to exclude the chickens for as long as possible to aid sward establishment. The trial demonstrates that establishing a sward under the trees is possible, but that the challenge is to maintain the sward in the presence of chickens. Careful planning of the agroforestry system to optimise chicken pressure across the range appears to be the key, with rotation of flocks to allow swards to establish and recover.

Further information

Smith J (2014). Poultry in the UK: Sainsbury's Woodland Chicken Development Group (Woodland Eggs). Organic Research Centre, UK. http://www.agforward.eu/index.php/en/Poultry-systemUK.html

Smith J, Gerrard C, Westaway S (2016). System report: Poultry agroforestry in the UK. Organic Research Centre, UK. http://www.agforward.eu/index.php/en/Poultry-systemUK.html?file=files/agforward/documents/WP5_UK_silvopoultry_system_description.pdf

Woodland Trust guide to tree planting for free range poultry (2014). https://www.woodlandtrust.org.uk/mediafile/100256924/tree-planting-for-free-range-poultry.pdf?cb=9a

Sally WESTAWAY
sally.w@organicresearchcentre.com
Organic Research Centre, Elm Farm, Hamstead Marshall, West Berkshire, RG20 OHR, UK
www.agforward.eu

November 2017

Lactating sows integrated with energy crops

Produce pork and tree biomass on the same area

www.agforward.eu

The trees provide the sows and piglets shade and shelter *Ref : KR Hansen*

Why introduce trees?

Trees, like poplar and willow, can provide pigs, managed in pasture-based systems, with a natural and stimulus rich environment. Sows and piglets can find shade in hot seasons and shelter in wet and windy weather. Further, the pigs can rub against the trees for skin care.

The introduction of trees can reduce the nutrient leaching from soils in outdoor production because, compared to grass, fully established trees are more robust to the pigs rooting behaviour. Further, trees have a deep root system with nutrient and water uptake occurring over a long growing season. The trees can be harvested to provide biomass to be used for production of energy, or as rooting material for pigs in housing systems.

Trees in pasture based systems also have a positive effect on biodiversity and landscape aesthetics.

Where and how to plant

Two private organic pig farms in Denmark have been studied for two years. The farms are involved in large-scale organic pig production, with 200 and 300 sows, respectively. The sows are kept outdoors all year round on grassland (grass clover). On both farms, poplar and/or willow have been established in the areas used for lactating sows. On one farm, the paddocks are approximately 30 m long and include two rows of trees at one end. On the other farm, the paddocks are 40 m long and include five rows of trees at one end. Behavioural studies were carried out. In addition, data on nitrogen in soil and soil water was collected on one of the farms to evaluate the effect of trees on animal welfare and nutrient leaching.

Poplar or willow?

Willow has a more shrub-like growth compared to poplar and may grow to 7-8 m. The dense multiple stem growth may hinder supervision of the animals and restrict human movement between the trees, for example, when catching piglets. On the other hand, the shrub structure provides the pigs with a solid shelter all year round.

Poplar has a more vertical growth and may become 20-30 m tall. It gives a more "open" expression and the shelter effect may be lower compared to willow. No matter whether willow or poplar is chosen, it is recommended that the area to be established is planted with, at least, three different clones in order to reduce the risk of diseases.

The sows use the trees for "skin rubbing".
Ref : HM-L. Andersen

Willow has a more shrub-like growth compared to poplar. *Ref : AG Kongsted*

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Tree protection

To prevent damage, the trees should be established at least four years before sow access. Piglets can be given access after two years, and this reduces the need for supplementing weed control. When well-established, the trees are resistant to the sows and piglets rooting behaviour. Lactating sows may bite off smaller branches to use them as nest building material. This may increase the risk of piglet mortality through inhibiting their mobility inside the huts during the first hours after birth. Further, browsing can cause severe damage on individual trees. Cutting branches below a height of 1-1.2 m will limit the sows' access to branches and reduce bark damage.

Cutting off the branches below 1 m height reduces tree damage and lowers the risk of sows using the branches as nest material in the farrowing huts.
Ref : K.R. Hansen

Anne Grete KONGSTED, Heidi M.-L. ANDERSEN, Malene JAKOBSEN, John E. HERMANSEN
anneg.kongsted@agro.au.dk
Dept. Agroecology, Aarhus University
www.agforward.eu

November 2017

Left: The trees can be harvested on a regular basis to remove nutrients from the paddocks.
Right: The tree biomass can be used as an attractive rooting material for pigs (mixed wood chips and leaves) (*ref: K.R. Hansen*).

Paddock design

When a few rows of trees are placed in one end of a rectangular shaped lactation paddock, a large proportion of the excretory behavior is performed outside the tree zone as shown in the table below. This reduces the beneficial effect of the trees in relation to reducing nutrient leaching. If the trees were placed in the middle of the paddock with the main resources (hut and feed) placed on each side of the tree area it is possible that a larger amount of the urine and faeces will be deposited in the tree zone.

Distribution of excretory behaviour (% of behavioural observations) in five different zones in a paddock with two rows of poplar trees at one end of the paddock. Relative area is equal to the proportion of the area of each zone

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
		Feed		Hut	Trees
Relative Area, %	27	27	14	12	20
Urine, %	50	32	10	0	8
Faeces,%	31	22	14	12	21

At high temperatures, sows with access to trees spent more time in the tree area, whereas sows with no access to trees spent more time in the hut. From 2018, it will be mandatory in Danish organic outdoor pig production that pigs are provided with access to shade during the summer months, in addition to that provided by the hut. Establishment of trees in the paddocks seems an appropriate way to comply with this requirement. However, two rows of five-year-old poplar trees at one end of the paddock (as shown above) is not enough to avoid incidences of severe sunburn on ears and udders. Wallow holes are also required to provide pigs with a quick and effective means of cooling off.

Further information

Cultivation guide: https://okologi.dk/media/235799/dyrkningsvejledning_farefolde.pdf (In Danish)
Ecosystem (A Danish project, in Danish): http://agro.au.dk/forskning/projekter/pecosystem/
Homepage of an organic pig farm with poplar in the paddocks for lactating sows (in Danish): http://hestbjerg.dk/
Video clip from the farms. https://www.flickr.com/photos/agforward/15605200701/

Pigs and poplars

A smart combination for environmental protection, animal welfare and meat quality

www.agforward.eu

Growing organic pigs in a newly planted (2nd year) high density poplars. *Ref : Bondesan, 2015*

Why keep pigs together with poplars ?

Free-range systems aim to support animal welfare and are common in organic pork production. However, they do represent an environmental risk due to the depositing of manure. Maximum stocking rates are prescribed assuming that nutrients released with manure will be spread uniformly in the field and may be absorbed by cover crops roots. In practice, there are several problems with these assumptions: pigs often decide to use one specific part of the paddock to defecate; sandy-soil fixes a small amount of nutrients; and herbaceous cover crops are more active during spring summer and less so in other seasons (Tagliapietra et al. 2007).

Trees, especially fast growing ones, such as poplar (but also willow, black locust) absorb high amount of nutrients and can reduce the risk of leaching, as well as spot water contamination through better drainage (AA.VV. 2011). Moreover, developed trees can provide a good welfare environment for pigs: cool shade in hot weather conditions and shelter from cold winter wind.

Newly poplars high density plantation (1st year)
Ref: Bondesan, 2014

How to establish poplars within open range systems

To assess different options, experimental trials were developed within an organic free range pig unit in an agroforestry system located in the northeast of Italy-Padania plane. (Veneto Agricoltura Azienda Sasse-Rami, Ceregnano – Rovigo , 45.050760° N; 11.880257° E)

Poplar is a fast growing species well-suited for free range pig production in plain alluvial deep-soil where groundwater is normally present (1.5-2.0 m underneath). Spacing, intra-inter row distance and the final number of trees per hectare depends on soil type, field range design, pigs categories, stoking expected during the production, and the wood destination at harvesting. In sandy soil types, tree density should be higher than those with loamy-clay textures, which have a better root-net capacity of manure nutrients absorption.

Under normal conditions, the harvesting cycle of poplar for packaging wood (main logs) or firewood (woodchip) could be every 10-12 years with a medium density plantation (200-300 trees/ha), but as short as 5-6 years (woodchip) with high density "short rotation" (1500-2000 trees/ha). Spacing of low-density plantations may vary from 3.0-4.0 m between trees and 16-25 m between rows. For high-density planting, recommended for growing-fattening heavy pigs, the common spacing is between 1.5-2 m x 3.0-3.5 m (with sufficient spaces left without trees for locating huts or feeding and drinking points).

Planting should be done in late autumn or early spring, using one year old rods (3-4 m long), planted at a depth of 1.3-1.5 m. Newly planted poplars must be protected from pig damage (mainly bark biting and scratching) by proper shelters. The area cannot be used by pigs until the second year, by which time the trees will be more resilient. There are very few types of shelter that can be used to protect newly planted trees from damage by pigs. According to the findings, a metal cage of 60-70 cm high around the trees will provide the best protection. Nevertheless, a low percentage (5-12 %) of trees are still likely to be seriously damaged (Bondesan, 2016). Metal cages should be removed before the tree growth incorporates it within the bark; if that happens more labour will be required to pull it away before harvesting.

AGFORWARD Agroforestry for Europe

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

Incorporating high-density poplar fields within the production system of organic free range fattened heavy pigs (slaughtering live weight about 180-220 kg), brings several benefits.

- High-density trees ensure an extensive root covering and good absorption of manure nutruents in the "defecation area" chosen by pigs.
- Poplar growth receives a beneficial effect from the pigs' manure, and woodchip production may increase.
- Welfare of restricted feed intake growing pigs improves, especially during the hot summer weather, since good shadow cover provides temperature control at ground level.
- A more friendly "animal and environmental" system, organic plus agroforestry, may represent an extra quality attribute that influences consumers choice towards traditional pork products.

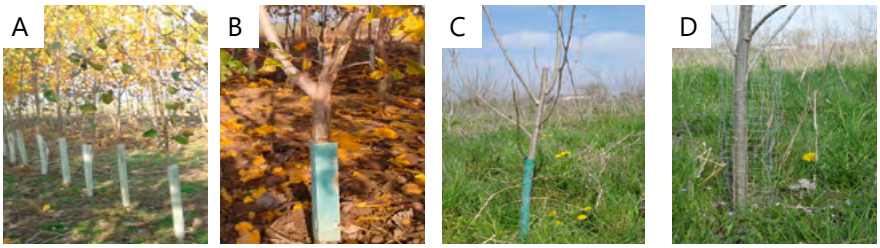
Feed restricted growing pigs could increase bark biting and tree damage *Ref : Bondesan, 2014*

Valerio BONDESAN
valerio.bondesan@venetoagricoltura.org
Veneto Agricoltura - Agenzia veneta per l'innovazione nel settore primario
Viale dell'Università, 14 – 35020,
Legnaro (Padova, Italy)
www.agforward.eu

November 2017

Using fast growing trees in free-range fields for organic pigs provide several benefits. Nevertheless, the combination of growing pigs and trees, with high-density spacing, needs a detailed knowledge of animal behaviour and management. Pigs, being very curious and interactive animals, like to explore the environment and will exhibit both social and natural behaviour. In organic systems, with pigs not being nose-ringed, rooting is a main activity. In the wettest areas, due to rolling in the mud, tree-roots damage and soil structure deterioration may reach severe levels. Soil conditions may deteriorate in wet periods and annual tillage could be necessary.

During the fattening period (9-11 months), in order to prevent excessive fat deposition in the carcass and limit production costs (due to a lower feed conversion rate), pigs are normally restricted for a few months. During this period, pigs tend to increase the time spent for searching for food, rooting, biting bark and, if present, increase grass ingestion. In a newly established plantation, pigs may cause serious damage to trees if they are not protected with proper shelters. If a tree is left without protection, severe bark damage may occur, leading to the death of the tree. Monitoring the trees' condition, replacing the damaged shelters, reducing stocking rates, and shortening the rotation time can help to reduce the percentage of damaged trees.



	A	B	C	D	E
Type of shelter	FruitWrap	Square shelter	Spiral ribbon	Metal cage shelter	Control
	One side open tube with spiral wrap effect (h=75 cm)	A four side open box with flaps of closure system (h=60 cm)	Holed plastic ribbon, with spiral curving (h= 60 cm)	Thin metal wire net, with hooks to making a cage around the tree (h=66 cm)	No protection
Proportion of trees	%	%	%	%	%
Shelters damaged (1st trial)	4.0	14.0	37.0	2.0	
Shelters damaged (2nd trial)	13.0	21.0	64.0	4.0	
Trees damaged after 1st trial	1.0	3.0	6.0	0.0	9.0
Dead trees after 1st trial	0.0	0.0	2.0	0.0	4.0
Trees damaged after 2nd trial	3.0	5.0	9.0	0.0	11.0
Dead trees after 2nd trial	0.0	1.0	3.0	0.0	7.0

Four different types of shelter used to protect poplars (above): metal cage"D" is the most effective shelter. (Based on assessment of 200 trees for each type of protection.) *-Ref: Bondesan, 2014*

Further information

AA.VV. (2011). Agroforestazione: Produrre con gli alberi per un'agricoltura differente. Scheda tecnica, pp. 20; Veneto Agricoltura Eds.) Legnaro, Padova.

Bondesan V (2016). Agroforestry for free-range pig production in Veneto Region (Italy): system description report. Veneto Agricoltura. http://www.agforward.eu/index.php/en/free-range-pigs-with-energy-crops-italy.html.

Tagliapietra F, Bondesan V, Dal Maso M, Schiavon E, Merenda M, Stefani A, Schiavon S (2007). Effects of raw soybean seeds low in antinutritional factors on growth perfor mance, carcass quality and nitrogen excretion of heavy pigs in an organic farm. Poljo privreda, 13, 61:65.

Mulberry (*Morus* spp.) for livestock feeding

A useful source of protein

www.agforward.eu

Mulberry experiment established in Galicia (NW Spain).

Why use mulberry to feed livestock?

Mulberry is used as a livestock fodder in many countries around the world (e.g. India and Japan). The leaves of the mulberry are known for its high protein content (15-28%), good amino acid profile (> 46%), high digestibility (>80%), high mineral content with ash values up to 25%, low fibre content (7.1-8.1%) and excellent palatability.

The high biomass yield of the plant, together with its low tannin content, makes it an attractive resource for livestock. Moreover, mulberry is an excellent species to overcome pasture shortage during summer, which is a common issue reported in many Mediterranean countries.

Mulberry established in the field to feed livestock

How to plant mulberry?

Mulberry can be established in any part of Europe, but it especially suited to areas such as Galicia (NW Spain), which face summer droughts. In such areas, animals can consume mulberry directly if they are shaped as shrubs. To determine the adaptation, productivity and fodder quality of *Morus* spp. in the temperate region of NW Spain, four mulberry clones (*Morus alba* criolla, *Morus alba tigrenda*, *Morus alba illaverde* and *Morus nigra*) were produced using two different techniques: in vitro propagation and rooted cuttings. In the field, mulberry clones were evenly distributed in the plot, at a distance of 50 cm to avoid intra-specific competition.

Morus spp. can be used for harvesting following a short rotation coppice system, and this can provide fresh forage to animals in stables or be stored for later use. If a short rotation coppice strategy is used, weeds should be controlled in the early stages of establishment. If *Morus* spp. are planted for direct consumption, they must be protected from the outset. However, no weed control is needed as animals will eat the surrounding herbaceous species. In our trials, to enhance initial tree development, mulch was added to the soil after establishment of the mulberry clones.

Production of mulberry after in vitro propagation/rooted cuttings

AGFORWARD Agroforestry for Europe

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

- *Morus alba* L. and *Morus nigra* L. have proven to be a productive forage with a high level of protein. This is especially useful for feeding livestock during periods of pasture shortage.
- Ecosystem services will also be improved through reduction in the need for concentrates.

Mulberry to feed livestock in summer

Mulberry in autumn

Management

Morus spp. production varies according to location. In Galicia (NW Spain) production levels average around 0.2-1.4 Mg DM/ha. In this region, the levels of crude protein were also high (leaf: 10 to 18% and stem: 4 to 18%). In general, however, mulberry has a high potential as forage, and its establishment and use is easy. Where possible, local varieties should be established on farm. Due to their adaptation to weather conditions, local varieties can often provide better production and higher quality forage than exotics.

Environment

Establishing *Morus* spp. as permanent crop, or as an element of permanent grasslands, will increase nutrient recycling, biodiversity, water quality and animal welfare. Moreover, it will reduce the need of concentrates due to its high protein content, and also reduce the carbon footprint of the farm as less external inputs are needed.

Adaptation

Growing *Morus* spp. can make the farm more resilient against climate change by providing an additional source of fodder. If *Morus* spp. is used as a hedgerow it will also improve ecosystems services, such as pollination, and will reduce the negative effect of winds.

Further information

Benavides JE (1999). Use of *Morus alba* in animal production systems. In: Sánchez MD, Rosales M (Eds.), Agroforestería para la producción animal en Latinoamérica. Memorias de la Conferencia Electrónica. Estudio FAO Producción y Sanidad Animal 143, FAO, Rome, Italy, pp. 275-281.

Fernández-Lorenzo JL, Perez V, Liñayo S, Mosquera-Losada MR, Rigueiro-Rodríguez A (2004) . Micropropagation of three clones of *Morus alba* L. selected for fodder use. In: Mosquera-Losada MR, McAdam J, Rigueiro-Rodríguez A (Eds.), Silvopastoralism and sustainable land management, CABI Publishing, Wallingford, UK, pp 121-123.

Mosquera-Losada MR, Fernández-Lorenzo JJ, Ferreiro-Domínguez N, González-Hernández P, Hermansen J, Villada A, Rigueiro-Rodríguez A (2017). Mulberry (*Morus* spp.) as a fodder resource to overcome climate change. In: Porqueddu C, Franca A, Lombardi G, Molle G, Peratoner G, Hopkins A (Eds.), Grassland resources for extensive farming systems in marginal lands: major drivers and future scenarios. Wageningen Academic Publishers, The Netherlands, pp. 585-587.

Sánchez MD (2000). Mulberry is an exceptional forage available worldwide! In: Mulberry for animal production. In: Sánchez MD (Ed.), Animal Health and Production 147, FAO, Rome, Italy.

María Rosa MOSQUERA-LOSADA
Juan Luis FERNANDEZ-LORENZO
Antonio RIGUEIRO-RODRIGUEZ
Nuria FERREIRO-DOMINGUEZ
mrosa.mosquera.losada@usc.es
Crop Production and Project Engineering Department. Escuela Politécnica Superior. University of Santiago de Compostela, 27002 Lugo, Spain
www.agforward.eu

November 2017

Fodder trees for micronutrient supply in grass-based dairy systems

Multiple advantages for biodiversity and animal welfare

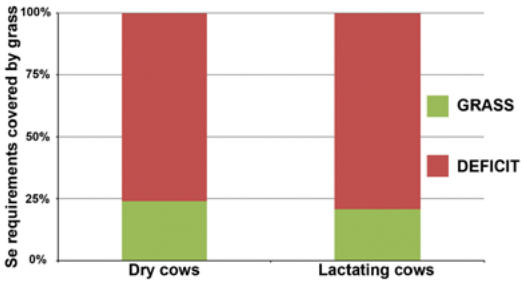
www.agforward.eu

Cow and calf browsing from willow fodder trees *Ref : Louis Bolk Institute*

Why plant trees?

In order to meet the CAP (2014-2020) demands for a low carbon and climate resilient economy, it is necessary to create sustainable farming systems by reducing dependency on external feed inputs, and to sequester carbon on the farm.

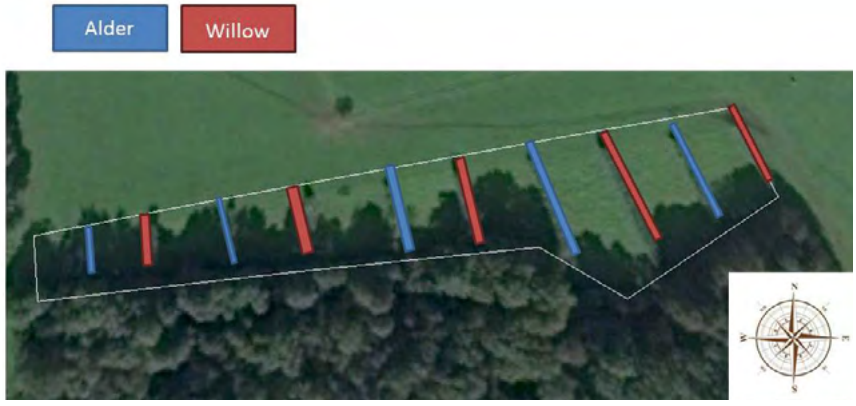
Currently, Dutch dairy farms usually feed their cattle with a combination of spring/summer grazing and imported maize silage and/or concentrates. Incorporating fodder trees in dairy farms can be a good alternative option to maize silage and concentrates, and for supplementing cows with macro and micro elements. In this leaflet, focus is placed on selenium, as it has been found to be lacking in the diet of grass-fed ruminants in the Netherlands.



Selenium intake from grass, shown as a percentage of the total cattle nutrient requirements for dry and lactating cows. The 'deficit' represents the percentage that is normally covered via mineral supplements.

Where, how and which trees to plant

Historically, trees were planted as borders of hedgerows or wooded banks. However, trees can also be planted within the pasture. If tree rows are planted in a north-south direction, the shade effect is minimalized. This design offers the highest amount of available tree leaves for browsing and is relatively easy to manage. Choosing tree species that are fast growing, high in leaf mineral content and compatible with the Dutch climate is essential. Willow trees (*Salix sp.*) and nitrogen fixing alder trees (*Alnus glutinosa*) are a good match for the Netherlands temperate climate, as they grow quickly and are richer in macro and micro-nutrients than grass. Also, varieties that branch out widely, providing many young twigs within browsing height, are good choices for



Trial field at 'de Kerkhoeve' farm. Red lines represent willow trees, and blue lines represent alder trees, planted in twin rows with 24 m between rows and 20 cm between trees

Twin rows of willow trees during a browsing experiment with dairy cows. The willows are planted on a north-south axis. In the back, an exclosure was constructed (behind the bamboo stick), where the cows were not able to browse. This picture shows the difference between browsed trees (in front of stick) and protected willow trees.

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

Incorporation of trees provides animals with shade during spring and summer grazing. Animal welfare is a significant factor in shaping consumers' choice of livestock products, so this brings benefits, both for the animal and possibly to the income of the farmer.

Willow and alder trees are valuable additional sources of nutrition. On our test site, the dairy cows preferred to browse on willow trees. Although the intake rate was low, the fodder trees provided a natural source of macro- and micro-nutrients. Willow leaves are particularly high in selenium and zinc.

Planting trees assists in building a low carbon and climate resilient economy. Trees enhance carbon sequestration, nutrient cycling, soil drainage and soil stabilization. Four years after planting, we measured an increase in soil organic matter of 0.5% under willow and 0.3% under alder tree rows. Also earthworm biomass increased by 52% under alder tree rows.

Diseases and pests

Infestation with diseases or leaf beetles can be an issue for both willow and alder. In large numbers, leaf beetles can defoliate the tree, and make it less attractive for browsing. Natural enemies like ladybirds, parasitic wasps and lacewings often keep pest populations low. Coppicing is a good method to restore vigor to the tree and help it recover from diseases or pest infestation.

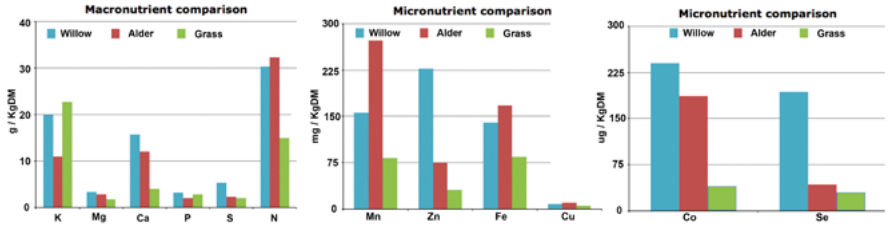
Boki LUSKE, Andreas ALTINALMAZIS KONDYLIS, Suzanne ROELEN
b.luske@louisbolk.nl
Louis Bolk Institute, Kosterijland 3-5, Bunnik, The Netherlands
www.agforward.eu

November 2017

Willow twigs up to a diameter of 1 cm were browsed by dairy cows. *Ref : Boki Luske*

Yields of willow

A five year old willow tree, planted in twin rows, produces 1.5 - 3 kg of fresh shoots annually, depending on the variety. Branched varieties produce less biomass, but are more accessible to the cows, which may enhance the intake of macro and micro elements through browsing. Willow and alder leaves have a mineral content that is higher than grass. Selenium content is especially high in willow.



Nutritional value of tree leaves and grass, for: a) macro elements (g/kg DM) and b) micro elements (mg/kg DM) (µg/kg DM).

Tree management

Management of the trees is limited to annual coppice performed immediately before the growing season. The newly grown vegetation is then browsed naturally by the cows. Edible parts of the trees are the leaves, twigs (diameter < 1 cm), and bark. Cows should not be allowed to browse from the trees until approximately two years after planting. This is because cows can inadvertently damage a young tree's growth.

Further information

Charlton J, Douglas G, Wills B, Prebble J (2003). Farmer experience with tree fodder. Using trees on farms. Grassland research and practice series 10: 7-16.

Dijk H v, Schukking S, Berg R (2015). Fifty years of forage supply on dairy farms in the Nether lands. Paper presented at the Grassland and forages in high output dairy farming sys tems. Proceedings of the 18th Symposium of the European Grassland Federation. Wage ningen, The Netherlands, 15-17 June 2015.

Luske B, N v Eekeren (2015). Potential of fodder trees in high-output dairy systems. Grass land Science in Europe 20: 250-252.

Smith J, Pearce BD, Wolfe MS (2012). A European perspective for developing modern mul tifunctional agroforestry systems for sustainable intensification. Renewable Agriculture and Food Systems 27 (4): 323-332.

Fodder trees on dairy farms

Extend the grazing season with trees and shrubs

www.agforward.eu

Dairy cows grazing a paddock recently planted with fodder trees *Ref : Sandra Novak*

Why browse woody plants?

To face the challenges arising from decreasing water and fossil fuel resources, dairy systems will have to limit their use of irrigation, mineral nitrogen fertilisers and exogenous concentrates.

Grazing is a critical aspect of energy and water-saving management. However, the quantity and quality of grazed forage are highly dependent on climatic conditions. In Atlantic French regions, grazed grasslands currently provide forage in spring and, to a lesser extent, in autumn. However, grassland production is much reduced in summer. Climate change will probably increase drought conditions in late spring and summer, and also the overall variability of grassland production annually. Trees and shrubs could provide a complementary forage resource on dairy cattle farms.

White mulberry and grassland in August 2016
Ref : Sandra Novak

How to integrate woody plants in a grazed paddock

An agroforestry paddock (3 ha) was co-designed with farmers, researchers, technical institute engineers and extension agents and implemented in February 2015 on the experimental cattle dairy farm of INRA in Lusignan (Nouvelle Aquitaine, France). Fodder trees were planted in the grazed paddock to be browsed by cattle in a couple of years, but also to provide wood chips. Two types of pruning techniques of fodder trees will be tested: pollards of *Morus alba* and *Alnus cordata*, and coppices of *Salix caprea, Ulmus minor, Robinia pseudoacacia* and *Alnus incana*. High stem trees (*Pyrus communis, Gleditsia triacanthos, Sorbus domestica*) were also planted, mixed with various layouts with pollards and coppices, as farmers wanted to test the diversification of tree uses.

Three spatial organizations of trees were tested with single, double or triple-row sets, with an inter-row spacing of 20 m. To restrict the browsing of the newly established trees, seven types of tree protection were compared: single or double line of electric fence, electric fencing tape, metal or plastic fences, olfactory repellents and a barrier tape. Another option of tree protection was to exclude the paddock from grazing and to mow the grassland during the first years of the establishment phase.
Additionally, the nutritive value of several woody plants leaves was evaluated to determine the woody species that could be included in the diet of lactating cows.

A pasture-fodder tree agroforestry demonstration paddock for ruminants in Lusignan (France)
Ref : Sandra Novak

AGFORWARD Agroforestry for Europe

Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

- Integrating fodder trees and shrubs in a cattle dairy farm can provide additional fodder, especially in summer and autumn, when grassland production is low. It therefore contributes to strengthening the resilience of the farm.
- Integrating trees and shrubs can also improve animal welfare by providing shade in summer and shelter from wind and rain in winter.
- The deep rooting of trees and shrubs also permits them to use soil nutrients and water resources not available to herbaceous plants, and hence to produce fodder without the need for fertilisers and irrigation.

Leaves of Italian alder collected to be analysed
Ref : Jean-Claude Emile

Sandra NOVAK
sandra.novak@inra.fr
INRA – Experimental Unit Forage, Environment, Ruminants, Lusignan, France
www.agforward.eu

November 2017

How to protect young trees from cattle

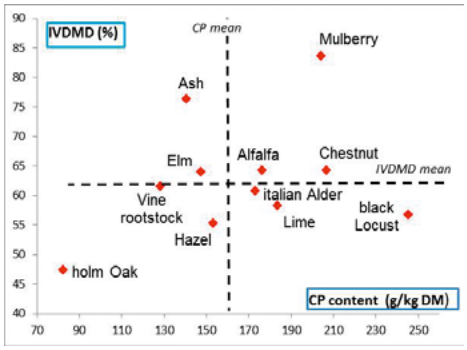
After two years of evaluation, the most efficient forms of protection were the following: electric fence, electric fencing tape and metal fence. Electric fence and electric fencing tape are quickly installed and facilitate the mechanical control of the vegetation although they are relatively expensive. Metal fencing is cheaper and offers the opportunity to be used as a trellis for fodder climbing plants (e.g. vines). However, it needs more time to be installed and it complicates the control of the vegetation on the tree rows. To limit the damage of deer, it is necessary to use mesh tree guards and it is recommended to spray a wild deer repellent.

Spatial organization

Planting trees reduces the available grazing area. This loss will be recovered once trees become productive. However, when considered relative to the number of tree seedlings, double and triple row sets could become more beneficial than single row sets in terms of time needed to control the vegetation on the tree rows and on costs. Double and triple row sets also open opportunities not provided by a single row set, e.g. a mix of different tree uses. An understorey cover composed by species with low growth helps to limit the maintenance of the vegetation within the tree rows.

Nutritive value of tree leaves

The composition, nutritive value and ruminal degradability of leaves from woody resources exhibit large variation between species. White mulberry and common ash have sufficient digestibility and nitrogen degradability to be included in the diet of lactating cows in mixed crop-livestock systems, and their quality is higher than those of grasses or lucerne in summer. Other species such as lime, elm, Italian alder are also promising and may be used to feed ruminants with lower needs (e.g. suckler or dry cows).



In vitro **digestibility (IVDMD, %) and crude protein content (CP, g/kg) in leaves of woody plants and lucerne collected in summer 2015 (Emile et al. 2017)**

Further information

Emile JC, Delagarde R, Barre P, Niderkorn V, Novak S (2017). Evaluation of the feeding value of leaves of woody plants for feeding ruminants in summer. 19th EGF Symposium on "Grassland resources for extensive farming systems in marginal regions: major drivers and future scenarios", Alghero, Sardinia (Italy) Grassland Science in Europe, vol 22, 548-550.

Emile JC, Delagarde R, Barre P, Novak S (2016). Nutritive value and degradability of leaves from temperate woody resources for feeding ruminants in summer. 3rd European Agro forestry Conference. INRA, Montpellier, 23-25 Mai 2016, France, pp. 409-412.

Novak S, Liagre F, Emile JC (2016). Integrating agroforestry into an innovative mixed crop-dairy system. 3rd European Agroforestry Conference. INRA, Montpellier, 23-25 Mai 2016, France, pp. 396-398.

Magnard A (2015). Video related to the future use of fodder trees in the diet of cattle in the OasYs project of the INRA experimental station of Lusignan. http://www.lafranceagricole.fr/videos/elevage/elevage-laitier-des-arbres-dans-la-ration-des-vaches-1,0,16901225.html

Combining organic livestock and bioenergy production

A novel trial integrating willow and alder short rotation coppice and cattle

www.agforward.eu

Why combine livestock and energy production?

Agricultural land is subject to many competing demands: for increased food production to meet the needs of a growing world population; for bioenergy production from biomass crops such as short rotation coppice (SRC) to meet renewable energy targets; and the demand for agricultural land to protect the environment including soil, water and air quality, reducing climate change, and supporting biodiversity.

Agroforestry has the potential to help to meet these conflicting demands by integrating energy production from short rotation coppice and livestock production, without compromising the environment.

Applying woodchip for weed control *Ref : Jo Smith, ORC*

Cattle and short rotation coppice. *Ref : Jo Smith, ORC*

Design and establishment of the system

Trees were planted in north/south rows with 24 m of pasture between tree rows in spring 2011. Willow (*Salix viminalis*) was chosen as it has a dual use as both a productive bioenergy source and a livestock fodder.

Common alder (*Alnus glutinosa*) was also planted as it coppices well and it fixes nitrogen, which may be useful for organic systems. However, its value as a fodder crop was unknown. Trials comparing different weed control approaches found that woodchip mulch can perform as well as fabric mulches. Further, as it can be sourced on-farm or from local tree surgeons for free, it provides a good approach to weed control in organic systems. Tree establishment rates were initially low due to dry spring weather in the first two years, and there was a high level of replanting, particularly of the willow. Trees were cut to a height of 10 cm after one year to encourage multiple branching and a silage cut was taken from the alleys once or twice a year for the first four years, with cattle first introduced in the fifth year. In the sixth year, the pasture was ploughed in and oats grown for whole-crop silage before re-seeding with a diverse pasture mix.

Cutting for silage *Ref : Jo Smith, ORC*

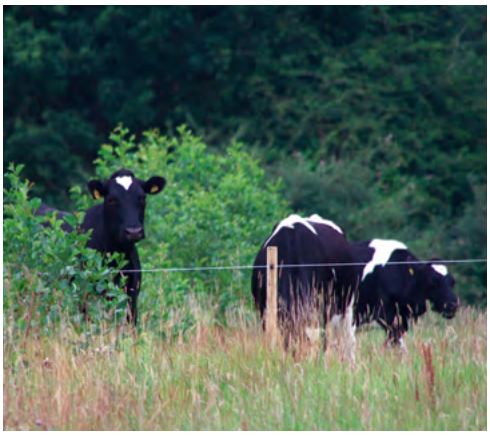
Produced by the AGFORWARD research project funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613520

Advantages

The key advantages of the system are self-sufficiency for the farmer in energy production, combined with shelter and shade for cattle and the provision of alternative feed resources.

Other advantages include, improvements to soil organic matter, support for farmland biodiversity, and the substitution of fossil fuel with renewable energy.

Coppiced alder drying in field before chipping. *Ref : Jo Smith, ORC*



Browsing trial. *Ref: Jo Smith, ORC*

Cultivating the alleys. *Ref : Jo Smith, ORC*

Woodchip and pasture production

The trees were first harvested after five years. Alder yields were on average 160 kg/100 m (30% moisture content) or 663 kg/ha of agroforestry, while average willow yields at this first coppice were just under 8 kg/100 m or 32 kg/ha of agroforestry. It appears that the willow is not well suited to the site. With hindsight, other species of willow may have been a better choice. For example, white willow, (*Salix alba*) which has been planted in nearby hedges, has survived and grown very well. Yields of the pasture were monitored over the first five years, and no significant impacts were found, suggesting that in the initial years of establishment, competition between the trees and grass was minimal.

Tree and livestock interactions

A browsing trial found that cattle have a preference for willow over alder. However, after a few days, the cattle also started browsing the alder trees, suggesting that as they become 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 bio-energy, 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. Cattle will also take branches up to 10 mm 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. Using a single strand electric fence was sufficient to protect the trees from the cattle, while allowing them to reach grass in the understorey of the tree row.

Further information

Caslin B et al. (2015). Short Rotation Coppice Willow. Best Practice Guidelines. TEAGASC and AFBI Publication. https://www.agriculture.gov.ie/media/migration/ruralenvironment/environment/ bioenergyscheme/TeagascCoppiceWillowGuidelines260315.pdf

Smith J, Gerrard C (2014). System Report: Agroforestry for Ruminants in England. AGFORWARD Report.

Jo SMITH
jo.s@organicresearchcentre.com
Organic Research Centre, Elm Farm, Newbury.
www.organicresearchcentre.com
www.agforward.eu

November 2017