

DO HEDGES HELP CONTROL PESTS AND DISEASES IN VINEYARDS?

Agroforestry to improve vineyard management



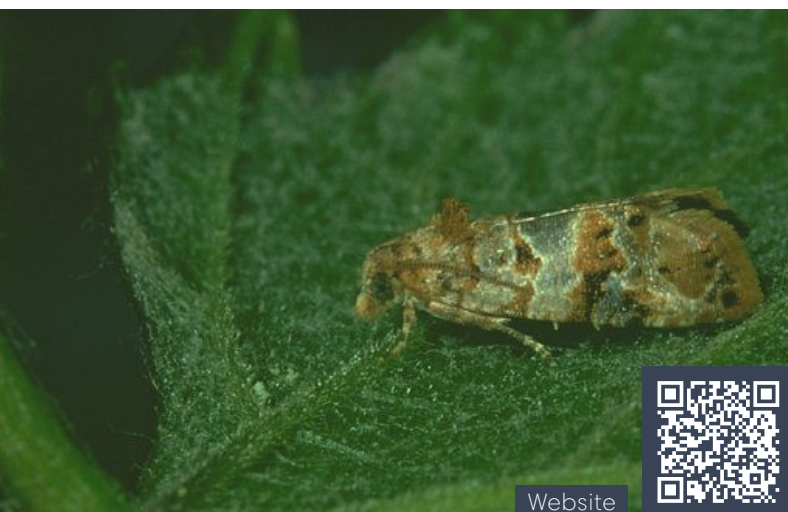
THE WHAT AND WHY

Grapevine moth causes increasing damage in Mediterranean regions

The grapevine moth causes important losses to vineyard owners: the larvae perforate the grapes and help spread diseases. By doing so, they reduce the yield, but also increase the likeliness of grey mould (*Botrytis cinerea*) and acid mould (flies). The larvae of the first generation appear in April, while those of the last generation generally appear in August. The butterflies lay their eggs at dusk. The presence of larvae and

rotten fruit lowers the quality of the crop; moulds render vine making difficult and may require the crop to be harvested prematurely.

Growers faced with an infestation have no choice but to spray their vines with chemicals. As an alternative, bats and insectivorous birds can help control the grapevine moth, but need suitable habitat to be provided.



Website

Butterfly of *Lobesia botrana* (Denis et Schiffermüller).
INRA HYPPZ
<https://bit.ly/2RV1XN7>



Lagardère EARL vineyard in Lagardère (32310), France
Association Française d'Agroforesterie
www.agroforesterie.fr

HOW IS THE CHALLENGE ADDRESSED

Tree and vegetation cover for improved biological control

Bats can play an important role in the protection of economically important crops against lepidoptera pests. They seek out particular features where insects tend to be most abundant, such as hedgerows, clearings or forest edges.

A recent French study concluded that bats are present in vineyards and help reduce the losses related to grapevine moth and diseases like grey and acid mould. The study also confirmed that although they are present in intensive vineyards, bats still prefer hunting in more natural environments such as hedgerows. On pilot plantations, mixing vineyards and tree alignments

in the South-West area of France, a reduction of occurrence of grapevine moth has already been reported along with an increased presence of bats at dusk.

Other pilot plantations rely on the screening effect of hedges to isolate plots from each other, contributing to slowing down the spread of pathogens and diseases like grey mould. With the economic value of timber and hedge wood, the owner of the vineyard can compensate for some of the loss of production resulting from these optimisations of the biological control of the plots.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Vineyards; biological control; bats; birds; grapevine moth; grey mould; acid mould, quality; image

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HIGHLIGHTS

- Trees and hedgerows improve the habitat conditions for bats and insectivorous birds.
- It is observed that bats and birds will be more present in agroforestry vineyards, reducing the presence of grapevine moth and the occurrence of diseases such as grey and acid mould.
- Hedgerows may also help to isolate infested plots from healthy plots, slowing down the spread of pathogens and diseases.



watch video

Vineyard under mature trees
La Ruche Qui Dit Oui

FURTHER INFORMATION

This article details the launch of a study on the impact of trees on the presence of insectivorous birds and bats in Bordeaux vineyards.
<http://revue-sesame-inra.fr/des-vignes-sous-laile-des-chauves-souris-vignoble-bordeaux>

The ARBELE project (in French) investigates the techniques and impacts of tree in herbivore livestock farms.

<http://idele.fr/presse/publication/idelesolr/recommends/casdar-arbele-larbre-dans-les-exploitations-delevage-herbivore.html>

This factsheet describes biological techniques for the control of grapevine moth in vineyards.

<http://ephytia.inra.fr/fr/C/7025/Vigne-Methodes-de-protection>

ADVANTAGES AND DISADVANTAGES

Experiments to confirm the efficacy of the approach

Choice of species

Little information is available regarding the combination of tree and bat species and their efficacy against pests, but also crop auxiliaries. Additional work is necessary to better understand the interactions between trees, bats, auxiliaries, pests and crops.

The definition of the woody perennial objectives is crucial at the start of the project. Some tree species might provide a better habitats for bats than others. Shade, on the other hand, will be quickly obtained with fast-growing species like poplar. This quick growth will also shorten the period for production of an added value from sale of timber or wood.

Compatibility between trees and vines

Nitrogen competition can occur between trees and vines ; a negative impact on yield (-35%) was noticed for vine rows closer than 5 metres to the trees. Therefore, a distance of at least 5 metres is thus recommended between the trees and the first vine rows. This will also facilitate the mechanisation of the vineyard.

Unpruned trees can also complicate the maintenance of the vineyards. Besides allowing machines to work in the vineyard, pruning allows the production of quality wood and a fair income at tree harvest.

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Content editor: Maria Rosa Mosquera-Losada (USC)
12 DECEMBER 2018

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MUSHROOM CULTIVATION

Mushroom cultivation brings additional income to forest owners



THE WHAT AND WHY

Why mushroom cultivation?

For many of the more than 600 thousand private forest owners in Finland, forestry is an additional source of income. However, the income generated from harvesting small-diameter trees during thinning is quite low and amounts to just a couple of euros per tree. Active mushroom cultivation in forests can markedly increase the earnings from forests. Mushroom cultivation as a way to create value from forests can yield anytime between 1 year from inoculation to as much as 8 years with chaga (*Inonotus obliquus*). In addition, it is an ecologically friendly way of increasing food production in

forests. Instead of producing only wood as a raw material, the forest now also delivers high quality food. Moreover, mushroom cultivation on living trees can be applied as an ecological forest management tool saving costs on thinning operations. There are intensive mushroom cultivation techniques which will produce a mushroom harvest every year, as well as more extensive techniques producing a mushroom harvest every 5–6 years. The more extensive techniques are particularly suitable for forest owners who live far away from their forest or for people without much time.



Shiitake mushrooms (*Lentinula edodes*) grown on birch logs, Karjalohja, Finland.
Michael den Herder



Shiitake mushrooms grown on birch stacks in a mixed forest on the Suomen Agrometsä oy forest farm
Michael den Herder

HOW IS THE CHALLENGE ADDRESSED

Managing a mushroom forest farm

Shiitake, oyster (*Pleurotus ostreatus*) and lingzhi mushrooms (*Ganoderma lucidum*) are grown on logs. Shiitake and oyster mushrooms are edible mushrooms and lingzhi is a medicinal mushroom mainly used in Asia. These mushroom species are grown on birch, alder, oak or aspen logs (about 10 cm in diameter) cut to 1 m length and piled in stacks.

Logs are inoculated with mushroom mycelia from early spring to autumn. Holes are drilled in the logs with a 10–12 mm drill to insert cultured mycelium. Shiitake and oyster mushrooms can be harvested twice during the

growing season, with about 8 weeks between harvests. A log can produce mushrooms for about 3–4 years. Chaga is a medicinal mushroom used in Asia and it is grown on living birch trees. After inoculation, the first chaga mushrooms are harvested after 5–6 years. Hereafter, it is still possible to get two additional mushroom harvests every fifth year after the last harvest until the tree dies after about 15 years. Hereafter the tree can be harvested and sold as fire or fibre wood. This mushroom cultivation method can be used as a forest management tool by selecting those birches which will be cut later on during thinning.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Intensive mushroom cultivation; forest management techniques; forest management tool; oyster mushroom; chaga (pakuri); lingzhi (reishi); shiitake

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HIGHLIGHTS

- Mushroom cultivation can provide a significant additional income for forest owners and makes forest management more eco-friendly and profitable.
- Chaga mushroom cultivation can be applied as a forest management tool by selecting small-diameter trees which will be cut during tending or thinning.
- Mushroom cultivation increases eco-efficiency by producing food in addition to wood production.



watch video

Chaga mushroom on birch
iStock.com/amarinchenko

FURTHER INFORMATION

Suomen Agrometsä oy provides advice, equipment, inoculum (dowels and spawn) and full hands free service for growing mushrooms <https://www.agrometsa.fi>

Gifts from Metsä organises courses on mushroom cultivation <https://www.giftsfrommetsa.fi>

Vanhanen, H. & Peltola, R. 2015. Rerouting Finland's Agroforestry Scheme. Conference Proceedings: Public Recreation and Landscape Protection - with Man Hand in Hand, 3-5 May 2015, Brno, Czech Republic, pp. 215-219. Available online: https://www.researchgate.net/publication/276420578_Rerouting_Finlands_Agroforestry_Scheme

Lee, K.-H., Morris-Natschke, S.L., Yang, X., Huang, R., Zhou, T., Wu, S.-F., Shi, Q., Itokawa, H., 2012. Recent progress of research on medicinal mushrooms, foods, and other herbal products used in traditional Chinese medicine. *Journal of Traditional and Complementary Medicine* 2, 1-12. [https://doi.org/10.1016/S2225-4110\(16\)30081-5](https://doi.org/10.1016/S2225-4110(16)30081-5)

ADVANTAGES AND DISADVANTAGES

Mushrooms a superfood?

Higher added value

Mushroom cultivation makes forest management more ecologically friendly and profitable. It is possible to get a higher value from your forest as compared to conventional management only. Shiitake and oyster mushrooms are sold in the supermarket, through direct on-farm sales and to restaurants. The value of birch harvested during first thinning is only a couple of euros, but the production of for instance chaga mushrooms on a single birch can be worth 100 euros.

Mushroom cultivation can be used as a new forest management tool as it increases the profitability of early thinning operations. It fits with conventional forest management practices as well as continuous cover forestry. As chaga cultivation doesn't need much management apart from inoculation and harvesting, it also suitable for forest owners who live far away from their forest or for people without much time. If you don't have any time, you can even outsource the whole cultivation process to a professional mushroom cultivation company. If you don't own any forest, you can still grow mushrooms as a hobby in a small garden, on a balcony or even on the kitchen table. Frequent watering is needed!

Healthy food

The health benefits of mushrooms have been demonstrated in many scientific studies (Lee et al. 2012). Oyster and shiitake are edible mushrooms. Lingzhi and chaga are used in the preparation of nutritional supplements and medicines.

Eco-efficiency

Mushroom cultivation contributes to more efficient land use. In addition to producing wood, the forest now also produces food.

Market opportunities

Medicinal mushrooms such as chaga and lingzhi create opportunities in the Asian market. Medicinal mushroom production in Finland is currently low, but if cultivation starts now the first harvest is expected in 5-6 years when the demand is predicted to be much higher than the availability.

Things to bear in mind

Mushroom logs need to be sufficiently moist for the mycelia to develop. It is beneficial for mushroom growth that it rains at least once a week. If the logs become too dry, mushroom mycelia start degenerating or can even die. In dry periods during summer, it is important to have access to water in order to sprinkle the mushroom logs when needed.

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18 FEBRUARY 2019

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WALNUT TREES (*JUGLANS REGIA*) IN AGROFORESTRY SYSTEMS

What do I need to know to produce walnuts or walnut timber in Belgium?



THE WHAT AND WHY

Why walnut trees?

Walnut trees (*Juglans regia*) are being cultivated in large parts of Europe. They are known to be trees with a high market potential. Their nutritious nuts and good quality timber are highly valued and the market demand is correspondingly high. Southern European and EU Mediterranean countries are leaders in the European market, while the US and China are the most important global players. Commercial walnut cultivation is still rare in Flanders and almost all nuts are imported. This opens

up a lot of opportunities for regionally produced walnuts. Ever since the Flemish government started subsidising agroforestry in 2011, there is a growing interest in implementing walnut trees in agroforestry systems. These robust trees fit perfectly within the framework of agroforestry, not least because of the relatively low competition for light with other crops due to their open crown, late leaf appearance and early leaf fall. Walnut leaves are also rich in nutrients and decompose quickly, speeding nutrient cycling.



Young alley cropping system of walnut trees with cultivation of *Buxus* spp. in between rows (Flanders, Belgium)
Inagro

Female flowers, young fruits ; male catkins spreading pollen
Inagro

HOW IS THE CHALLENGE ADDRESSED

The right tree in the right place

Planting walnut trees for timber is a long term investment (50 years and more), but nut production can start from just 7 years after planting if conditions are favorable and the trees are well managed. *Juglans regia* prefers sunny conditions and well-drained, deep (60 – 80 cm) soils rich in organic matter. They are relatively fast-growing reaching a total height of 18 – 30 m and a canopy width of 12 – 18 m. Roots are sensitive to oxygen depletion which can occur in wet conditions. Optimal pH is 6 or more, however they still grow well on pH 5 – 6. Spring frosts can damage flowers and shoots, making late flowering

varieties more suitable in frost prone areas. Walnut trees are monoecious with male (numerous hanging catkins, April/May) and female flowers (tiny and at the end of the branches, usually appearing later) maturing at different times, limiting self-pollination. Planting a combination of varieties will improve the wind-driven pollination and hence increase productivity. However, variety choice will depend on the purpose of the trees, i.e. either high value timber production (where usually improved varieties based on selective breeding are used) or fruit production.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: silvoarable; silvopastoral; productivity; biodiversity; tree management; varieties.

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HIGHLIGHTS

- Walnut trees for nut and timber production are highly valued with a high market demand
- Crown characteristics and leaf appearance and falling period makes them very compatible to crop production in agroforestry systems
- Leaves are good litter, speeding up nutrient cycling
- Problems with diseases (walnut blight and leaf blotch) are easily avoided by smart choice of varieties



Varieties of *Juglans regia* are numerous and come in all sorts of shapes and colours
Inagro

FURTHER INFORMATION

Crawford, M. 2016. How to grow your own nuts. Choosing, cultivating and harvesting nuts in your garden. Green Books, Cambridge, UK, 320p.

Oosterbaan, A. 2015. Walnoot+. Een boom voor iedereen. BoekenGilde, Netherlands, 88p.

More information (in Dutch) on the usage of walnut trees in agroforestry systems can be found on <https://www.agroforestryvlaanderen.be/NL/Kennisloket/Boomspecifiekeinfo/tabid/9776/language/nl-BE/Default.aspx>

Within the European AGFORWARD project innovation leaflets have been written on the usage of walnut trees in agroforestry systems (16. Grazing sheep under walnut trees ; 33. Walnut and cherry trees with cereals in Greece). These can be found on <https://www.agforward.eu/index.php/en/Innovation-leaflets.html>

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FEBRUARY 2019

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ADVANTAGES AND DISADVANTAGES

Getting the most out of your agroforestry system

Nuts or timber? That's the question you need to answer first. This decision will determine all your choices onwards.

Planting

The advised tree spacing in agroforestry systems varies from 10 to 20 m, depending on the purpose of the trees and combined cultivation, usually grassland or arable crops in Flanders. In a silvoarable system the lower density is preferred and the combination with winter cereals is considered suitable due to its early cropping. Planting is carried out between late November and early March. In humid conditions a pollinating tree should be no further than 50 m away when you want maximal walnut production. Adding organic manure and/or mulch to the area under the canopy can help establishment and growth.

Varieties

Juglans regia is the best species choice for walnut production in Flanders. There are many varieties to choose from, each with their own specific set of characteristics. Considering the humid climate in Flanders, resistance to disease is a priority. Also late leaf appearance varieties are preferred in temperate agroforestry systems. Broadview and Buccaneer are examples of two commonly used self-fertile varieties, but there are many others to explore. *Juglans nigra* x *J. regia* hybrids are preferred for high quality timber production.

Pruning

The best pruning period, avoiding sap bleeding, is from June to late-November (usually following crop harvest). For nut production, pruning aims to increase incidental light on branches, for timber it focuses on creating a branch-free stem to reduce the knots in the timber. Removing lower branches also facilitates harvesting and cultivation in silvoarable practices.

Harvesting/yield

Time of nut ripening varies from mid-October to late-November depending on the variety. Production starts on average after 7 years, reaching a peak between 30 - 50 years of around 18 kg dry nuts per tree (5 and 10 kg for 10 and 20 year old trees respectively). Collect nuts directly after falling. They can be eaten fresh, dried and preserved or processed into other products like oil. Timber production takes at least 50 years and each tree yields on average 1 m³ of timber at that stage. Prices vary from 250 to 500 euro/m³.

Diseases and pests

- Leaf blotch (*Gnomonia leptostyla*): fungus causing brown blotches on leaves and young fruit in wet conditions, causing defoliation and blackening of the nuts in extreme cases.
- Walnut blight (*Xanthomonas juglandis*): damages leaves, flowers, buds and shoots in wet conditions. Up to 80% of the crop may be lost in severe attacks. The bacterium overwinters in healthy dormant buds and catkins and can readily infect young shoots through wounds.

There are no pest species that significantly influence yields, except maybe for the codling moth (*Laspeyresia pomonella*).

IMPLEMENTING SWEET CHESTNUT TREES IN BELGIAN AGROFORESTRY SYSTEMS

Why sweet chestnut trees and how to get started?



THE WHAT AND WHY

What do (sweet) chestnut trees have to offer?

Chestnut trees have been cultivated for centuries in Europe for their nuts and/or timber. Mountainous countries in the South are traditionally the largest producers of chestnuts in Europe. Although remaining a marginal crop, healthy chestnut industries are recently expanding over less rugged terrain.

Sweet chestnuts are the species with the highest economic importance. European sweet chestnut (*Castanea sativa*) originates from southern Europe, Asia and northern Africa. Its broad crown can reach a height of 30 m and more during its 250 to 500 year life span. Japanese chestnut (*C. crenata*) is a tree, introduced to Europe because of its resistance to chestnut blight. Euro-Japanese hybrids have been selected for their

excellent nut quality. Chestnuts are rich in carbohydrates (comparable to wheat and rice) and sugar while low in fat. Together with the rich flavour this makes chestnuts very attractive for consumers. Most of the produced nuts are directly consumed fresh, roasted, fried or boiled. There are also several value-added products. For example, some varieties are used for making gluten-free chestnut flour or bee hives are moved in chestnut orchards to produce chestnut honey.

Chestnut timber is highly valued for its colour, natural durability and ease of working. It is widely used for outdoor posts, furniture and flooring. The tannin rich wood makes the use of chestnut timber very sustainable.



Young plantation of European sweet chestnut (*Castanea sativa*) in an agroforestry system in Flanders.
Inagro



Detail of male and female flowers
Martin Crawford

HOW IS THE CHALLENGE ADDRESSED

The right tree in the right place

In the temperate climate of Belgium, the deep-rooting sweet chestnut trees grow well in the shade as well as full sun and are relatively drought-tolerant. A continental climate (hot summers, cold winters) is preferred. In cooler temperate climates, the European sweet chestnuts (and hybrids) usually are the best choice. Apart from heavy clay soils, they tolerate a range of soil types with a preference for well-drained loam soils. Optimal pH ranges from 5 to 6, but they also thrive on more acid soils. Blooming of male and female flowers is time-separated, meaning they seldom self-pollinate. Pollination (June – July) is wind-driven, although bees and other insects become increasingly important in humid and cold conditions. In terms of chestnut production, it is therefore advised to provide

a good pollinator cultivar for every 3 trees planted and plant different varieties.

In agroforestry systems, a minimal planting distance of 12 m in-rows and 20 m between rows is advised (e.g. density of 40 trees per ha) because of the broad crown resulting in a lot of shade. Minimal feeding (N and K) of the trees up to an age of 5 – 8 years can be useful on poor soils. Irrigation is needed with young trees in periods of severe drought, while mulch around the tree is always a good option when young. Except for some typical formation pruning in the first 3 to 4 years (removing low branches that can interfere with the harvest and access underneath the trees) relatively little pruning is required later on when aiming at chestnut production.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: silvopasture; *Castanea sativa*; design; productivity; yield; pest; disease.

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HIGHLIGHTS

- Nutritious nuts are very attractive to consumers and timber is highly valued
- European chestnut trees thrive in a wide range of climatic and soil conditions
- Broad crown and relatively slow decomposing litter make chestnut trees less interesting in silvoarable systems.
- Special attention needed in the prevention of several wide-spread pests and diseases



Productive chestnut tree
Inagro

FURTHER INFORMATION

Crawford, M. 2016. How to grow your own nuts. Choosing, cultivating and harvesting nuts in your garden. Green Books, Cambridge, UK, 320p.

Chastaing S., Méry D., Pages G. Tournade J. 2015 Conduite du châtaignier en agriculture biologique dans le sud-ouest. Chambre d'agriculture Dordogne. (http://lot-et-garonne.chambagri.fr/fileadmin/telechargement/Productions_vegetales/GuideChataignierAB_OK_Web.pdf)

Gauthier Michel. Les carnets du Croqueur de pommes - le châtaignier. ISBN 978-2-909717-63-0

More information (in Dutch) on the usage of sweet chestnuts in agroforestry systems can be found on <https://www.agroforestryvlaanderen.be/NL/Kennisloket/Boomspecifiekeinfo/tabid/9776/language/nl-BE/Default.aspx>

Within the European AGFORWARD project innovation leaflets have been written on chestnut trees in agroforestry systems (17. Protecting trees in chestnut stands grazed with Celtic pigs; 18. New approaches for producing selected varieties of chestnut). These can be found on <https://www.agforward.eu/index.php/en/Innovation-leaflets.html>

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FEBRUARY 2019

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ADVANTAGES AND DISADVANTAGES

Creating and managing a productive agroforestry system with chestnut trees

Silvoarable or silvopastoral systems?

Shade resulting from the broad crown of full-grown trees and the slowly degradable leaf litter makes chestnut trees less suitable for silvoarable systems on the long term. Silvopastoral systems with increased animal welfare due to shade and shelter offered by the trees is a better option.

Choosing the right variety

Variety choice is especially important when the focus is on chestnut production. The choice mainly depends on the climate and the usage of nuts. Sweet chestnuts come in a range of varieties each with their own harvest period, nut flavor and shape, preferred climate and resistance to pests and diseases. Late-ripening cultivars are usually better suited to warmer climates and store better than the early-ripening ones.

Some of the best French varieties interesting in the Belgian context:

- Early season: 'Marigoule', 'Vignols'
- Early to mid-season: 'Marron Comballe', 'Précoce Migoule'
- Mid-season: 'Bouche de Bétizac', 'Marron de Goujounac', 'Marsol'
- Mid- to late season: 'Belle épine', 'Bournette', 'Dorée de Lyon', 'Maraval', 'Marlhac'
- Late season: 'Bouche Rouge', 'Maridonne'

Harvesting and yields

Harvest period in temperate regions is from September to November. Nuts should be collected directly after falling or shaken from the trees. They can be hand-harvested or automatically with vacuum and sweeper harvesters. Starting from the age of 5 (variety dependent), the first small amounts of nuts can be harvested. The production peak is reached at the age of 12 - 15 years, with high production from then onwards. Average yields in agroforestry plantations are estimated around 1.5 - 2 tons per ha per year (i.e. 15 - 25 kg per tree), assuming a density of 70 trees per ha. To increase production in the first years, planting at half of the recommended planting distance is possible, but requires thinning after 10 years.

Pests and diseases:

- Oriental chestnut gall wasp (*Dryocosmus kuriphilus*): lays eggs on terminal buds and limits tree growth and fruit development (up to 80% loss in case of severe infestation). Biological control by parasitic wasps can be a solution. In smaller orchards, pruning and destroying infested branches can also be a way of reducing infestations.
- Chestnut weevils (*Curculio elephas*) and moth (*Pammene fasciana*): feed on the kernel of chestnuts just before harvest. Pheromone traps or housing animals under the trees (chickens) just before and after harvest can be a solution.
- Chestnut blight (*Cryphonectria parasitica*): parasitic fungus attacking aerial parts of the trees through wounds. This seems less devastating in Europe (due to hypovirulence) than it was in the past for the American sweet chestnut, but can loss can still be significant regionally. Desinfect your pruning materials and pay attention to the origin of your plants.
- Ink disease (*Phytophthora cinnamomi*): fungal disease attacking the trunk base through the roots. Roots cease growing and release a black liquid (oxidized tannin). Avoid standing water around the tree roots as this is an efficient dispersal medium. Research is going on to find or breed resistant varieties.

RAINWATER HARVESTING IN MEDITERRANEAN SILVOPASTORAL SYSTEMS

Swales and small ponds: tools for rainwater catchment under climate change



THE WHAT AND WHY

The importance of water harvesting and retention in Mediterranean silvopastoral systems

In dry areas such as the ones found in the Mediterranean region, water availability is a critical issue that requires the promotion of sustainable management practices and tools. These issues are even more relevant under current climate change scenarios. Rain may also be a cause of soil erosion. This happens, for example, in the cases where the land is not suitably designed to store water, and/or when extreme events such as intensive rainfall, occur in short periods of time. Some stakeholders

have implemented *swales* and small ponds to maximize water catchment. Ponds can be bigger or smaller depending on the size of the farm and the soil topography. The way they are built depends mostly on climate and soil conditions. *Swales* on the other hand, are ditches that go along contour slope lines and are used to reduce the flow of the water, and make it slowly infiltrate the soil. These features are relatively inexpensive and very effective as water management tools.



Small pond at Herdade das Cebolas, Campinho, Portugal. (Janeiro, 2018).
Axel Gosseries



Swale at Herdade das Cebolas, Campinho, Portugal. (Janeiro, 2018).
Joana Paulo

HOW IS THE CHALLENGE ADDRESSED

Most important criteria for creating small ponds and swales

There are two types of criteria to take into consideration for the selection of suitable sites for installation of rainwater harvesting structures: biophysical and socioeconomic. The most important from these two are, respectively: slope, land use/cover, soil type and rainfall regime; and distance to settlements, distance to streams, distance to roads, and cost. Frequently the sites are selected using geographic information systems, in combination with hydrological models and multi-criteria analysis. Selecting the most relevant criteria

requires a good insight into local conditions. The success rate of the projects tends to increase when these variables are considered.

Slope can be frequently considered the most important factor, since it also plays an important role in the quantities of runoff and sedimentation, the speed of water flow, and the amount of material required to construct a dyke. FAO (2003) guidelines are presently the most comprehensive for the identification of potential rainwater harvesting sites (Ammar, 2016).



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: rainwater catchment; runoff; rain; water conservation; shallow soils; soil conservation; drought; climate change

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HIGHLIGHTS

- Ponds and *swales* help to improve water catchment and infiltration, keeping rain water in the system and decreasing soil erosion.
- Ponds and *swales* increase soil nutrient levels and organic matter content in the surrounding soil.
- Ponds and *swales* increase water availability for irrigation, livestock and wild animal populations.
- Ponds and *swales* are relatively inexpensive landscape features, a climate-smart way of water management, and are very important in semi-arid regions.



Pond under construction at Herdade das Cebolas, Campinho, Portugal. (Janeiro, 2018).
Joana Paulo

FURTHER INFORMATION

Literature:

Ammar, A. et al. (2016). Identification of suitable sites for rainwater harvesting structures in arid and semi-arid regions: A review. *International Soil and Water Conservation Research* 4:108–120. doi.org/10.1016/j.iswcr.2016.03.001

Falk, M.W. et al. (2013). Striking the Balance between Nutrient Removal, Greenhouse Gas Emissions, Receiving Water Quality, and Costs. *Water Environment Research* 85(12):2307–2316

FAO (2003). Land and water digital media series, 26. Training course on RWH (CDROM). Planning of water harvesting schemes, unit 22. Rome: Food and Agriculture Organization of the United Nations, FAO

Inspiring movies:

<https://youtu.be/nak-UUZnvPI> (Regreening Ethiopia's Highlands: A New Hope for Africa)

<https://www.youtube.com/watch?v=OpUI00vUsAk> (Green Ethiopia Planting Hope with Trees)

<https://www.youtube.com/watch?v=4UwCC8Nlly4> (Building a 4.5 acre farm pond. FarmCraft101)

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APRIL, 2019

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ADVANTAGES AND DISADVANTAGES

Building *swales* and ponds in the farm: how and where

Ponds

Ponds can be used on slopes up to 5% usually using a backhoe and being relatively cheap to build. In arid and semi-arid areas ponds need to be deeper, and in sandy soils they need to be sealed. Ponds can be made by: i) building an embankment or dam across a stream or watercourse; ii) digging a pit in an almost level area; iii) excavating and building a dam in gently to moderately sloping areas.

The pond bottom may need to be sealed, and this can be made using several materials.

Cement or plastic liners can last a long time, but are very expensive. An easier way is to use a mixture of clay and animal manure or other compostable material, and cover it with cardboard. This will mimic the natural gleying process.

There are many advantages to building ponds on farms: increased water infiltration and catchment; increased available water for farming, households or livestock; the possibility of raising ducks or fish; it is beneficial to wildlife.

The following conditioning aspects should be considered:

the distance to buildings in order to guarantee that damage to foundations does not occur is generally 3.5 m, but it may be more; rainwater might be polluted by bacteria, chemicals or animal waste, requiring treatment before usage. Slow sand filtration and solar technology are available methods to reduce the pollution.

Swales

Swales can be built in almost every case as long as slopes are 5% or less, usually using a backhoe. When building a *swale* you should remember: a) They should be approximately 1m wide, between 0.5 and 1.5 m deep, and usually can have any length. b) The earth removed from the digging is generally collected on mounds that can slow erosion. These piles are also used to plant trees, increasing soil depth available for root growth.

Swales can be filled with *mulch*, pruning or wood residues to decrease evaporation and increase organic matter content. Soil fauna will decompose these materials and increase nutrient levels.

Building *swales* improves water catchment and helps prevent flooding by delaying stormwater surface runoff, and also contribute to the retention of pollutants. Nevertheless, the following conditioning aspects should be considered: a) They are not needed in wet landscapes, deep and well drained soils; b) In some cases they can even be dangerous, like steep slopes where they can cause mudslides (Falk 2013).

SHELTERBELTS AND WINDBREAKS: PRINCIPLES FOR INSTALLATION

The importance of species selection, installation and management



THE WHAT AND WHY

Tree elements for wind protection

Wind can affect crops and animals, by directly or indirectly acting on mechanical or physiological processes related to microclimate and soil. There are several tree elements that, when correctly planned, allow the reduction of these effects. At the landscape level, most of the time they are used in combination with each other to reduce wind damage. According to their structure three types of green barriers may be considered (Pavari 1961):

- 1) shelterbelts – strips of wide multiple rows of trees or shrubs;
- 2) windbreaks – afforestation with single or multiple rows of trees (up to 4 or 6 maximum);
- 3) single hedges – single linear elements for the immediate protection of crops, composed by trees, shrubs or other.

HOW IS THE CHALLENGE ADDRESSED

Species selection and installation

Choosing the right woody plants to include in shelterbelts or windbreaks requires careful and timely assessment of the ecological needs, of the structure required, the climate, soil, crops and other elements on the farm. Regardless of location or conditions, there are some vital principles that ensure success. Windbreaks and shelterbelts should:

- Provide protection from prevailing winds.
- Include a minimum of two or three rows of trees and/or shrubs, planted at spacing that meets the maintenance objectives.
- Be designed so that the width between the outside stems does not exceed the tree height.
- Be installed after guaranteeing that the site preparation ensures high rooting success and high initial growth, good soil drainage and respiration. This may be achieved through tillage, summer fallowing, subsoiling, terracing, contour planting, fertilizing, etc., according to local conditions.
- Include beating up practices (replacing dead trees after planting), as early as possible, following the year of planting.
- Be monitored to guarantee the necessary tree thinning, pruning and cutting operations.
- Be monitored to guarantee that after they reach maturity and gaps start appearing, tree replanting is carried out.

Trees		
Species	Advantages	Disadvantages
<i>Populus spp</i>	Well adapted to riparian areas	Deciduous tree, ineffective for wind protection in winter unless shrubs are combined
<i>Alnus spp e Salix spp</i>	Suitable for riparian and row afforestation Can be used in pollarding and coppice Good for secondary windbreaks together with <i>Populus spp</i>	Some species are not adapted to dry soils
<i>Platanus spp</i>	Vigorous growth Dense canopy	Deciduous tree, ineffective in winter for wind protection unless shrubs are combined Not adapted to very humid soils
<i>Robinia pseudoacacia</i>	Fast growth Dense canopy Grows well from the coppiced stump Quality wood Good for honey bees Very useful in slope areas with a tendency to erode High protein content to feed animals	Becomes invasive due to root shoots (suckering)
<i>Ulmus pumila</i>	Adapted to several types of soil Fast growth and dense canopy Used as natural trellises in vineyards	Ill adapted to low temperatures
<i>Eucalyptus spp</i>	Fast growth Well adapted to several environments	There are some current government restrictions to planting
<i>P. pinea</i> <i>P. halepensis</i> <i>P. pinaster</i>	Well adapted to Mediterranean areas Do well in shallow soils Do well with high summer temperatures	<i>P. pinaster</i> should be used in multiple rows instead of single lines
<i>P. radiata</i>	Suitable for dense rows Good income source in short rotations (15 to 20 years)	Does not adapt to arid climates
<i>Cupressus sempervirens</i>	Fast growth Root system not invasive in the first few decades Well adapted to cold climates	
<i>C. macrocarpa</i>	Very fast growth	Not adapted to low temperatures or limestone or clay soils Does not last long
<i>C. arizonia</i>	More resilient than <i>macrocarpa</i> Hybridizes easily with <i>glabra</i> and <i>lusitanica</i> , and other species, its 1 st generation hybrids are very vigorous	Sensitive to ice
<i>C. glabra</i> and <i>C. lusitanica</i>	Very fast growth	Less resilient than <i>C. arizonia</i>

Some species of trees suitable for windbreaks and shelterbelts



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Hedgerows, wind protection, hedgerow installation, hedgerow management, trees, shrubs

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HIGHLIGHTS

- Windbreaks and shelterbelts are fundamental in minimizing the unpleasant effects of wind upon crops, livestock and property.
- Their function depends on factors including height, length, thickness and density.
- In order to maximize their wind protection function, it is essential to ensure suitable species selection, good installation and management.
- Shelterbelts and windbreaks have a multitude of advantages and their disadvantages can be overcome by clever choice of crops for their adjacent areas.

Shrubs

Species	Advantages	Disadvantages
<i>Tamarix galica</i> <i>T. africana</i>	Well adapted to saline soils and salty wind	
<i>T. articulata</i>	Unlike other <i>Tamarix</i> species it is perennial It can be used in combination with vegetable gardens and orchards (due to non-invasive root system)	
<i>Casuarina spp</i>	Non-invasive root systems Fast growth	Not adapted to harsh winters Not adapted to hot climates
<i>Myosporum spp</i>	Quickly forms a dense barrier Perennial Well adapted to salty winds and the coast Well adapted to warm climates Non-invasive root systems Easily multiplied by cuttings	
<i>Ulex europaeus</i>	Quickly forms a dense barrier Perennial Well adapted to acid soils Enriches soil with nitrogen Fast growth	

Some species of shrubs suitable for windbreaks and shelterbelts.

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ADVANTAGES AND DISADVANTAGES

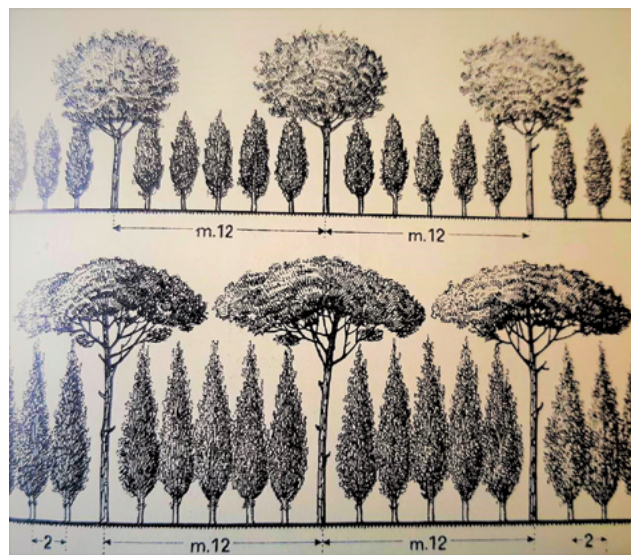
Of the presence of shelterbelts and windbreaks

Advantages

- Helps to regulate the microclimate of adjacent areas, where crops and animals are present.
- Protects crops from heavy winds (e.g. reduces the frequency of wind damage to crop leaves).
- Prevents some seeds from blowing away.
- Reduces soil erosion.
- Benefits animal husbandry (e.g. improves the quality of animal life, reduces energy losses, increases the accessibility of tree fodder).
- Enhances biodiversity, providing habitat for wildlife and shelter for beneficial insects and birds and reducing the need for pesticide use, effectively becoming an important integrated pest management tool.
- They are carbon sinks.

Disadvantages

- Improper installation and management of windbreaks or shelterbelts can have the opposite effect on crops, livestock and property, so it is essential to ensure good management and installation!
- Windbreak and shelterbelt root systems may be a problem if they became invasive, and with time and the increase of light competition, they can reduce crop yields.



Two stages on the development of an hedge with Stone pine and Cypress (distance is in meters).
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AGROFORESTRY CONTRIBUTES TO CIRCULAR BIOECONOMY

The potential of bio-based products generated in agroforestry farms



THE WHAT AND WHY

How can a farm contribute to circular bioeconomy?

Economic growth has usually been at the expense of the environment. The need to change our development to a more sustainable economic model, makes bioeconomy to be part of the solution to address some of the most eminent European and global challenges: climate change, biodiversity loss, forest fires, the ocean plastic... Furthermore generating less residues across the value chain and recycling those still produced is also key to

close the cycle and conform the circular bioeconomy.

Given that most products derived from fossil fuels can be obtained from biomass, either woody or other plant species, the opportunities for agroforestry are manifold. Agroforestry is known for the diversification of products that can be obtained in an integrative way in the same land unit, providing a great variety of raw materials that may be transformed into bio-based products.



Wool in different colors.
Sampo Luukainen



Wood chip for energy
Francisco Braga

HOW IS THE CHALLENGE ADDRESSED

Which bio-based products can be produced in agroforestry systems?

Tree and shrub products

Activities like pruning or felling produce biomass that can be used as fuel (pellets, biochar), soil amendment, compost or mulching material. Trees provide timber for construction, but also wood-based textile fibres (lyocell, ioncell). Trees like birch and maple provide sap as drink or sweetener. Juice can also be made from spruce needles. Alternative uses of cork are insulation and floors, in transport vehicles and the aerospace industry.

Livestock products

It is possible to make textile fibres from powdered milk. Other by-products from livestock are wool, used for textiles or insulation materials, bone meal as crop fertilizer, or manure as mulch, fertilizer or biofuel. Dairy whey can have several uses as lactic acid in probiotics, green solvent,

natural preservative, biostimulant and in bioplastics and personal care products.

Crop products

Many fibre rich crops are now used as a source of carbon fibre for cars, planes, tennis rackets, wind turbine blades. Maize, wheat, sugarcane, sorghum can be used to generate bioethanol and biodiesel. Agricultural by-products can be converted into biogas and biochar, they can be used to produce bioplastics for packaging, cutlery, plates, or even toys. Sugar beet pulp provides cellulose for personal care products or detergents and paints, arabinose for flavors. Cardum provides organic acids for lubricants and cosmetics, and can be used for energy and feed. Fruits and vegetables not reaching a commercial quality can be used for juices, jams or as food for snails.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: diversification; innovation; renewable material; closing production cycles; using side-products; reducing waste; non wood forest products

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HIGHLIGHTS

- Basically all items made from fossil fuels can also be made out of renewable materials.
- The European Bioeconomy Strategy answers to the challenges that Europe and the world are facing: increasing populations that must be fed, depletion of natural resources, impacts of environmental pressures and climate change.
- Farmers and agroforesters together with industry need to join forces for bio-products to become a reality.



Bioplastics made from rice.
Adobe Stock

FURTHER INFORMATION

The European Forest Institute has a leading role in developing a European Forest Bioeconomy. Watch the video 'The bioeconomy is the future'
<https://www.youtube.com/watch?v=hrFQqW45Nn0>

You may find more information at EFI's Bioeconomy Unit
<https://efi.int/bioeconomy>

The platform AllThings.Bio
provides a wide range of biobased products
<http://www.allthings.bio>

The European Bioeconomy Strategy
<http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy>

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7 MAY 2019

ADVANTAGES AND DISADVANTAGES

The pros and cons

Given that industry and producers are always evolving and adapting to new circumstances and demands, there are bio-based products constantly being prototyped, tested and released to the market.

Some bio-based products are not new and have been used in the past (paints, dyes, solvents) until the industrial revolution brought cheaper and unsustainable alternatives. The advantage of producing bio-products is that they provide added value to the farming system, thus increasing farmer profits, whilst also contributing to global sustainable economic growth and to the sustainability of the planet by reducing the environmental impact and lowering greenhouse gases emissions. Biodegradable polymers for instance, could become an everyday reality in a few years, given the existing large amounts of waste in the agri-food chain.

A major concern to develop new products can be the lack of a nearby industry to produce such bio-products and so the demand of these resources from farmers. The lack of demand for materials is the main limitation to increase the number of bio-products originated from farms and so contributing to the bioeconomy and to the farm income. Once the production of bio-products become cost-effective for the industry, they are part of our economic growth. Therefore, policy funds should be directed to the establishment of systems based on bioeconomy, and to develop the needed socio-economic infrastructure to make them profitable.



watch video

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USING OLIVE LEAVES BY-PRODUCTS IN GRAZED ORCHARDS

The benefits of olive leaves for feeding sheep



THE WHAT AND WHY

Valorization of residues for high quality sheep nutrition

Olive leaves are fibrous with a low digestibility, especially in crude protein, and they promote very poor rumen fermentation. However, if adequately supplemented, they may be successfully used in animal diets mostly fresh when the nutritive value of olive tree leaves is greater. When olive leaves are rich in oil, ruminal protozoa decrease, and this could increase the efficiency of microbial protein synthesis in the rumen. Furthermore, for lactating animals, olive tree leaves result in an improvement in

milk fat quality due to the high linolenic acid content, compared to diets based on conventional forages. Feeding olive tree leaves to ewes also has a positive effect on the fatty acid profile of cheese and therefore improves its human nutrition quality. Olive orchard grazing can offer a lot of benefits: sheep reduce costs by controlling grass and suckers growing and increasing nitrogen recycling, while the olive leaves provide high quality feed in winter when the availability of grass is reduced.



Sheep in a traditional olive orchard in Orvieto, Italy.
Claudia Consalvo



Sheep feeding on olive tree pruning residues.
Claudia Consalvo

HOW IS THE CHALLENGE ADDRESSED

A virtuous cycle made of synergies

The by-product “olive leaves” refers to a mixture of branch and leaves from both the pruning of olive trees as well as the harvesting and cleaning of olives prior to oil extraction. The production of olive leaves from pruning has been estimated to be 25 kg per olive tree.

There are different ways to include olive leaves in animal diets, varying from feeding it fresh, ensiled, dried or as a component of concentrate pellets and multi-nutrient feed blocks.

In a silvopastoral system with sheep and olive groves, it is sufficient to leave pruned residues on the ground and, after the branches have been cleaned by sheep, place them in windrows for chopping. All these operations must be done during the winter. In the spring, despite the abundance of pasture, the sheep will continue to feed on olive leaves, contributing to the control of the suckers. In autumn, when it is the time of oil extraction, it is possible to keep the olive leaves to provide cheap energy and fibre to the animal.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

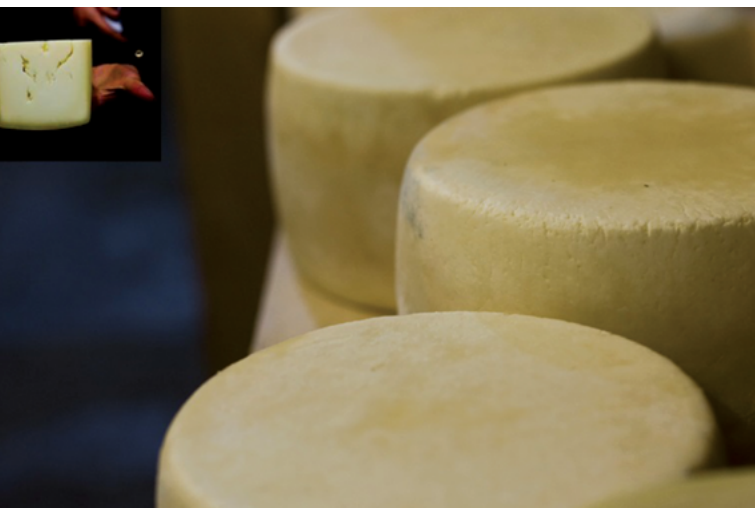
Keywords: Animal husbandry and welfare, waste, coproducts, residues management, olive tree leaves, sheep cheese, fatty acid

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HIGHLIGHTS

- Olive orchard grazing reduce treatment costs and chemical inputs.
- Sheep benefit from a good source of grass and so reduce cutting costs of weeds and olive shoots. In periods with food shortages, the olive leaves can supplement their diet reducing concentrate needs.
- In lactating sheep, feeding with olive leaves leads to an improvement in the quality of milk fat compared to diets based on conventional forages.



Traditional cheese production made by a farmer that manages a silvopastoral system with sheep in an olive orchard.
Gaetano Alfano

protect against fungal (Peacock spot) and bacterial (olive knot) infections. The copper content in olive leaves varies depending on the number of chemical treatments applied and the weather (wind, rain, etc.).

- Given that the production of olive leaves by-products is seasonal their use in animal feeding over the whole year should require adequate preservation and storage. Drying

ADVANTAGES AND DISADVANTAGES

An important feeding resource for ruminants

Olive orchard grazing can offer financial and environmental benefits. Sheep can successfully graze in orchards which have been pruned to a minimal height of 1.6 m, without noticeable losses in olive yields. On the other hand, keeping the olive orchard at that height can reduce the humidity rate in the lower part of the crown of the olive trees, avoiding Peacock spot and cercosporiosis, fungal diseases responsible for severe defoliation. It means that the farmer can reduce orchard treatment costs and chemical inputs into the environment. Harvesting is not hampered by the height of the plants as in the past because now the harvesting tools overcome this problem excellently. Therefore, in this way, the farmer can benefit from a good source of grass while, as a consequence, reducing cutting costs of weeds and olive shoots, while in the period with food shortages, the olive leaves can supplement the diet of the sheep. In lactating sheep, feeding with olive leaves leads to an improvement in the quality of milk fat compared to diets based on conventional forages. Since extra-virgin olive oil and cheese production are very common in the Mediterranean area, it is very important to consider olive leaves as a feed and not just as waste or compostable matter.

However, the valorisation of olive leaves by-products can present challenges, and the following points need consideration:

- Feeding olive leaves to ruminants could have a potential toxic effect due to treatments. It should be noted that they represent by-products obtained from crops subjected to chemical treatments such as copper, which is applied to

may preserve olive leaves but excess drying could decrease intake and nutritive value.

- Although ruminants consume olive leaves without problems of adaptation, olive leaves are fibrous with a low digestibility and crude protein, and they promote very poor rumen fermentation. The olive leave product refers to a mixture of leaves and branches, and the higher the percentage of the wooden part consumed, the slower the digestibility.

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AUGUST 2018

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NEW BIO-PRODUCTS AND INNOVATIVE VALUE CHAIN FROM OLIVE PROCESSING

Promote the bio-economy of the olive oil value chain



THE WHAT AND WHY

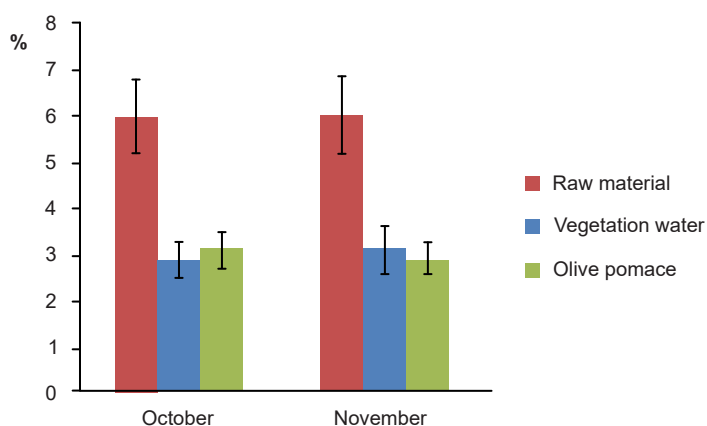
The bio-products of the olive oil value chain

Traditional olive orchards account for a large share of the area under olives in the EU, particularly in marginal areas. Traditional olive growing can survive only by improving olive farmer incomes and recognizing its multifunctional role. Italy is the second largest olive oil producer of the European Union, and Umbria can be considered as one of the most interesting regions because of the high quality production of extra virgin olive oil and a close connection with traditional knowledge and the local environment. The regional olive

oil chain involves about 30,000 farms growing olive trees covering about 27,000 ha and including 270 oil mills. The olive oil production phase comprises the extraction of the oil and additional by-products (water, pomace and husk). By-product management is very important; the olive oil mill wastes have a great impact on soil and water environments because of high phyto-toxicity (phenol, lipid and organic acids). On the other hand, such wastes may be potentially valuable.



Production of olive pâté from the re-utilization of wet pomace. The possibility to produce innovative products reduces the management of waste at oil mills
Andrea Pisanelli



Percentage of raw material, vegetation water and olive pomace compared with the quantity of olive fruits harvested during the season. The yield of olive pâté is about 3% of the olives processed at the oil mill.
Giuseppe Russo

HOW IS THE CHALLENGE ADDRESSED

Olive pâté from olive processing at oil mills

Currently often the prices of extra virgin olive oil do not guarantee an adequate income for the operators. The situation is aggravated by the fact that the processing residues resulting from the oil production (pomace and vegetation water) represent a problem for the millers in terms of disposal. With an innovation it will be possible to obtain two products of the highest quality from olives.

The production of olive pâté has been empirically tested in October-November 2017. The experimental protocol has been set up adopting the following steps:

1. Check of the integrity and quality of the olives
2. Check of the integrity and quality of the raw olive pomace extracted during the processing
3. Transport of the raw material in suitable containers (stainless steel) to the processing laboratory
4. Processing with the addition of other ingredients and sterilization or pasteurization
5. Packaging of the final product (olive pâté)

The olive pâté production is estimated to be about 6% of the weight of the processed olives (about 50% constituted by water).



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Bio-economy, olives, residues, bio-products

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HIGHLIGHTS

- Currently often the prices of extra virgin olive oil do not guarantee an adequate income for the operators.
- The processing residues resulting from the oil production represent a problem for the millers in terms of disposal.
- The olive pâté production is an example of a possible innovative value chain that could be implemented using bio-residues.



Bio-residues from the olive processing can be used also to produce bio-materials
Cecilia Cecchini

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ADVANTAGES AND DISADVANTAGES

Olive can provide many valuable products, but...

Olive mill wastes can be considered as resources to be recovered. Olive pâté production is an example of a possible innovative value chain that could be implemented using bio-residues. However, its promotion depends on market demand and implementation of specific legislative roles.

In our experiment the olive pâté yield can be integrated with the extra-virgin olive oil production, guaranteeing an alternative source of income at the oil mills. However, the commercialization of such product, since it is destined for human consumption, requires the respect of appropriate regulations and the implementation of specific technical skills at the oil mills. The relevant legislation is the Legislative Decree 3 April 2006, n. 152 "Environmental regulations", published in the Official Gazette no. 88 of April 14th 2006 - Ordinary Supplement n. 96, on waste management.

Additional uses of bio-residues from the olive process that can give a surplus of income are:

- Olive husk used to produce bioenergy;
- Olive pomace used to produce biogas;
- Residues also used to produce bio-materials.

Countries must have strong governmental policies regarding olive mill wastes, taking into account the economic role of this sector at small villages in remote areas and at large premises at the same time. This requires an integrated approach in the waste management operations of the olive sector, with provisions made for the farmers, industries, energy, water resources, and regulatory bodies.

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JULY 2018

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MANAGING THE TREE ROW UNDERSTOREY IN AGROFORESTRY SYSTEMS

A range of possibilities



THE WHAT AND WHY

The tree understorey – challenges and opportunities

In a silvoarable agroforestry field, there is always a certain area under the tree canopies (e.g. strips of land under the tree rows in alley cropping systems), where it is difficult to cultivate the main crop. We call that the tree row understorey here. However, these areas can have several important functions: (i) tree protection against possible damage through e.g. agricultural vehicles, (ii) giving access to the tree row for tree maintenance or fruit harvest, (iii) a range of ecological aspects like habitat function and food provision for beneficial biodiversity. The tree row understorey

can also be part of the AF production system itself, although the management of this area seems often to be a challenge where following questions need to be addressed:

- (i) What is the optimal width of the tree row understorey?
- (ii) What is the best way to manage this area?

Managing the tree row understorey in silvoarable practices can be done in many ways, and will depend on the main objective of the trees, the type of understorey vegetation, the available machinery and the amount of time one can or wants to spend.



Sowing a mixture of green manures is one option to manage the tree understorey. Furthermore, hazelnut shrubs are planted in between the trees.
Bert Reubens - Consortium Agroforestry Vlaanderen



Short rotation coppice (hazelnut) at an agroforestry field at Wakelyns farm.
Victoria Nelissen - Consortium Agroforestry Vlaanderen

HOW IS THE CHALLENGE ADDRESSED

A range of possibilities for managing the tree understorey

There is a range of possibilities for managing the tree row understorey:

- Controlling the understorey vegetation through mowing.
- Keeping a strip with bare soil under the tree canopy.
- Controlling grasses and weeds through the use of mulch materials.
- Sowing a cover crop or a flower mixture.
- The tree row understorey could also be cultivated with short rotation coppice, berries or hazelnut shrubs, or through the introduction of alternative crops like herbs, flowers, or perennial crops.

Generally, a width of at least 2 m is recommended (1 m on each side of the trees). However, if you want to manage the strip mechanically, a width of 2 m on each side of the trees is better. The width can be adjusted as the trees grow older; but reducing the width by e.g. ploughing half a meter closer to the trees after 5 years would damage tree roots with negative future consequences for tree growth and health. Conversely, it is advisable to broaden the strip after a couple of years, for instance to harvest fruit more easily.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Biodiversity; productivity; efficiency; alley cropping; silvoarable

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HIGHLIGHTS

- Managing the tree understorey is a function of the main objective of the trees, type of understorey vegetation, available machinery and the amount of time one can spend.
- Possibilities are mowing, keeping the area free from vegetation, the use of mulch materials, sowing a mixture of green manures, or introducing short rotation coppice, berries, etc.
- Generally, a width of at least 2m is recommended.



Keeping the area under the walnut trees free from any vegetation, in order to facilitate nut harvest and other activities such as fertilizing the trees.
Bert Reubens - Consortium Agroforestry Vlaanderen

FURTHER INFORMATION

More information (in Dutch) on the management of the tree understorey in agroforestry systems can be found at <https://www.agroforestryvlaanderen.be/NL/Kennisloket/Praktischeaanpak/Beheer/beheerboomstrook/tabid/9437/language/nl-BE/Default.aspx>

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Content editor: Maria Rosa Mosquera-Losada (USC)
31 OCTOBER 2018

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ADVANTAGES AND DISADVANTAGES

Evaluate the feasibility of each option

Leaving the tree row understorey undisturbed can result in the development of undesirable plants, which can then be spread throughout the field in arable lands. Furthermore, uncontrolled growth of grasses and herbs can reduce tree growth. Controlling the understorey vegetation through mowing before seed production can reduce the spread of weeds in the field. However, farmers need to be careful to avoid tree damage, and weeds that are spread through rhizomes won't be controlled sufficiently.

Keeping the strip under the tree canopy free from any vegetation could be advantageous for fruit or nut harvest, and facilitates other activities such as fertilizing the trees.

Another option is to control the grass and herbs in the understorey vegetation through the use of mulch materials. Many materials are available: wood chips, coconut/hemp/miscanthus fibre, cacao shells, bioplastics, geotextile, etc. Each type of material has its own (dis)advantages, but the use of these kind of materials is often expensive, limited in lifespan and rather labour intensive but it increases soil organic matter and fertility and maintains temperature and humidity for the tree growth if placed around the tree. Furthermore, the additional ecological advantages of an understorey vegetation, such as the creation of food and a habitat for beneficial biodiversity (pollination and natural pest control) and other animals, will be missing at short term.

In order to suppress weed growth and to create a habitat for beneficial biodiversity, a mixture of cover crops (grass species and leguminous plants) could be sown. This will also force tree roots to grow below the root zone of the crop and be better anchored, due to the competition for water in the top layer of the soil. In this way, it is expected that there is less competition between the crop and the trees for water in the future.

A flower strip will function as food source for insects, which will increase beneficial biodiversity. However, practical experience shows that it is not easy to install and to manage a flower strip in a tree row, and that it is inevitable that undesirable grasses will become dominant after a few years.

The tree row understorey could also be part of the production system itself through the cultivation of short rotation coppice, berries or hazelnut shrubs, or through the cultivation of alternative crops as herbs, flowers, or perennial crops like artichoke, rhubarb, mushrooms, etc.

ALLEY CROPPING DIVERSIFIES YOUR FARM AND IMPROVES THE ENVIRONMENT

Which species can be used in Finland?



THE WHAT AND WHY

Opportunities for agroforestry in Finland

Alley cropping, or planting woody perennials rows in arable or vegetable fields, is an innovative idea worthy of exploration by farmers seeking both an additional long term income, rather than income based solely on annual production, and to increase the environmental resilience of their system.

It is advisable that the trees and shrubs planted should have some of the following characteristics: i) produce a product or multiple products (e.g., timber, nuts) with an acceptable local market, ii) have deep roots to reduce competition with the crops, iii) do not produce allelochemicals or acid foliage that would prevent some crops growing under them.

Companion crops, planted in the alleys between the tree rows, may be: 1) cereal and forage crops; 2) fruits, berries, ornamental or aromatic/medicinal plants; or 3) biomass producing crops.

In the initial stages, the growing environment in the alley will be favorable to row crops requiring full sun. As trees grow, they will increase shade, water and nutrient competition and humidity levels, decreased temperatures and wind, so shade tolerant species will be more suitable then.

The management of trees includes weed control, pruning and thinning.



Alley cropping system on contour lines with apple trees, cherries, pears and plums together with comfrey and aronia in southern Finland
Iiris Mattila



Blossoming apple tree
Iiris Mattila

HOW IS THE CHALLENGE ADDRESSED

Which species are suitable?

Trees recommended for alley cropping are those providing fine hardwood timber or edible nuts, but also other added-value products, like syrups or medicines:

- Alder or birch for furniture, firewood and syrup
- European ash and black walnut for high value timber
- Norway maple, wych elm and European oak for timber and furniture
- Aspen for timber, biomass, firewood and purification of contaminated soils
- Poplars, willow, maple or birch as coppice biomass crops.
- Apple or pear for cider production
- Plum and cherry for high value fruit

Alley crops that can be grown are fruit bearing shrubs, regular

and forage crops, ornamental and medicinal crops, or even coppice biomass crops:

- Regular crops include wheat, rye, oats, peas, pumpkins, etc.
- Forage crops such as meadow fescue, ryegrass or alfalfa for hay production or willow for livestock feed.
- Ornamental woody plants like Christmas trees, dogwood, curly willow, curly birch.
- Medicinal crops like St John's-wort, elderberry, willow.
- High value fruits or superfoods for example, blueberries, strawberry, raspberry, cranberry, currant, saskatoon, sea buckthorn, chokeberry, gooseberries, currants and American hazel.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

productivity; combinations; diversification;
tree rows; crops

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HIGHLIGHTS

- Alley cropping helps preventing erosion, especially when trees are planted as contour lines
- Alley cropping reduces run-off, improving the quality of surface water
- Tree roots and fallen leaves improve soil organic matter, reducing soil compaction and increasing soil carbon storage
- Alley cropping leads to increases in biodiversity and overall productivity.
- Trees provide additional farm income in the long run.



Strips of willow as windbreak
Iiris Mattila

have never been tried in Finland and therefore it is hard to find external advice. The success of these systems should be based on trial and error and common sense. Therefore, it is advisable to start any new alley cropping project on a small area to test it works before expanding to a larger area.

When planting shallow-rooted trees or shrubs (e.g. willow) make sure that the new plantings are at a safe distance (>15 meters) of drainage pipes or tile drains as the pipes can

FURTHER INFORMATION

The Center for Agroforestry at the University of Missouri, established in 1998, is one of the world's leading centers contributing to the science underlying agroforestry http://www.centerforagroforestry.org/pubs/training/chap3_2015.pdf

The USDA elaborates very practical and friendly factsheets on agroforestry <https://www.fs.usda.gov/nac/documents/agroforestrynotes/an12ac01.pdf>

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ADVANTAGES AND DISADVANTAGES

Testing what has not been tried before

Advantages

Integrating crops and trees leads to a diversification of the farm products, thus minimizing risks due to climatic events or to uncertain markets. At the same time it increases the resilience of the system and biodiversity.

Planting trees as contour lines on erosion-prone slopes can markedly reduce soil-erosion and leaching of excess nutrients which will improve soil conservation and the quality of the surface water in the surrounding area.

Fine tree roots and fallen leaves improve the soil organic matter content thereby improving soil nutrient levels and nutrient availability for the crops. A higher soil organic matter content also increases soil microbial activity, which leads to a faster nutrient turnover and reduces soil compaction. Trees and strips of natural vegetation provide a suitable habitat for pollinators and natural enemies improving crop production and reducing the need for use of pesticides.

Agroforestry practices can store more carbon compared to conventional agriculture, which helps to mitigate greenhouse gas emissions. The extra carbon is stored in the trees, in the tree roots and in the soil.

More diverse production (fruits, crops, nuts, timber) can generate some extra farm income throughout the year.

Bear in mind

An alley cropping system is more complex to manage than a mono-cropping system and its management can present some challenges.

Agroforestry generally requires more work and knowledge than a mono-cropping system. Most of these alley cropping systems

easily be blocked by shallow tree roots under wet conditions.

In northern Europe, light is a limiting factor for crop growth, however agroforestry is possible at northern latitudes with low tree density and sufficient distance between the tree rows. North-South orientation of tree lines is better at high latitudes to reduce light competition. As the trees grow, shade will increase. Thus the understorey crops might need to change over time to adapt to the new conditions.

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4 JUNE 2018

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BROWSE, PRESERVED TREE FODDER AND NUTRITION

How offering access to browse and feeding tree fodder can supplement the diet of domestic animals



THE WHAT AND WHY

Why offer animals access to browse or tree fodder?

In general, browse (i.e. fresh tree leaves and small branches) and tree fodder (preserved browse) are good sources of nutrition and compare favourably with grasses grown in the same environment. Trees are also a good source of micronutrients including vitamins and particularly minerals. Where animals have access to trees or hedgerows, they will readily browse indicating its attractiveness as a feed. Browse can range from 12-55 %, 20-76 % and 60-93 % for cattle, sheep and goats

respectively. Goats tolerate high levels of browse in the diet due to their saliva that can bind tannins and a large liver that effectively processes tannins. Although the gastrointestinal tract of cattle is well adapted to a grass diet, it does not inhibit efficient digestion of browse. Browse is accessible up to a height of 2 m for cattle and 1.2 m for sheep. Goats are termed vertical browsers, having no meaningful browse height, given their physical agility.



Trees with a clear browse line from cattle in 2017 Stonehenge, UK.
L. Whistance



Hereford cattle browsing in a mixed-species hedgerow in 2014, Hereford, UK
L. Whistance

HOW IS THE CHALLENGE ADDRESSED

The benefits of feeding browse and tree fodder

Sourcing good protein for animal feed is a global issue. Crude and degradable protein levels in tree leaves, particularly in ash, lime and mulberry, compare well with levels found in alfalfa and ryegrass. Additionally, although condensed tannins in browse inhibit normal digestion of protein in the rumen, the stomach enzymes binding the proteins are themselves broken down in the abomasum, effectively delivering a good-quality rumen

bypass protein to the small intestine. Mineral content in browse can also be high. Zinc plays a role in important biological functions and promotes the efficient metabolism of protein and carbohydrates. Selenium deficiency is common in natural grazing systems. Selenium and zinc are abundant in willow. Browse can also be an important source of vitamin E, particularly in dry conditions.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Tree fodder; Browse; Protein; Minerals; Selective feeding; Learning; Silvopastoral systems.

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HIGHLIGHTS

- Browse and tree fodder are good sources of protein, vitamins and minerals.
- Browse and tree fodder are readily eaten by farm animals.
- Silvopasture is more productive than open pasture
- Animals with nutritional deficiencies can seek out appropriate feed sources in a diverse environment.



Ewe browsing on hawthorn (*Crataegus monogyna*) in 2009, Hald Ege, Denmark.
L. Whistance

The content of some minerals is higher in tree fodder than fresh browse, increasing its value as a sustainable source of minerals. Nevertheless, controlling intake is important as excess minerals can be toxic particularly for susceptible breeds.

Browse/tree fodder systems require sufficient yields for all animals to have access. For browsing, controlled defoliation (up to 50%) and sufficient time (around eight

ADVANTAGES AND DISADVANTAGES

Diverse systems promote self-regulation in diet and intake

Overall, silvopasture produces more forage per unit area than pasture alone. With a varied diet, animals tend to eat more of everything, where more palatable plants act as a buffer. Browse can be highly palatable and summer growth offers a good additional feed source to pasture as well as being preserved as tree fodder for winter to feed animals. Preserving tree fodder by drying or ensiling increases palatability by reducing the bitter taste of tannins.

Through the presence of condensed tannins, good quality protein is available as rumen-bypass protein. Additional protein promotes 1) growth of juveniles, 2) production including improved wool quality, 3) reproduction including improved fertility, and 4) health including an increased resilience to intestinal parasites. However, although condensed tannins at 1-4 % of dry matter intake can be of benefit, beyond 5% it can cause digestibility problems. Animals are considered capable of self-regulating intake, but this is only possible with a diversity of feed sources so that they can avoid excessive intake of single species.

Animals are sensitive to nutrient deficiencies and can seek them out if a defining property (taste or smell) enables learning to occur. The relationship between taste and ingestive processes can alter the palatability of a feed so for animals, suffering from a deficiency, the importance of taste diminishes in favour of other components.

weeks) for regrowth is needed as hard browsing can reduce a tree's ability to regrow. The more palatable a species is, the harder it will be browsed. Establishing silvopasture is a long-term investment and browsing is not recommended until trees are three years old. To function well, silvopastoral systems need to be well-designed and well-managed. The quality of management of both plants and animals is key to success.

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APRIL 2018

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TREES FOR SHADE, SHELTER, SURVIVAL AND BODY MAINTENANCE

How offering access to trees can improve the welfare of domestic animals



THE WHAT AND WHY

Why offer animals access to trees?

The benefits of silvopasture to domestic animals include access to shelter in the winter and shade in the summer, as well as providing scratching posts to maintain coat condition. The behaviour of domestic animals can be grouped into the categories of locomotion, maternal, nutritional, reproductive, social and resting behaviours and access to trees can be of some benefit to them all. Much of an animal's daily behaviour is involved in maintaining balance, or homeostasis, for example, when an

animal is hungry it will seek and eat food. Similarly, when hot or cold, it seeks shade or shelter and trees, shrubs and shelterbelts can offer effective protection. Coat condition is important in maintaining animal health and tree trunks and branches are readily used as scratching posts. The newborn offspring of farm animals are either hiders (e.g., cattle) or followers (e.g., sheep) but mothers of all species, seek out available shelter when giving birth.



Sheep using low hanging branches as a scratching post in 2010, Dollerup, Denmark
L. Whistance



Evergreen plantation: a living barn providing shade and shelter for dairy cattle, 2011 in Over Viskum, Denmark
L. Whistance

HOW IS THE CHALLENGE ADDRESSED

Placing and managing trees for the benefit of animals

Trees can be included in an animal's grazing environment in many ways. Trees offer a canopy that provides shade in the summer and, globally, this is their most important role. A canopy also provides shelter from rain and cold, acting as a buffer for temperature fluctuations, and minimum grass temperatures can be raised by 6 °C. Trees with an alternative primary function can offer good shade and shelter, including biofuel plantations for pigs and commercial pine for living barns. The latter also

offers protection against insects, since pine species have insect repellent properties. The positioning of trees is important in their effectiveness as protection against the weather. Shelterbelts offer good protection when perpendicular to the prevailing wind and porous shelterbelts slow down wind, offering better shelter than dense barriers that cause high levels of turbulence. Access to tree trunks and low branches enable animals to use them as scratching posts.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Shade, Shelter, Grooming, Behaviour, Homeostasis, Silvopastoral systems, Survival

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HIGHLIGHTS

- Shade and shelter are important for good animal welfare.
- In hot weather, normal animal behaviour patterns are less disrupted in silvopasture than on open pasture.
- Good shelter promotes the bonding of mother and offspring and increases the survival rate of newborn animals.
- Coat condition is improved and risk of disease from external parasites is reduced with access to trees as rubbing posts.



Ewes and their lambs sheltered by trees in 2009, Hald Ege, Denmark
L. Whistance

Cattle and deer are 'hider' species and mothers utilise trees and shrubs to hide their offspring for several days after birth. Even 'follower' species, like sheep, benefit from access to shelter at lambing time. Exposure and starvation together cause 30% of lamb deaths and lambs can lose as much as 10 °C body heat in the first 30 minutes of life so they are highly reliant upon shelter from the environment.

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APRIL 2018

ADVANTAGES AND DISADVANTAGES

Understanding animal behaviour and tree management

Grooming helps to maintain coat condition and trees make good scratching posts. Moulting hair and fleece can be removed by rubbing against trees, along with seeds that can penetrate the skin and external parasites (e.g., ticks) can be dislodged, reducing risks of associated diseases. Additionally, excessive rubbing can alert carers to flystrike or mite infestations. Good access to different heights and angles including low-hanging branches allows animals to access most body parts however, appropriate positioning of such trees is important since they can make pasture more difficult to manage.

Shade from a well designed silvopasture can reduce solar radiation by 58% compared to open pasture and skin temperature of cattle can be 4 °C lower. Along with higher welfare, animal productivity is better maintained when they have access to shade in hot weather and the landscape is utilised more evenly than open pasture. With too little shade there is a risk of overcrowding and disease, parasite contamination, death of vegetation and soil compaction.

Cold winds negatively effect air temperature. For example, with a windspeed of 24 kph, and an air temperature of 2 °C, the effective temperature becomes -7 °C. Trees act as a buffer against temperature fluctuations reducing the need to feed animals extra energy for heat production. Shelterbelts, perpendicular to the prevailing wind, offer good shelter if well designed. Planted too densely, they can increase wind turbulence and if they are open at ground level, they can cause driving cold winds at animal resting level.

Offering ewes shelter close to feed and water encourages them to stay longer at a sheltered birth site promoting a strong ewe-lamb bond and increasing lamb survival. Since energy intake is directed towards growth rather than keeping warm, lambs with shelter have a higher growth rate than lambs with no shelter. Overcrowding of ewes at lambing time reduces lamb survival from mis-mothering, starvation and exposure.

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PRODUCTIVE USE OF THE TREE ROW UNDERSTOREY

Opportunities for crop diversification



THE WHAT AND WHY

The tree understorey – a waste of space?

Planting trees into arable or vegetable fields means that land is taken out of annual production; depending on the design of the system, this could be up to 25% of the cropping area. There may be no return from the trees for many years after planting; this varies from approximately five years for fruiting species or short rotation coppice systems, to several decades for timber species. In many agroforestry systems, the area in the tree rows between the



watch video



Wakelyns Agroforestry, Suffolk UK; an aerial view shows how 25% of the land area is occupied by the tree rows. Permaculture Association, UK

trees trunks and under the tree canopy is an overlooked and underutilised space and, unmanaged, this can create problems with weed control. Rather than being viewed as a wasted space, this tree row area could provide new opportunities for introducing new crops, therefore increasing production and diversifying the range of marketable products from the farm.

Rhubarb as an understorey crop at Tolhurst Organics, UK. Organic Research Centre



watch video



HOW IS THE CHALLENGE ADDRESSED

Herbs, flowers, fruit, vegetables..... take your pick!

One option to use the understory of the tree row is to plant new crops to provide an income in the years following tree establishment, or longer term if shade tolerant species are used. Ideally, the new crop will complement what is already produced (e.g. new lines of fruit or vegetables in a horticultural enterprise) but new markets may need to be sought or interest generated for the new crop within existing markets; some creativity may be needed (e.g. direct selling or adding value to

produce by making jam). New crops that could be established underneath the trees include herbs, flowering bulbs or cut flowers, perennial fruit and vegetables such as globe artichokes or rhubarb, mushrooms and berry bushes. Within the different crop types, some species and varieties will be better suited to the conditions found in tree rows (particularly levels of tolerance to shade) and it may be worth trialling varieties or species on a small scale first to identify those best suited, before scaling up.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Diversification; silvoarable; eurafagroforestry.eu/afinet tree row; crops; understory



HIGHLIGHTS

- Establishing understorey crops can provide income in the short term before the trees reach a productive stage.
- Understorey crops can help repay tree planting costs within two to three years, if a market can be found for the new crops.
- Introducing new crops to the system diversifies the range of marketable products as well as increases overall productivity.



watch video

Spring bulbs for bunches of cut flowers.
Silvoarable system in Nottinghamshire,
UK. Ref: Organic Research Centre

FURTHER INFORMATION

The Agroforestry Research Trust (www.agroforestry.co.uk) has produced some beautiful and useful publications that cover a range of potential understorey crops.

Crawford, M. (2010) Creating a Forest Garden describes the design process and suggests a number of temperate species that could be considered for the tree understorey, as well as on-going maintenance requirements. Green Books ISBN 978-1-900322-62-1.

Plants for a Future (www.pfaf.org) is an on-line database of over 7000 edible and medicinal plants which allows you to search using a number of criteria e.g. a plant for sandy soils, between 1 and 5m tall, that likes shade.

Smith et al (2017) Lessons learnt: Silvoarable agroforestry in the UK. Report on new silvoarable system including opportunities for including understorey crops.

http://www.agforward.eu/index.php/en/silvoarable-agroforestry-in-the-uk.html?file=files/agforward/documents/LessonsLearnt/WP4_UK_Silvoarable_2_lessons_learnt.pdf

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March 2018

ADVANTAGES AND DISADVANTAGES

Increasing complexity; the pros and cons.....

As well as increasing overall productivity, integrating new understorey crops can diversify the range of marketable products from the farm. The new crops may also benefit biodiversity such as bees and butterflies by providing new habitats and resources. However, this increase in complexity can also present challenges, and the following points need consideration:

Be realistic about the extra resources needed.....

The initial establishment costs need to be considered, as well as the extra labour requirements for planting new crops. Looking forward, what extra infrastructure is needed for the new crop product? For example, extra storage space, or processing equipment. What are the labour requirements for on-going maintenance and harvesting? Ideally, choose crops that can be harvested and managed during quieter periods of the year.

Is there enough space under the trees for new crops to succeed?

In some tree systems, such as short rotation coppice, or high density fruit trees, the competition for resources such as sunlight, water and nutrients from the trees may be too strong to allow any understorey crops. Bear in mind that as the trees grow, the microclimate conditions will change, with shade and belowground competition increasing. This may mean that the understorey crops will need to change over time also, or eventually be out-competed.



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AGROFORESTRY AND AGRICULTURAL POLICY DEFINITIONS

Defining agroforestry and agroforestry practices in temperate areas

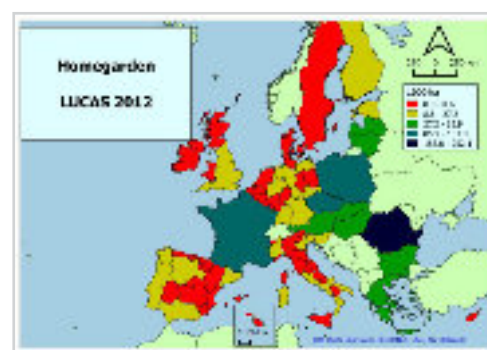
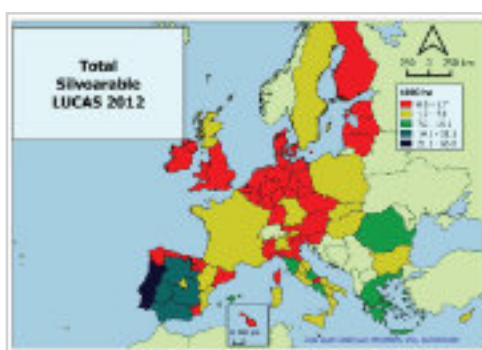
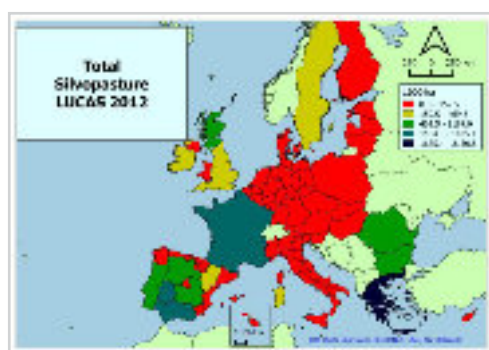


THE WHAT AND WHY

Agroforestry: a sustainable land use practice and system

Agroforestry has been recognized by international organisms (FAO, UN, EU) as a sustainable land management system, that is not extensively used in temperate areas. One of the main reasons for this fact is the lack of knowledge of agroforestry by different types of stakeholders such as policy makers, farmers and general public. Having a clear definition of agroforestry and the practices that it involves will help farming systems to move into the Climate Smart Agriculture objectives including

increasing farm income and productivity, adaptation and resilience, and mitigation to climate change. Identifying agroforestry practices should be targeting main land uses to help farmers to adopt this sustainable land use system. Five agroforestry practices can be identified in Europe: silvoarable, silvopasture, riparian buffer strips, forest farming, and homegardens that are able to be introduced in more than 90% of the European Agricultural area.



Extent of silvopasture, silvoarable and homegardens in Europe and share among different practices.

Multipurpose is referred to fruit trees included in the permanent crops definitions of the CAP.

Santiago-Freijanes JJ, Mosquera-Losada M

HOW IS THE CHALLENGE ADDRESSED

Improving AF knowledge

Agroforestry EU definition should consider the current definitions given by different international and national organisms to make agroforestry accountability standardized and to facilitate statistics about the country extension but also about the ecosystem services they provide for payments. Two main agroforestry practices are subjacent to the rest "silvoarable" and "silvopasture". The enormous potential of agroforestry to depurate waters identifies Riparian buffer Strips as the way to include woody perennials to protect water bodies from agricultural activities (i.e. fertilization). The extended division between forest and agricultural land use justifies the "forest farming", an agroforestry practice exclusively linked to forest areas. Homegardens are associated to urban areas.

Agroforestry practices in Europe 1) Silvopasture 2) Silvoarable 3) Riparian Buffer Strips 4) Forest farming and 5) Homegardens
Santiago-Freijanes JJ, Mosquera-Losada MR

Agroforestry practice		Description
Silvopasture		Combining woody with forage and animal production. It comprises forest or woodland grazing and pastoral land with hedgerows, isolated/scattered trees or trees in lines or belts
Homegardens or kitchen gardens		Combining trees/shrubs with vegetable production in urban areas, also known as part of "trees outside the forest"
Riparian buffer strips		Strips of perennial vegetation (trees/shrubs) natural or planted between croplands/pastures and water sources such as streams, lakes, wetlands, and ponds to protect water quality. They can be combined with arable lands (silvoarable) or grasslands (silvopasture) but are signified by its role in preserving water streams
Silvoarable		Widely spaced woody vegetation inter-cropped with annual or perennial crops. Also known as alley cropping. Trees/shrubs can be distributed following an alley cropping, isolated/scattered trees, hedges and line belts design
Forest farming		Forested areas used for production or harvest of natural standing speciality crops for medicinal, ornamental or culinary uses, including those integrating forest and agricultural lands



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

HIGHLIGHTS

Agroforestry is a farming system that fits in the Climate Smart Agriculture concept and a type of land use able to be developed in agricultural lands such as arable lands (silvoarable), permanent grasslands (silvopasture) and permanent crops (silvoarable/silvopasture) in forest lands (silvopasture and forest farming) and in urban areas (homegardens).



Agroforestry provides good forage resources with different tree species
Santiago-Freijanes JJ, Mosquera-Losada MR

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ADVANTAGES AND DISADVANTAGES

Defining agroforestry

Agroforestry can be defined as the deliberate integration of woody vegetation (trees and/or shrubs) as an upper storey on land, with pasture (consumed by animals) or an agricultural crop in the lower storey. The woody species can be evenly or unevenly distributed or occur on the border of plots. The woody species can deliver forestry or agricultural products or other ecosystem services (i.e. provisioning, regulating or cultural). Agroforestry can take place at a range of scales (e.g. plot, farm and landscape). At farm and landscape scale it can be implemented in systems that are able to diversify production (e.g. food, forage, timber and fuelwood) and provide ecosystem services (e.g. soil restoration, water preservation, climate regulation, and biodiversity enhancement), thus increasing both resilience and profitability. Silvoarable is the integration of widely spaced woody vegetation inter-cropped with annual or perennial crops. Also known as alley cropping. Silvopasture is the combination of woody perennials with forage and animal production. Forest farming is a forested area used for harvesting of natural standing speciality crops for medicinal, ornamental or culinary uses. Riparian buffer strips are strips of perennial vegetation (trees/shrubs) natural or planted between croplands/ pastures and water sources such as streams, lakes, wetlands, and ponds to protect water quality. They can be recognized as silvoarable or silvopasture but are signified by its role in preserving water streams. Homegardens are the combination of trees/shrubs with vegetable production in periurban and urban areas, also known as part of “trees outside the forest”. Agroforestry practices can be implemented in Agricultural lands as silvopasture, silvoarable and riparian buffer strips, in forest lands as silvopasture and forest farming and in urban areas as homegardens. Agroforestry increases biomass production as a result of the enhancement of the use of the sun radiation (agroforestry provides a higher amount of leaves per hectare) and nutrients from soil, while associated to a higher environment and market resilience of the farm. From an environmental point of view, it is able to increase biodiversity which is the basis of the sustainability of farming systems providing a better nutrient resource and therefore improving the quality of water bodies, and mitigating climate change through the increased soil carbon sequestration. All these benefits are aligned with a better development of rural areas linked to social aspects such as a higher employment generation, increasing tourism...

ROSA MOSQUERA MR, SANTIAGO-FREIJANES JJ, FERNANDEZ-LORENZO JL, SILVA-LOSADA P, FERREIRO-DOMÍNGUEZ N, RODRIGUEZ-RIGUEIRO FJ, GONZÁLEZ-HERNÁNDEZ MP, VILLADA-PILLADO A, RIGUEIRO-RODRÍGUEZ A
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1 OCTOBER 2018

Keywords: Silvoarable; silvopasture; homegardens; forest farming; riparian buffer strips



IMPORTANCE OF BROWSING ON SHRUBS

Opportunities for animal nutrition and conservation of shrublands silvopasture systems



THE WHAT AND WHY

Browsing shrubs as a food resource and management tool

European heathlands are usually linked to land use practices as cutting, burning and grazing, and are supported by the EU within the high nature value farming framework. Nonetheless, the rural depopulation and abandonment of management practices contribute to large accumulations of highly flammable phytomass in heathlands and other shrublands of the Atlantic area of EU, thus being more susceptible to wildfires.

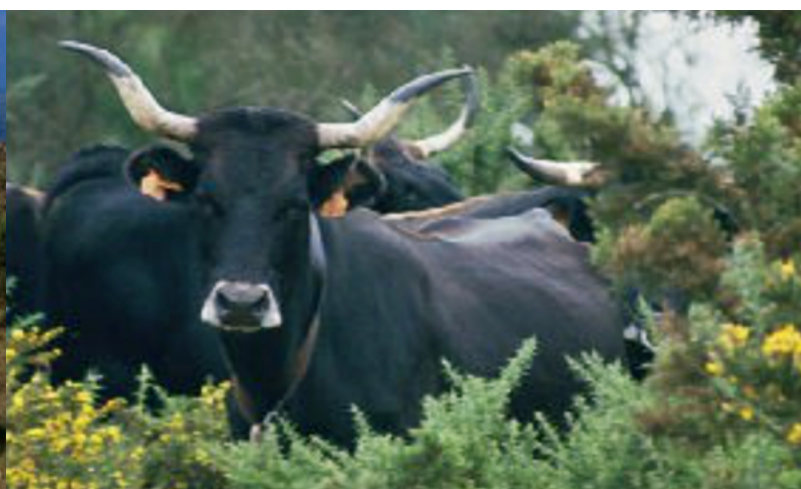
Grazing by livestock can improve rural sustainability while controlling the accumulation of flammable woody

vegetation. It can also be a sustainable management tool for shaping and maintaining semi-natural habitats, and promoting greater biodiversity and multifunctionality.

There is a social demand of organic products, which includes meat obtained from free-range livestock management. Rustic local breeds can benefit from browsing on different shrubs that not only cover their austere nutritional needs, but also provide with natural antibiotics compatible for an organically grown animal production.



Local breed Cachena, a rustic traditional cattle located in areas bordering the National Park Xurés/Peneda-Geres.
<http://www.verinbiocoop.com/cachena>



Native and rustic Caldela from NW Spain, registered as one of the various European endangered cattle breeds.
<http://www.verinbiocoop.com/caldela>

HOW IS THE CHALLENGE ADDRESSED

The chance for traditional rustic animal breeds

European local cattle breeds (e.g. Vianesa, Frieiresa, Cachena, Maronesa or Arouquesa, in NW Spain and Portugal) are recognized by their important environmental, social, cultural, market and public values, and have the protected geographical status from the European Commission. Over the past decades, its population has suffered a drastic decline and there is great interest in their recovery. These traditional breeds are very rustic and their nutritional requirements, frequently expressed

as protein and energy needs, are easier to manage. They are adapted to browse on plants considered of "limited" nutritional value (heaths, gorse and hard grasses). Free ranging horses are also compatible with heathland conservation management, maintaining biodiversity values and animal production in Europe. They can effectively reduce gorse biomass (*Ulex*), a leguminose shrub that they prefer instead of heaths.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

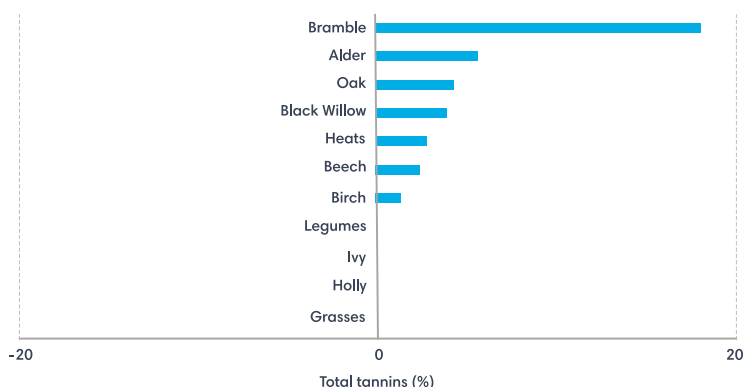
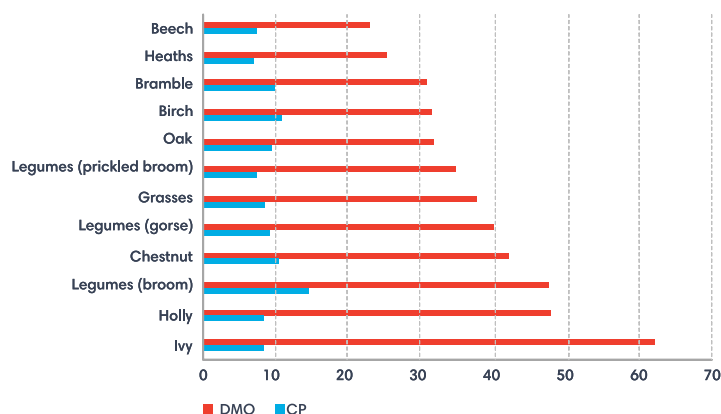
Keywords: Browsing, extensive livestock production, Atlantic heathlands, heaths, woody legumes

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HIGHLIGHTS

Rustic local breeds benefit from browsing on shrubs that cover their austere nutritional needs and provide natural antibiotics compatible with an organically grown animal production. Moderate levels of tannins in heaths can be beneficial. Optimum to moderate protein content in woody legumes can be an important protein resource. Digestibility of shrubs is in the moderate-to-low side, but compatible with rustic breeds that can act as efficient management tools to reduce combustible phytomass and prevent fire risk.



Percentages of digestibility (DMO), crude protein (CP), and tannins in some woody plants. Values correspond to apical portions no longer than 15 cm and less than 1 cm in twig diameter, or leaves. González-Hernández, MP

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The European Bioeconomy Strategy
<http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy>

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ADVANTAGES AND DISADVANTAGES

Nutritional attributes of shrubs; their pros and cons.....

Nutritional requirements for extensive livestock are often expressed as protein and energy needs. Coarsely, optimum of crude protein in diets is established around 9% (6% for maintenance and up to 12% to meet livestock needs in lactation stages). Digestibility of feed intake is desirable to reach 45% (digestibility of organic matter). Based on these minimum values, a mix of different shrubs and seasonal forbs and grasses can meet nutritional requirements for rustic cattle and free-range horses (see figure). On the other hand, the presence of tannins, frequently in shrubs, can induce beneficial effects, especially in ruminants. They are complex cocktails that can prevent gastrointestinal parasites, and have higher difficulty to develop resistance compare to synthetic antibiotics. This can become an inexpensive alternative with potential in organic farming. Their also antioxidant properties help with reducing fat oxidation and therefore preventing rancid flavor in meat. The insoluble tannin-protein complexes in the digestive tract reduce methane production (consequently also pollution) in livestock with diets rich in legumes. Low to moderate levels of tannins led to higher retention of nitrogen in sheep and cattle, resulting in higher growth rates and milk yield, and acting as preventive on bloat.

Conversely, tannins may perform as nutritional constraints causing toxicity, acting as deterrents because of their bitterness, or negatively interfere in digestion or absorption of proteins. Browsers used to rich tannins diets have adaptive mechanisms to neutralize those effects, whereas grazers that prefer herbaceous plants with no tannins will show less tolerance. Levels of tannins between 20–40 mg/g are considered moderate, and with possible benefits, whereas, above 70 mg/g, are too high and possibly detrimental. Leguminose shrubs such as broom (*Cytisus* spp.) and gorse (*Ulex* spp.) lack tannins and are a good protein source. In general, heathlands are rich in tannins but with contents considered moderate for ruminants (see Figure).

Considerations: Browsing increases biodiversity and may act as an efficient tool when is well managed. Horse grazing, for example, can decrease gorse dominance and promote heaths composition in heathlands of conservation value, thus facilitating grasses and forbs, which are more preferred plant groups for cattle or sheep. On the other hand, high cattle densities may invert this tendency affecting plant diversity negatively. Animal stocking rates should be monitored in sustainable management of shrublands and promote balance of animal and plant productivity. This can be complex, but there are ways - as observing and managing the presence or disappearance of key plant species (i.e. intense grazing: plants of high and low quality are consumed; moderate grazing: some plants of medium and high quality are used; light grazing: only preferred plants of better quality consumed).

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SILVOPASTURE

A land use management systems for grasslands

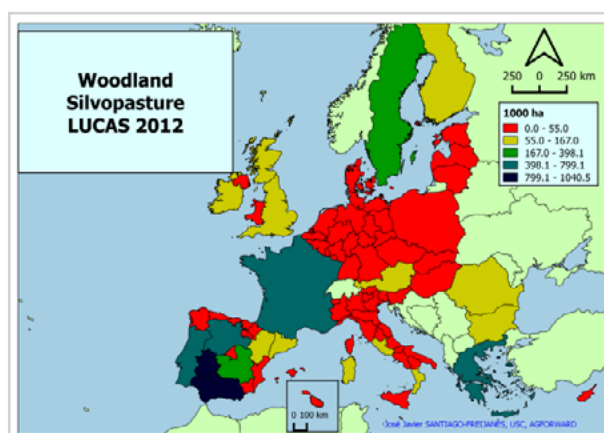
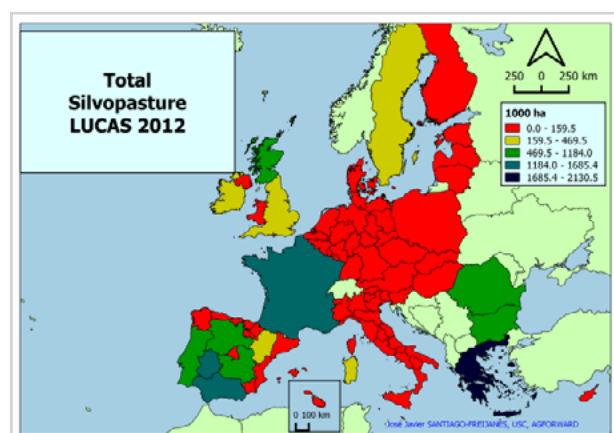


THE WHAT AND WHY

Silvopasture a land use management systems for grasslands

Silvopasture represents the 85% of the agroforestry practices in Europe, being the most extended among other agroforestry practices (silvoarable, riparian buffer strips, forest farming and homegardens). Silvopasture is a practice that can be associated to sustainable grassland management mainly located in the South and North of Europe, that provides enormous

advantages to reduce livestock production costs. However, it is not extensively used in Europe as only the 10% of the grassland area is occupied by silvopasture. One of the main drawbacks to foster agroforestry in Europe for farmers is to really identify the potential that silvopasture has to increase productivity in livestock systems.



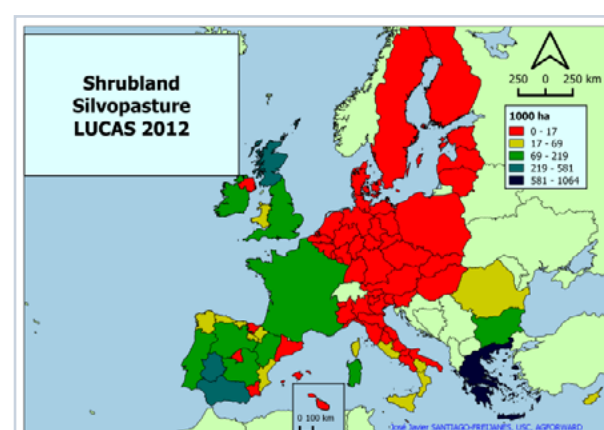
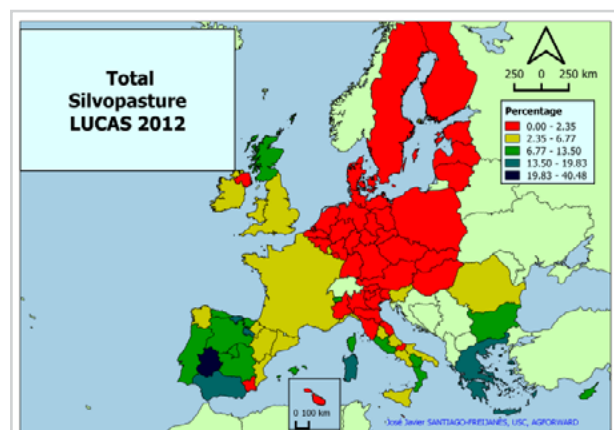
Silvopasture extent (a) and share (b) in different Regions of Europe – Santiago-Freijanes JJ

HOW IS THE CHALLENGE ADDRESSED

Improving AF knowledge

Fostering the benefits of silvopasture in Europe should be based on the understanding of the main types of pastures it covers. Livestock feed restrictions are associated to summer and winter in South of Europe while only in winter in the North, being the period of pasture shortage usually longer in the South than in the North of Europe. South of Europe grasslands associated to Mediterranean areas are naturally composed by woody perennials, the unique type of vegetation able to persist during the long summer periods, while maximum pasture production

occurs in summer in Northern herbaceous grasslands with a scarce proportion of woody perennials. Woody perennials can help to overcome these shortage periods in both North and Southern countries, while promoting the delivery of ecosystem services linked to environment. Silvopasture in the North of Europe has trees as woody perennials while in the South shrubs are the woody perennial component. Fruit trees silvopasture agroforestry is less used in Europe in spite of being full paid by the CAP direct payments.



Extent of silvopasture in woodlands and shrublands – Santiago-Freijanes JJ



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Silvopastoralism; sustainability, livestock, shortage periods

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HIGHLIGHTS

- Silvopasture is an excellent tool to improve biodiversity
- Silvopasture is an excellent tool to mitigate climate change
- Silvopasture is an excellent tool to increase systems resilience as it provides feed to animals during the shortage periods
- Silvopasture is an excellent tool to improve animal welfare

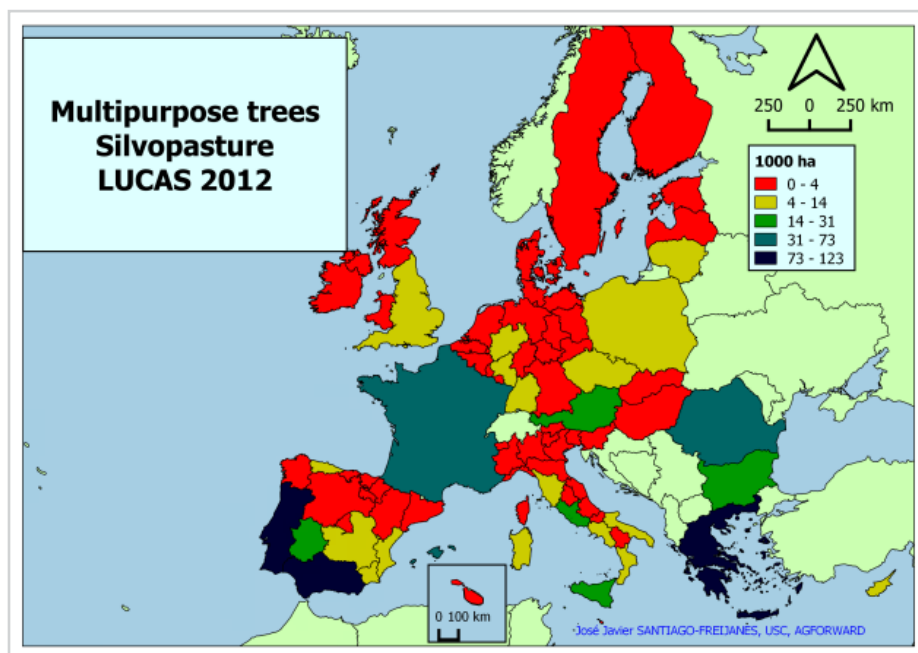
ADVANTAGES AND DISADVANTAGES

Silvopasture a good way to enhance bioeconomy

Silvopasture is able to provide a series of advantages to grazing systems in Europe. From an economic point of view having palatable woody perennials allow animals to graze in summer, autumn and winter when shortage periods occur in a sporadic or stable form while increasing livestock health (tannins associated to antihelmintic capacity). Summer grazing avoids high concentrate costs, as happen with the consumption of acorns or fruits during the autumn. Moreover, the price of the concentrate and the fruits could conduct to decide if fruits should be given to animals or not (harvesting for

selling) providing a more resilient farming system also linked to pruning during those especially dry summers. In the North, the use of woody perennials can be a good partial replacement of concentrates as happen with *Morus alba* with a protein content similar to clover. Moreover, if adequate stocking rate is employed the combination of woody vegetation with animals also tends to increase biodiversity as 1) animals select some plant species instead of others, and 2) they unevenly fertilize the soil, creating patches of varying fertility which favour different plant species, and 3) animal trampling generates micro perturbations allowing annual species to share the same plot than perennials (Rigueiro et al. 2012). If

more than one animal species is allowed to graze, their different behaviour also improves biodiversity because they select different species (i.e. goats feed preferably on woody vegetation) but also because the form of their mouth and grazing action allows some plant species to grow better than others (i.e. *Agrostis* spp. adapted to sheep grazing). Moreover, agroforestry is usually linked to autochthonous breeds, therefore preserving them.



Extent of fruit trees/multipurpose silvopasture
Santiago-Freijanes JJ

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1 OCTOBER 2018

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MANAGING HEDGES FOR FIREWOOD PRODUCTION

Case study: converting a flailed field boundary hedge into an economic crop of firewood



THE WHAT AND WHY

Can hedges increase your farm profitability?

Ross Dickinson, a commercial farmer and wood fuel supplier in Dorset, explains "I changed the management of one of my hedges from trimming it every year to letting it grow and coppicing once every 15 years for firewood production. Taking into account the savings on trimming costs, I was able to return a good profit - enough to keep someone employed". Ross has been managing many hedges on his farm like this, some for three coppice cycles. His son is now working with him on the family firewood business. Both see a strong future

in managing and cropping hedges for firewood, particularly with rising prices for logs. As they say "What could be better? We are producing an environmentally friendly fuel for a profit just by changing the way we manage our hedges. The loss of production from the fields is negligible. Even better, the condition of the hedges is improving and they are better for wildlife." Looking ahead, all the signs are that they may benefit too from public support payments designed to replace the Basic Payment Scheme.



Whole-tree hedgerow material left in field to air dry following coppicing. Organic Research Centre, 2015



Most hedge material is processed with a saw bench. Ross Dickinson, 2017

HOW IS THE CHALLENGE ADDRESSED

A coppiced hedge: converting a flailed field boundary hedge into an economic crop of firewood

This case study demonstrates that it is economically viable to move a hedge from annual flailing to a 15 year coppice rotation to produce firewood. The farm is a 400 acre low intensity livestock farm in SW England, with 12 miles of hedges all managed on a 15-20 year coppice cycle, except the roadside hedges which are flailed annually. Half a mile of hedge is coppiced annually. The farm has a small firewood business selling c.175 tonnes logs per year, hedges make up part of this. Hedge coppicing produces logs sold for the firewood business, smaller material is used on-farm or sold as 'ugly sticks' at lower price and brash is fed through a branch logger, netted and sold as kindling. All firewood products are stored undercover for 10 months to reduce moisture content

prior to use or sale.

The farmer, Ross Dickinson, is interested in the economics of the process and in 2017 coppiced a trial hedge and recorded in detail the time, costs, outputs and income. The hedge was mixed species, 220m long, 6.5m high, with 15 years growth, on an old hedge bank. The hedge was coppiced by chainsaw, material processed with a log splitter and a branch logger. 220m of hedge produced 21.41 tonnes of saleable or useable material. The overall cost was £3,378 (including labour for hedge preparation, coppicing, processing, burning brash and delivery). The overall income was £4,908 (including sales and savings from not flailing annually). So the profit from 220m of hedge was £1530 with no subsidy payments.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Hedge, coppice, firewood, logs, farm business, economics

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HIGHLIGHTS

- Firewood production from hedge coppicing can be economically viable.
- There are a range of machinery options for coppicing to suit most farms. In addition, support may be available from environmental stewardship payments.
- Changing farmer's perception of hedges so they are viewed as a useful resource rather than a cost gives hedges a securer future.
- Coppicing can rejuvenate hedges allowing new young growth at the base of the hedge, restoring the structural integrity of old hedges.



The finished case study hedge with standards left on the bank.
Ross Dickinson, 2017

FURTHER INFORMATION

Link to full report: <http://devonhedges.org/wp-content/uploads/2018/11/Converting-a-Hedge-to-Firewood-Production.pdf>

Productive hedges: Guidance on bringing hedges back into the farm business
<https://zenodo.org/record/2641808#.XQDZ6Y97nct>

Guide to Harvesting Woodfuel from Hedges: <http://tinyurl.com/TWECOM-BPG>

Hedgeline website - for the hedgerow management cycle, other useful information and hedge related resources: www.hedgeline.org.uk

Video: Dymax tree shears coppicing hedge at Elm Farm, UK:
<https://www.youtube.com/watch?v=gHLPxH55Om4>

ROSS DICKINSON and SALLY WESTAWAY

Racedown Farm, Dorset

Organic Research Centre

sally.w@organicresearchcentre.com

Content editor: Maria Rosa Mosquera-Losada (USC)

16 MAY 2019

ADVANTAGES AND DISADVANTAGES

Advantages and disadvantages of hedge coppicing

The case study outlined here shows that it is possible to make a living wage from the sale of firewood products, combined with savings in annual maintenance costs. Hedge coppicing for woodfuel production is widely applicable, the process requires no particular skill set, minimum demand for new capital and can be adapted to different farm circumstances. The farm is relatively exposed with poor soils, so hedge growth is slower than average, and coppice rotation lengths may be able to be shortened in more favourable conditions. It is possible to carry out the work by hand as outlined above or to mechanise the process using tree felling machinery (e.g. an excavator mounted tree shears) and to produce logs or to use a whole tree chipper to produce woodchip for biomass boilers. Length of hedge to be coppiced, ability to access the hedge and available markets are the primary factors determining the choice of method.

When considering taking a hedge out of annual flailing and into a coppice rotation a number of factors should be considered. Select a hedge with a high percentage of viable species, for example Sycamore and Ash, avoid a hedge which bounds high value crops as there will be some shading and possible fallen material and choose one with relatively easy access for abstraction especially on heavy or seasonally waterlogged soils. There will be some loss of usable land of around of two metres each side of the hedge by the end of the fifteen-year cycle.

Coppicing generally improves the health and longevity of farm hedges, produces a local carbon neutral source of energy and can provide rural employment opportunities. The bulk of the work is carried out during winter when trees are dormant, this fits well with the farming calendar and availability of labour. It is also possible to extract firewood when laying a hedge, the amount of material will be lower than when coppicing, but the field boundary is retained immediately post management. The structure of a laid hedge is different from a coppiced hedge and in certain situations hedgelaying may be a preferable management method. Whether coppicing or laying, a range of management methods and different ages of hedge regrowth within a farm or landscape create a wider variety of homes and food resources for wildlife which is beneficial for biodiversity.

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COLLABORATION FOR SUCCESSFUL AGROFORESTRY SYSTEMS

The alternative multi-partner working model used at Dartington for their agroforestry tenants



THE WHAT AND WHY

Using alternative business models for successful agroforestry systems

Most existing agroforestry systems on UK farms have been established by the farmer who is also the landowner or tenant. However, many farmers lack both (a) the time and the specialist knowledge to plant and care for trees and (b) the capital to invest in trees, especially when setting up a new farming enterprise. In addition, trees are a long-term investment and the uncertainty of tenure and differences of opinion between farmers and landlords are both known disincentives to establishing new agroforestry systems on

tenanted land. Dartington Estate in south west England is delivering agroforestry in an innovative way not seen in the UK before, through a multi-tiered arrangement of land owner, farm tenant and tree license holders. What makes this unusual, and exciting, is that by enabling several different businesses to work together farming the field The landowner, Dartington Estate, has created an approach to agroforestry that overcomes some of the barriers which have prevented a wider uptake of agroforestry in the UK.



The 20 hectare agroforestry field at Dartington Estate, Devon, UK. Harriet Bell, 2018



Elderflower in the new agroforestry field at Dartington Harriet Bell, 2018

HOW IS THE CHALLENGE ADDRESSED

A multi-tiered arrangement

Old Parsonage Farm is a livestock farm on Dartington Estate. Part of the farm tenancy includes a 20 hectare agroforestry field. In this innovative model of agroforestry the farmers manage the alleys between trees rows as part of their 7-year silage/arable rotation and are financially compensated for the area lost to the tree rows by the separate tree licensees. The investment in the trees is made by three different businesses Luscombe Drinks (1600 elderflower trees); the Apricot Centre (600 apple trees) and; Salthouse & Peppermongers (150 Sichuan pepper trees). These businesses specialise in tree crops and have a market incentive to make

the tree crops work to meet the demands for their products. A licence was granted to the three businesses for the tree strips, with the farmers remaining in management control of the land upon which the trees are planted and able to claim basic farm payment on the area. However, the tree licensees needed the security of being able to use the piece of land on which the trees are planted for a sufficient period to see a return on their investment. The solution was that the land owner, Dartington Estate, provided a separate undertaking to ensure the continuation of the licence on the same terms regardless of the tenant.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Farmer cooperation; collaborative working; business model; tenant; land owner

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HIGHLIGHTS

- A key benefit of multiple partners is that combining different people's skills and expertise results in a system that is more socially and economically resilient – everyone brings their own markets for their own crop and by working together can access different markets; everyone has the potential to grow their market reach.
- Cooperation between all stakeholders and open communication right from the start and throughout the planning process are also key to making this model work.



Newly planted agroforestry field at Dartington Hall Estate
Harriet Bell

FURTHER INFORMATION

Description of agroforestry activities on the Dartington Estate:
<https://www.dartington.org/about/our-land/agroforestry/>

Harriet Bell's blogs detailing the agroforestry journey at Dartington:
<https://www.dartington.org/category/blogs/food-farming-conservation/agroforestry/>

Video of Harriet and the tenant farmer explaining the business model that has been used to set up the agroforestry system at Dartington: <https://www.youtube.com/watch?v=xRjG1xTAY6g>

HARRIET BELL and SALLY WESTAWAY
Dartington Hall Estate
Organic Research Centre
sally.w@organicresearchcentre.com
Content editor: Maria Rosa Mosquera-Losada (USC)
16 MAY 2019

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ADVANTAGES AND DISADVANTAGES

Lessons learnt along the way

For the land owner, Dartington Estate, agroforestry made sense in terms of maintaining and rebuilding soils, enhancing biodiversity across the estate and endeavouring to positively contribute to reducing the risk of localised flooding. However, the requirement by the Estate that the tenant farmer plant an area with agroforestry discouraged some potential farm tenants from applying. Trees are expensive, they can take years to return the initial investment of planting and many potential tenants saw it as a waste of a good arable field. A collaborative approach has provided a solution to this problem by combining different people's

skills and expertise in a system that is more socially, environmentally and economically resilient.

However, a large degree of cooperation is needed with this type of arrangement and one lesson learnt was the importance of getting all the multiple actors together throughout the project, particularly for the design process so that everyone is aware of everyone else's skills, interests and preferences from the start.

One of the big challenges of developing the tree licenses was ensuring that they were equitable for all parties, this tends to be very subjective. Ensuring the fairness of the financial arrangements was particularly difficult, taking into account: any loss of yield for the main farm tenant; increases in labour and administration; Basic Payment

Scheme and; potential increase in contractor costs for working a more challenging field – and balancing that against what's affordable for the licensees, including their upfront investment and long term payback.

The compensation element of the licence was also a sensitive subject; trees increase in value over time whereas normal investment items (farm buildings, machinery etc.) decrease in value so the usual depreciation method for calculating compensation rates was only partly applicable. Dartington Estate have developed their own compensation formula which required the Estate, as landowner, to back up the tenant's agreement. It is still too early to know if all elements of the tree licence are right. There's no comparable project and a review with data relating to yields and costs will be conducted a bit further into the project to see how it's all stacking up. However it is hoped that this could provide a useful model for similar future agreements.

AGROFORESTRY PRACTICE IN AGRICULTURAL LANDS

Silvoarable



THE WHAT AND WHY

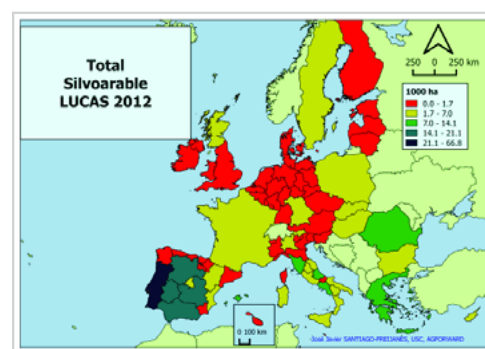
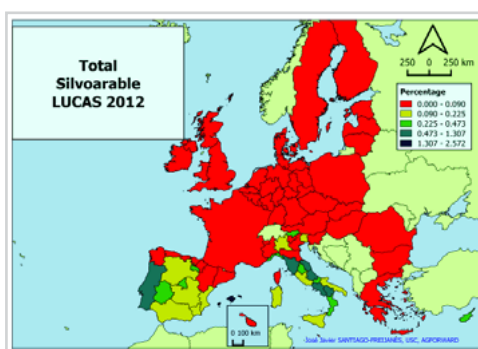
Silvoarable, a land use management practice for arable lands

Conventional farming systems developed in arable farms can be associated to a reduced provision of ecosystem services and, at the end, to a reduced crop production due to soil fertility decrease. Food quality is compromised in conventional farming systems by the use of herbicides and pesticides that are causing increasing human health problems. One of the main solutions to overcome these facts is agroforestry, as it has the capacity of improving

soil fertility and health by means of higher organic matter inputs into the soil system, reducing the use of pesticides and herbicides through an increasing biodiversity provision but also enhancing economy through the increasing of farm economic and environment resilience that agroforestry provides to both market and climate change (Figure 1). The main type of agroforestry practice that can be implemented at arable plot level is silvoarable.



Cereal varieties selection of agroforestry in Europe.
Fernández-Paradela, P.



Distribution (percentage -left- and number of hectares -right-) in Silvoarable practices
Mosquera-Losada et al. 2017; Santiago-Freijanes et al. 2018

HOW IS THE CHALLENGE ADDRESSED

Silvoarable practices, the solution of agroforestry systems

Silvoarable practices integrate arable crops with a woody component: trees or/and shrubs. The woody component can be distributed in different forms (borders, hedgerows, windbreaks, scattered trees, lines) within the cropland area, which can reduce the crop production losses that is usually associated to agroforestry when tree density is high. Silvoarable practices can be associated to annual crops intercropped among permanent crops (fruit trees, short rotation coppice, timber trees...), shrublands with and without sparse tree cover and woodlands. The total area occupied by silvoarable practices in Europe is rather small. LUCAS database shows that around 360 thousand hectares, representing less than 0.08% of the total and

therefore potential European arable area where silvoarable practices can be implemented is huge. This means that over 99% of the arable land can use silvoarable practices as a sustainable land use system. Silvoarable practices are mostly linked to permanent crops (fruit trees), coming to a total of 223 thousand hectares. However, the combination of crops with woodlands is also important and covers 133 thousand hectares in Europe, in some cases linked to a forest stand afforestation or reforestation. On the contrary, the proportion of silvoarable practices associated to shrublands is very small and amounts to only four thousand hectares (Figure 2). The greatest allocation of land to silvoarable practices occurs in southern countries such as Spain, Portugal and Italy.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Arable, biodiversity, sustainability, resilience, farming systems

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HIGHLIGHTS

- Silvoarable practices can contribute to increase the ecosystem services delivery from arable lands while generating employment
- Silvoarable practices enhance productivity, environment and social outputs per unit of land
- Silvoarable practices technical, economic, educational and policy challenges should be overcome through the adequate design and implementation of educational and policy programs.

ADVANTAGES AND DISADVANTAGES

Silvoarable advantages and disadvantages

Advantages

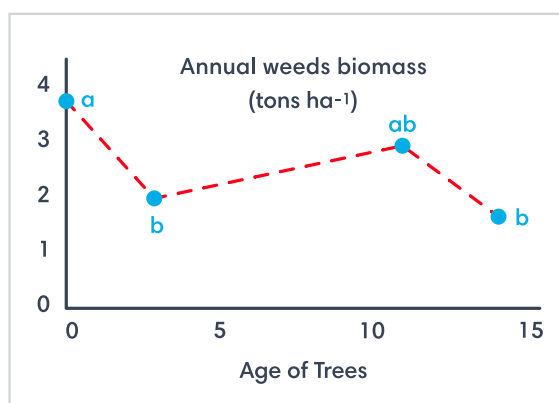
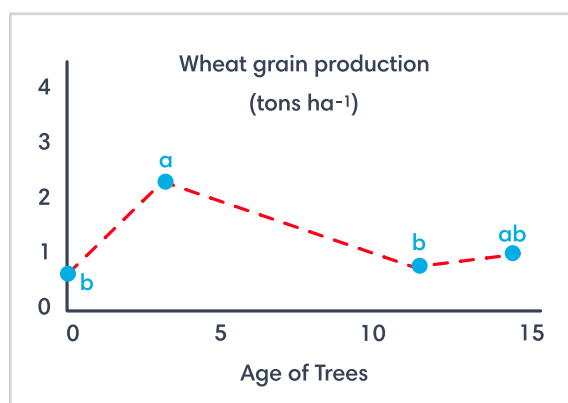
Silvoarable practices can contribute to the needed transition of conventional farming of arable lands towards sustainable land use systems as it improves the three pillars of the sustainability. From an economic point of view, agroforestry increases crop production through reducing desiccating wind effects or flooding but also thanks to the increased biomass production of the woody component that can be sold if adequately processed within the current bioeconomy framework (fibers, biomass for heating etc.). Environment is improving through the increasing environment biodiversity that creates different microhabitats

were vertebrates (birds, bats.), invertebrates (beneficial insects, worms) and microorganisms are placed. This has clear consequences for the land management as it improves soil fertility but also reduces the needs of pesticides and herbicides reducing the need of external inputs. Pesticides needs are reduced because birds

and bats are attracted to the woody component and reduce the pest population. Herbicides needs are reduced because small shade reduces the potential of annual species to be developed as they are high light demanding (Figure 2). Tree increases soil physical and chemical fertility as tree root development increases soil porosity facilitating water infiltration and percolation and reducing water and nutrient run-off but also because the fall of tree leaves makes nutrient inputs from the low depth soil layer on the soil surface, improving nutrient recycling. From a social point of view the recognized beauty of the landscape contributes to the increasing use of tourism in the arable land area, associated to strong incomes for the farmers, but also because the multiple production makes necessary more man-power for agricultural practices. Silvoarable practices generates more employment that contributes to the economic potential of rural areas that can reduce depopulation.

Disadvantages

Some concerns that prevents from the needed transition of arable lands to silvoarable include technical aspects related with the best time and spatial combinations of crops and woody perennials that should be linked to the adequate development of business plans considering the value chain. Education of farmers through their life is lacking but also the consumer education linked to the best quality and healthy food that silvoarable farming provides compared with conventional open arable farming and the more sustainable land use associated to silvoarable products. Silvoarable practices have been penalized in the past and current CAP through the limit of a maximum 50 trees per hectare (CAP 2007-2013) and 100 trees per hectare (CAP 2014-2020) or the discount of the tree cover in the arable lands from CAP direct payments.



Grain wheat production and weed biomass control in different tree ages. Wheat grain production increases when some shade degree is present due to the reduction of annual weeds that reduces crop/weed competition
Mosquera-Losada MR

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MAY 2019

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HEDGEROWS AND ISOLATED TREES ROLE IN EUROPE

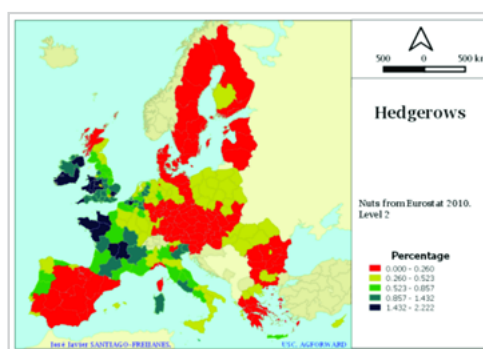
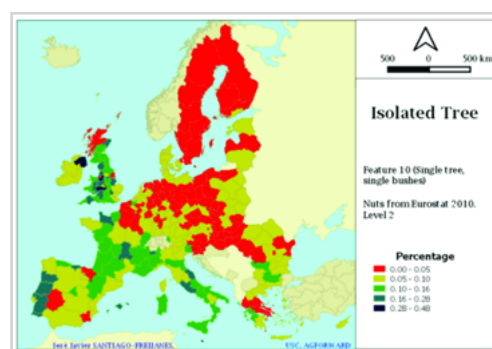
Cross-compliance fulfillment

THE WHAT AND WHY

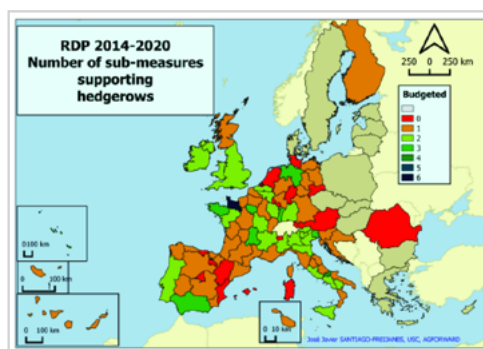
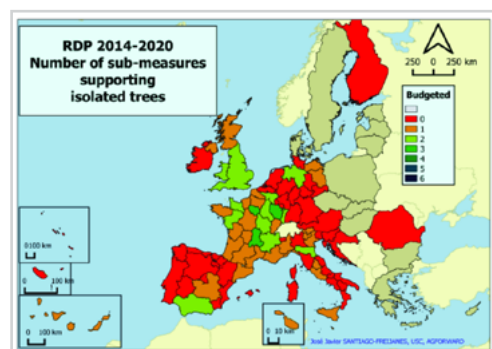
Landscape features as agroforestry

Agroforestry is a sustainable land use system that is directly supported by the Greening and in the Pillar II of the CAP (Measure 8.2). It can be also indirectly recognized in other parts of the CAP such as the cross-compliance or conditionality, where environment preservation is promoted. Cross-compliance applies to Pillar I but also to most environmental payments being part of the Rural Development policy (Pillar II) since CAP 2007-2013. Farmers receiving CAP funds have to comply with (i) Statutory Management Requirements (SMR) and (ii) standards for maintaining the land in Good Agricultural and Environmental Condition (GAEC). Current SMRs are related to environment, climate change, and good agricultural condition land

linked to (1) water (SMR1: Nitrate Vulnerable Zones), (2) biodiversity (SMR2: wild birds and SMR3: habitats), and (3) public: food and feed animal regulations among others and agroforestry can help to fulfil these environment goals. Agroforestry is indirectly contributing to those GAEC related with (i) water such as GAEC 1 (establishment of buffer strips along water courses), GAEC3 (Protection of ground water against pollution), (ii) soil and carbon stock related to GAEC 4 (Minimum soil cover), GAEC 5 (erosion), GAEC 6 (maintenance of soil organic matter), but more directly to GAEC 7 related with the landscape and the retention of the landscape features, because landscape features are related to hedges, trees in line, in group or isolated.



Percentage of Isolated trees and hedgerows in Europe
Mosquera-Losada MR
Santiago-Freijanes JJ



Number of sub-measures supporting isolated and hedgerows trees
Mosquera-Losada MR
Santiago-Freijanes JJ

HOW IS THE CHALLENGE ADDRESSED

Landscape features

Maintenance of landscape features, namely isolated trees and hedges, should be based on the adequate knowledge of their extent (Figure 1) and the usefulness of these features to provide ecosystem services delivery. Isolated trees are mainly linked to France, Portugal, part of Italy, Spain and UK, where the presence of trees in the land is more common. The highest percentage of hedgerow is found in France and UK, but also in Portugal and Italy, where this landscape feature is better represented than in other countries of Europe. However, neither

isolated trees nor hedgerows represent more than 0.5 or 2.5% of the territory, respectively. The countries where these two types of landscape features are present are those more prone to suffer strong negative effects of winds such as UK Islands and South of France. Landscape features are compulsory protected by Cross-compliance, but the establishment and maintenance are supported by different measures of the Pillar II of the CAP, being hedgerows more supported than isolated trees in most of the regions of Europe.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: ALandscape features, CAP, Mapping, Adaptation, Mitigation

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HIGHLIGHTS

- Landscape features should be preserved and their extent enlarged to increase the delivery of ecosystem services in both croplands and arable lands.
- Accountability of landscape features is essential to pay farmers for ecosystem services delivery that is aimed at next CAP 2021–2027.
- It is essential to recognize agroforestry as such when describing landscape features to increase awareness about the needed transition from conventional to more sustainable land use systems.



Isolated trees enhance ecosystem services linked to biodiversity, water quality
Linforth, P



Hedgerows enhance ecosystem services linked to biodiversity, production and water quality
Krämer, M

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ADVANTAGES AND DISADVANTAGES

Promoting landscape features

The presence of hedgerows in the borders of the fields or isolated trees contributes to increase biodiversity, production (through the reduction of desiccating wind effects), but also improve water quality.

European Union is aware of the importance of these landscape features in Europe, but they did not recognize them as agroforestry in spite of meaning woody perennials associated to croplands or grasslands.

As indicated by the European Court of Auditors, landscape features protection has not been very successful due to the difficulty of member states to control their extent.

A large amount of trees and hedgerows have been destroyed in the last decades due to the concern that farmers have to declare landscape features in their lands because the CAP can make these areas ineligible for CAP direct payments.

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OCTOBER 2018

PRODUCTION OF MEDICINAL PLANTS IN AGROFORESTRY SYSTEMS

Laurus nobilis L.



THE WHAT AND WHY

Importance of bay Laurel

The laurel (bay laurel, sweet, bay, true laurel, Greek laurel, laurel tree) is a woody plant linked to the Mediterranean region, distributing in the Iberian Peninsula mainly in humid and shady ravines of the coastal regions, both Mediterranean and Atlantic. Laurel is a plant easy to grow, with a possibility of establishment as silvoarable or as a silvopasture practices and a potentially broad market. In Galicia an import-export company buys the bay leaf (www.centralgalaicadeplantas.es). In Galicia it appears above all in low altitudes (<400 m), coastal areas and also in riverbank forests. This specie is widely cultivated and naturalized throughout the peninsula, being a very versatile plant when practical usefulness and possible economic returns are considered.



Laurus nobilis morphology
Franz Eugen Köhler, Köhler's Medizinal-Pflanzen.

Laurel leaves and fruits are used from ancient times with medicinal purposes as astringent, stomachic, stimulant and narcotic. Leaves decoction is used to treat problems of the urinary organs and dropsy. Laurel is also considered a powerful emmenagogue to facilitate women menstruation. Seed oil is used to treat rheumatic pain.

Leaves have also been traditionally used as condiment. Crushed or powdered bay leaves are an essential ingredient in product mixes and are used industrially in meat products, sauces, vinegar and cakes. Also, an essential oil is steam distilled from the leaves in the USA. Leaves are also employed as preservatives and insect repellent. The oil extracted from its leaves and fruits are used in cosmetics but also as biodiesel.



Culinary use of Laurel
Productos Ruca; Artemis; Juan Martel Henríquez; La Chinata.

HOW IS THE CHALLENGE ADDRESSED

Cultivation of Laurel

Dried bay leaves world trade exceeds 2000 t/year. Western Europe imports 800 t/year. In Galicia (NW Spain), wild populations are collected in the coastal regions (around 2 t/year). Since laurel market is deficient and the supply to companies is almost exclusively from natural populations, crop should be promoted. The crop can be made from both fresh seed previously soaked (germination takes 3 to 4 months and seedlings can be transplanted after 2 years) and by cutting (mature buds 10-12 cm long with apical buds). By cutting, leaves harvest can be carried out in the first year after establishment. Planting distance depends on the collection method and water availability. For small farmers who harvest manually, 3x3m is recommended, gradually thinning to 6x6m. In commercial

irrigated plantations in Israel, spacing is 2-3m, while in Russia 0.5x2m hedges are used in plantations mechanically harvested. Laurel can also be intercropped with annual crops (especially in the first 2-4 years). This will provide additional revenue to the producer and also ease weeds management. Laurel farming can fit agroforestry practices (silvopasture/silvoarable). To obtain a good quality product, cultivated area should have mean annual temperatures 8-27 °C and 300-2200 mm annual precipitation, low frost probability and high sunlight intensity. Once harvested, bay leaves and/or berries have to be dried to stabilize bioactive compounds. To reduce costs, leaves drying can be done by hand in thin layers in trays and a protected area for 12-15 days.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Medicinal plants, laurel, bay, shrub, tree

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HIGHLIGHTS

- Laurel is a plant with a strong potential to be used in combination with agroforestry practices, both silvoarable and silvopasture.
- Value chain and farmer cooperation should be promoted to better develop the market and the added value.



Laurel made cosmetics, soap.
Eugenio Cuppone

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OCTOBER 2018

ADVANTAGES AND DISADVANTAGES

Laurel advantages and disadvantages

Advantages:

It is an easy plant to establish for cultivation. The economic return is faster when vegetative material is used for establishment as leaf collection is possible during the first year. The crop admits two annual cuts of leaves and one for fruits, making it more profitable.

It is a woody crop that can be established in an integrated system (silvopasture/silvoarable).

Once the plantation is established, the commercial plantation duration is very high, reducing establishment costs at long term compared with other species.

It is a plant adapted to the Galician territory, integrated into its landscape and accepted by the population.

Possibility of obtaining artisanal products from direct sale easily (leaves as a condiment, flavored oils, soaps)

Disadvantages

From a scientific point of view, there is a lack of studies to evaluate if there are differences in production and quality in the currently used plant material (wild populations). The most productive and best quality would be those that should be cultivated. This would allow establishing own denominations and quality standards.

The cultivation area should be limited to the littoral zone and influence areas of the river valleys, since the quality of the plant depends to a great extent on the environmental factors (especially temperature and humidity). It is a crop whose performance on bioactive substances depends on environmental conditions.

Being a new crop, there is few information about the economic meaning of the laurel pest and disease damages. The two main known laurel diseases are the root rot caused by *Phytophthora* spp. and leaf spot caused by *Colletotrichum* spp.

The harvest is usually done manually which increases the production costs.

Appropriate marketing channels should be established.

If this activity attracts several producers, an association should be promoted.

PRODUCTION OF MEDICINAL AND CULINARY PLANTS IN AGROFORESTRY SYSTEMS

Sambucus nigra L.



THE WHAT AND WHY

Use of elder

The elder is a woody plant that appears naturally in almost all Europe, being present in cool, clear places and edges of mostly deciduous forests, with humid and rich soils regardless of their chemical nature. Elder can also be found close to human populations or livestock stables as it is favored by nitrogen-rich soils. It is a very versatile plant in terms of its practical use and possible economic returns. Wild collection is not enough to supply the market, so the interest of its cultivation is currently enhanced. It is an easy plant to grow as it reproduces well by staking. Elder can be established in both silvoarable and silvopasture systems. Galicia (NW Spain) already has experiences in the collection, cultivation and processing of flowers and elderberries (es.

carabunhas.com). The market of both the flower and the elder fruit and its different products increases every year providing a good perspective for their inclusion in silvoarable systems. It can be used for many purposes and both its flowers and ripe fruits are used in traditional medicine (diuretic, sudorific and emollient properties), respiratory conditions, flu, colds and mild laxative. Externally it is used to cope with dermatitis, wounds, burns, pharyngitis and conjunctivitis. The official European pharmacopoeia recognizes these properties. Ripe fruits can also be used for culinary purposes. The high vitamin C and flavonoid content of the fruits allows elderberry to be included in the so-called "super-foods" due to its antioxidant properties.



Sambucus silvopasture system
a) Farm woodland forum
b) Anna Regelsberger



Sambucus fruit and flowers
a) Edal Anton Lefterov
b) Kurt Stüber

HOW IS THE CHALLENGE ADDRESSED

The elder potential market

The flower and fruit are collected in the wild populations of many areas of Europe, mainly Balkans, Poland and Russia. A study by the International Trade Center on certified organic plants collected in the wild estimated that, in 2005, about 472 t of elderberry, 19 t of elderflower and six t of elder leaves were harvested in the world. The estimated annual amount of dried elder flowers collected in Bosnia-Herzegovina was approximately 44 t (95 percent exported) and in Romania about 150 t of elder flowers and 40 t of elderberry are harvested wild annually (2003). The European Herbal Growers Association (Europam) stated in 2010 that older flowers and fruits remain among the largest wild medicinal plants in Bulgaria and Romania for export trade, herbal teas

domestic and phyto-pharmaceutical production. In Galicia (NW Spain) elderberry cropping/extraction is incipient (www.centralgalaicadeplantas.es).

Countries such as Canada, US or Chile, where it is an introduced plant, are searching for more profitable and better quality markets, what is also needed in Europe.

The demand for European elderflower and fruit with sustainability certifications (eg, Organic Wild and FairWild) recommends the cultivation of this plant. So there are already initiatives in UK or in the German regions of Rhön and Lower Franconia, where it is grown organically. In Galicia, crops are also being started (es.carabunhas.com) with a plot of 1 ha planning to reach 10 ha in the coming years.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Medicinal plants, medicinal herbs, fruits

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HIGHLIGHTS

- The high potential market of Sambucus products makes it attractive for farmers all over Europe.
- Combination with livestock is possible to increase the profitability of the farms
- Adequate market channels and value chain should be established and promoted together with farmers cooperatives.



Sambucus products
carabunhas.com

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ADVANTAGES AND DISADVANTAGES

Sambucus pros and cons

Advantages:

Elder is easy to cultivate both from establishment and maintenance point of view. Elder flowers and fruit production starts after 2-3 years of the plantation. The average plant life cycle from the plantation is more than 20 years. A distance of no more than 2 m between plants is sufficient to allow easy access to the fruits during harvesting. The rows can be kept less than 4 m away. These recommended distances between rows make possible the combination with grazing animals, which would increase the farmer profit per hectare. Maintenance costs are low, just an annual fertilization of 100 gr of 10-10-10 (N:P2O5:K2O) fertilizer compound per plant is recommended.

The growing demand for flower and fruit wholesale guarantees its sale. The possibility of processing the flower and the fruit in origin (jams, jellies, sweets, liqueurs...) increase the economic yield.

There are previous experiences, both in America, Europe and Galicia (NW Spain) that support the possible success of this economic activity.

Disadvantages:

From a scientific point of view, there is a lack of studies to evaluate the existence of differences in production and quality in the plantation material (wild populations). The most productive and best quality would be those that should be cultivated.

Being a new crop it is still unknown the possible diseases that the plant can suffer in cropping conditions.

Like with any new use, some previous investments are needed and difficult to optimize.

The processing of the flower requires to have a dryer that guarantees non content variation in active principles responsible for its therapeutic activity.

For the processing of fruit, a destemmer is needed to separate the fruits from the peduncles as well as freezers. Usually the juice is extracted from the fruit and it is frozen until use.

If the fruit is going to be processed by the producer, it is necessary to foresee the type of product (jams, jellies, sweets, liqueurs) and have the necessary equipment to obtain these products: bottles, etc. In any case appropriate marketing channels and value chains should be established. If this activity attracts several producers, cooperatives should be promoted.

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OCTOBER 2018

IRIS CULTIVATION IN TRADITIONAL OLIVE GROVES

Medicinal plants as an innovative solution



THE WHAT AND WHY

The cultivation of medicinal plants in Europe

Italy imports most medicinal plants from Eastern European countries, the Far East and Latin America. For this reason, in our region, the cultivation of medicinal plants is particularly interesting and innovative. In Europe, France is the reference country for this type of production, while in Italy the cultivation of medicinal herbs has always been relegated to marginal areas because the flat areas have traditionally been used for more profitable crops. For that

reason, the Italian cultivation of medicinal plants is often adopted in hill or mountain areas, in limited areas and on land not suited to other more profitable crops. Iris is known and appreciated since ancient times for the properties of its dried rhizomes. For centuries, Iris has been used both in the medical and cosmetic sectors: as a remedy against coughs, against snake bites and depression, for perfumes, powders, soaps and pigments.



Iris cultivation could be an innovative solution for the production of product for medical and cosmetic sectors.

Gianni Pruneti



The cultivation of Iris in terraced hills offers important ecosystem services, preserving the typical landscape value of Central Italy.

<https://youtu.be/DouLyJxlmk>

Chiantilife

HOW IS THE CHALLENGE ADDRESSED

How to cultivate Iris

Iris is a robust plant that can grow in any type of soil, even in full sun and without any special need for fertilisation. Among the many varieties that exist in nature, the most suitable for cultivation in our hills is *Iris pallida*. It is very easy to grow. Since it has a rhizome, it does not need to be re-planted annually. The renewal of the plants can be done easily every 3 - 4 years. In the spring period it is

necessary manually control weeds around the plant. This operation also improves water availability in the summer months. Three years after the planting of the cuttings, using a particular tool, the iris can be unearthed and the root shaken to separate the plant from the rhizome, then the rhizome cleaned. Sliced rhizome pieces are left to dry for 5 -6 days on nets.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Medicinal plants, agroforestry, olive groves, silvoarable systems, Iris

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HIGHLIGHTS

Iris is a hardy plant easy to grow. After 3 years growth, the plant is removed from the ground and it is immediately processed. The rhizome is separated from the cuttings that will be stored in a warehouse and they will be used for the next planting in October, while the rhizome is processed. The production of 1 ha of Iris, with a planting distance of 25–30 cm, results in about 3 – 5 tons of dried product.



White Iris drying: rhizomes are left to dry for 5–6 days on nets.

Vannetto Vannini

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ADVANTAGES AND DISADVANTAGES

Simple but ... manual!

- Iris (*Iris spp.*) is a robust plant that can be grown in soils not suitable for other crops
- The plant is very suitable for intercropping in terraced olive groves
- When cultivated in the border of terraced olive orchards it doesn't cause an obstacle for mechanization
- The market of cosmetics offers good opportunities for the marketing of Iris derivatives
- The cultivation of Iris in terraced olive groves offers important ecosystem services, preserving the typical landscape value of central Italy
- The harvest is carried out mainly manually
- After planting, the Iris grows spontaneously, the only care needed is manage weeds, which are the main risk for the crop
- The rhizomes can be sold as "black" or "white". The latter are more valuable but require further processing, peeling, also carried out manually

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VINEYARDS ASSOCIATED WITH TREES AS LIVING SUPPORTS

A traditional agroforestry system in Italy and Portugal



THE WHAT AND WHY

Three thousand years of viticulture

In Italy and Portugal, as well as in many European countries, there are several examples of traditional agroforestry practices. These practices were common in many rural areas until the introduction of intensive agriculture practices. Currently such systems can play a role as an example of the historical evolution of agriculture because their presence is limited due to the high labour demand, difficulty to mechanise and the limited production in comparison to specialized vineyards. In Italy, historically,

the most important agroforestry systems involved olive trees (*Olea europea L.*) intercropped with cereals or combined with pasture and vines (*Vitis vinifera L.*) associated with trees as living supports. This system was also frequent in the central and northern regions in Portugal. In these regions, different tree species such as poplars (*Populus spp.*), maples (*Acer spp.*) and mulberries (*Morus spp.*) were used as living supports, chosen according to site conditions and management purposes of the farms.



Tall poplars with "married vines".
Jakob Philipp Hackert, 1973.



Traditional system in Portugal (Location: Guarda): Olive, almond and vine combined production.
Joana Amaral Paulo

HOW IS THE CHALLENGE ADDRESSED

Which trees can be associated with the vine?

Many trees can be used as living support for the vine according to the site conditions. Willow and poplar when there is water availability, elm and ash in more dry conditions, mulberry, in particular the white one, walnut for timber and/or nut production or maple as its competition with the vineyard plants is limited. Fruit trees can be used (almonds, apples etc); in this case they should be planted at the beginning

of the tree row in order to facilitate the harvest of fruits. When trees are used as living supports in the vineyard, it is essential that they are pruned regularly in order to facilitate light and air access to the plants. Pollarding can also be applied so that the trees do not grow too high. Support wires are placed between the trees so that vine can grow along them.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Vineyards, traditional agroforestry systems, pollarding

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HIGHLIGHTS

Vines grown with tree support was a common practice in many Italian and Portuguese rural areas until the adoption of industrialised agriculture. Following this period specialised vineyards replaced most of these systems, which are now threatened. Vines with tree support, even if production is limited, can have a great cultural and aesthetic landscape value, as evidence of agriculture evolution and for this reason the system should be preserved.



Hanged vineyard system (Location: Felgueiras): hedge from agricultural plot with three distinct layers. Vegetable production underneath; vines in the middle layer supported by Poplar trees that grown in the upper layer. Ana Tomás

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ADVANTAGES AND DISADVANTAGES

Extraordinary but complex landscape

Advantages:

- The greater height of the vines, in comparison to specialised vineyards, favour growth without any particular diseases like downy mildew and botrytis
- Farm production diversification with tree products: fuelwood, fodder, fruits
- Increase in soil organic matter and improvement of other physical properties as a result of the tree presence
- Increase in biodiversity and habitat diversity which contributes to the control of pests and diseases (see AFINET factsheet nº1)
- The specific grape varieties available for these systems with organoleptic properties may allow the development of new products

Disadvantages:

- It is a labor intensive system (management and grape picking)
- Willow roots are not very deep and the trees have a rather broad crown so must be pollarded
- Mulberry is widely used in this system due to the high production of forage but is a very demanding species with high competition for nutrients with the vines
- Walnut can be used for high quality wood production and nuts but gives a particular unpleasant taste to the grapes and can overshadow the vine

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JULY 2019

CAP AND AGROFORESTRY

Enhancing agroforestry in the CAP



THE WHAT AND WHY

Agroforestry the way to increase sustainable land use systems in Europe

Agricultural lands in Europe are associated to intensive farming systems that reduce the delivery of ecosystem services (ES). Agroforestry (AF) should be strongly supported by the CAP as a sustainable land management option that provides market and non-market goods and services that address societal goals. Governments need to develop policies and actions that foster AF within an EU policy framework. However, AF is not extensively known by farmers in their broad FAO definition; the deliberate integration of woody vegetation (trees and/or shrubs) as an upper storey on land, with pasture (animals consumed) or an agricultural crop in the lower storey. Woody species can be evenly/unevenly distributed or be located on the border of plots, providing forestry/agricultural products or

other ES (i.e. provisioning, regulating or cultural). AF can take place at a range of scales (e.g. plot, farm and landscape). At farm and landscape scale it can be implemented in systems that are able to diversify production (e.g. food, forage, timber and fuelwood), provide ES (e.g. climate regulation and biodiversity enhancement), thus increasing both resilience and profitability. Mosquera-Losada et al. (2016) describes five main types of AF practices. Silvopasture and silvoarable are the main subjacent AF practices. In order to facilitate AF recognition and implementation, considering their important role in biodiversity, water issues and pollination, we have extended "riparian buffer strip" category to include any kind of hedgerows and windbreaks.



Sheep and cherry tree agroforestry system in Galicia (NW Spain).
Rodríguez-Rigueiro, FJ.



European Economic and Social Committee thematic session on the CAP.

European Economic and Social Committee.

HOW IS THE CHALLENGE ADDRESSED

Promoting agroforestry in Europe

- Agroforestry promotion should follow 15 key points highlighted in the AGFORWARD project.
- Agroforestry definition should be the one described by the FAO
- The CAP should identify, recognize and foster the use of five agroforestry practices across Europe: silvopasture; silvoarable; hedgerows, windbreaks and riparian buffer strips; forest farming and homegardens. An 'agroforestry option' would be self-declared by the farmer in the direct payments of the CAP and supported/evidenced by a management plan, and they should be fully eligible when agricultural land is involved.
- In the EU CAP context, it is useful to distinguish between "agroforestry practices on agricultural land" and "agroforestry practices on forest land"; this is also useful for considering

the circular and bioeconomy framework, carbon accounting and EU directives.

- There should be a single "agroforestry" measure, encompassing the five agroforestry types linked to agriculture, forestry and peri-urban lands, linked to result-based payments as it has substantial potential to contribute to European SDG targets.
- The EU should support co-operation measures which allow the benefits of agroforestry to be recognised within the value chain that can be achieved by facilitating co-operation among different actors along the value chain.
- Agroforestry needs to be supported through excellent EIP-Agri with extension services promotion, knowledge co-creation should be promoted under relevant Pillar II measures.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Pillar I, Pillar II Rural Development Programmes

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HIGHLIGHTS

- Agroforestry is a sustainable land use system that should be promoted by the CAP.
- Pillar I should support agroforestry on their 3 types of lands through the recognition of management plans at short and long term.
- Pillar II should support the establishment and maintenance of agroforestry in agricultural and forestry lands, and in the first case to ensure the land to remain eligible.
- Agroforestry transition should be promoted through the development of innovation and extension services.



Mushrooms production in forest boundaries.
López-Garre, Enrique

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ADVANTAGES AND DISADVANTAGES

CAP recognition of agroforestry

CAP recognition of agroforestry will allow farming systems to move towards the needed transition from intensive farming systems towards more sustainable land use systems.

The recognition of agroforestry as such will help to simplify the CAP.

The adoption of agroforestry definition given by the FAO will allow to account in a better form for international bodies linked to the carbon accountability (IPCC)

Agroforestry can be implemented in any type of land and the advantages that agroforestry provides have to be recognized in all of them.

A clear support of agroforestry at the farm and landscape scales and cooperation measures among farmers should be considered to foster the benefits that at temporal and spatial scale agroforestry has.

The lack of knowledge about the implementation of agroforestry by farmers should be overcome through the enhancement of the innovation and extension services in Europe.

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AGROFORESTRY, CAP AIMS AND SUSTAINABLE DEVELOPMENT GOALS

Fostering sustainability



THE WHAT AND WHY

Sustainability of land use systems

In Europe, agriculture generates 44 million jobs in the food chain, provides food security for 500 million consumers, and stewards 48% of EU Land. The Common Agricultural Policy (CAP) is the main policy driver for agriculture in Europe and aims to provide not just food for European citizens (Cork 2.0 Declaration) but also compliance with global strategic policies such as the Sustainable Development Goals (SDGs) (United Nations, 2015). At the Meeting on "Sustainability Challenges delivering the 2030 Agenda" the EU showed that the first three priorities of the Seventh European Action Programme (EAP) corresponded to the UN SDGs: (1) "protect, conserve and enhance the Union's natural capital" (SDG 6, 14-15), (2) "develop a resource-efficient, green and competitive low-

carbon economy" (SDGs 7-9, 11-13) and (3) "safeguard the Union's citizens from environment-related pressures and risks to health and well-being" (SDGs 2-3). These 3 priorities have been deployed into nine CAP objectives, namely: ensure a fair income to farmers, increase competitiveness, rebalance the power in the food chain, climate change action, environmental care, preserve landscapes and biodiversity, support generational renewal, vibrant rural areas and protect food and health quality. The CAP objectives changed from the exclusive increase of food to a more sustainable agriculture and will be based on 9 objectives in the Post-2020 period that can be reached, among others, through the implementation of Agroforestry.



Agroforestry contributes to sustainable development and efficient management of natural resources.

Wall, Nico

HOW IS THE CHALLENGE ADDRESSED

Agroforestry as a tool for sustainable land use management

The Agenda 2000 reforms started the division of the Common Agricultural Policy into a "first pillar" (based on single farm payments) and a "second pillar" focused on rural development measures. Payments in Pillar I are completely funded from the European Union, while Pillar II payments are partly-funded by national governments (between 50 and 85% depending on the country). Following the CAP reform in 2003, payments were decoupled from the production of a specific product, with farmers instead receiving payments based on a set amount per hectare of agricultural land. The CAP has also aimed to become more environmentally-oriented. For the 2007-2013 period, Pillar I across the EU27 was worth just over three times as much as Pillar II. The



European Economic and Social Committee thematic session on the CAP. European Economic and Social Committee (EESC).

Agroforestry measure 222 appeared and provided support for agroforestry within the forestry measures within the EU, but it was not appropriately designed (Santiago-Freijanes et al. 2018). For the 2014-2020 period, rural development and environmental issues account for close to 24% of the total CAP budget and coupled payments were decreased and the description and aims of the agroforestry measure, the so-called measure 8.2 were improved also after the OMNIBUS regulation. Now, the EU is preparing the CAP Post 2020 where result-based payments will be key to foster the implementation of agroforestry in Europe in both Pillar I and Pillar II as agroforestry is one of the land management practices able to fulfill the objectives of the future CAP.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Pillar I, Pillar II, CAP Post 2020

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HIGHLIGHTS

Agroforestry importance within the CAP has been increased in the last decades, but there is still a lot of land use that will be sustainably improved through the implementation of AF.

AF is able to fulfill the objectives of the CAP post 2020 to support viable farm income and resilience across the Union to enhance security, foster to sustainable development and efficient management of natural resources.



Chestnut agroforestry system in Galicia (NW Spain).

Rodríguez-Rigueiro, FJ

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ADVANTAGES AND DISADVANTAGES

Agroforestry and the objectives of the CAP Post 2020

Agroforestry contributes to the CAP aim of support viable farm income and resilience across the Union to enhance security through the optimization of the farm use of the resources including water and sun and the provision of farm multiple products including those replacing fossil fuels and new products associated to the bioeconomy development. Moreover, agroforestry practices increases production per hectare of multiple products and reduce the needs of external inputs. The CAP aim related with fostering to sustainable development and efficient management of natural resources such as water, soil and air linked to a more efficient soil management can be associated to agroforestry that increases biomass production per unit of land and therefore the inputs of organic matter into the soil thanks to the better use of the sun radiation but also by increasing the surface soil nutrients as the nutrients placed in deeper soil layers are placed in the soil surface. Agroforestry also contributes to the CAP aim related to climate change mitigation and adaptation as well as sustainable energy as the last report IPCC Global Warming of 1.5 °C report already recognizes that agroforestry is one of the mitigation and adaptation options related to land use and ecosystems while providing biomass based renewable energy sources. The CAP aim of contribute to the protection of biodiversity, enhance ecosystem services and preserve habitats and landscapes is also fulfilled by agroforestry land use as agroforestry is able to protect and increase biodiversity thanks to the heterogeneity it creates, but also enhance provision, ecological and cultural ecosystem services. The CAP aim related to improve the farmers position in the value chain is tackled through the increase of products delivered from the farm that allows farmers cooperatives to have a better position in the value chain and be more resilient to climate and market changes. The aim related with the key objective of promote employment, growth, social inclusion and local development in rural areas, including bio economy and sustainable forestry can be reached through the farm competitiveness increase caused by agroforestry through the multiple products delivered from the same land associated to new market opportunities at local level associated to bioeconomy, this will also improve the development of business plans and the establishment of young farmers in rural areas therefore the establishment of vibrant rural areas.

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WOOL, WILD FRUIT AND WHAT ELSE?

Livelihoods, biocultural diversity and nature-based lifestyles supported by agroforestry



THE WHAT AND WHY

Innovations from the past: the case of wood pastures

A key characteristic trait of agroforestry systems is diversity. Wood pastures are primarily known for the diversification of grazing land, they take advantage of the different conditions provided by the trees and form a mosaic of habitats managed less intensively. Besides providing shade, another important feature that trees offer is their role in nutritional supplementation. Selection of planted or retained trees may also include a consideration of their nutritional value for livestock.

Additionally, agroforestry systems can promote the renewal of traditional practices (e.g. combining trees and livestock, handcraft, gastronomy etc.), which have been forgotten throughout much of Europe. An example is the use and processing of wild fruits and wool. In this case study, the farmers combine their background in folk art and folk culture with their experience as modern shepherds in order to produce good quality and unique products from the “fruits” of their wood pasture system.



Edible wild fruits (e.g. wild pear) were traditionally an important income from wood pastures. It was used as forage, but for gastronomy also. Wood pasture restoration could improve those uses as well (Bogyiszló, Hungary). Anna Varga



An abandoned wood pasture was renewed by a family and give their livelihood today. Main trees are wild pear, wild apple. They are mainly grazed by sheep, but also cattle and pigs (Vácza-kő Farm, Bakony, Hungary). Anna Varga

HOW IS THE CHALLENGE ADDRESSED

Discover you forest patches and change policy

Diversification of use is based on the diverse properties dominating agroforestry systems. In the case of wood pastures, this effect can be based on the selection of a wide variety of trees. An excellent example includes the caring for and planting of wild fruit trees. Eating their fruits raw or in some processed form may be of great benefit for the farmer as it is also an extra source of income when sold. Besides growing and processing wild

fruits, people also deal with the processing of the wool of their grazing sheep livestock in Vácza-kő Major in Bakony region in Hungary. When wool dying is carried out plants found on the wood pasture may be used. Finished products are sold on the farmer market or by direct ordering, while the procedure of traditional wool processing is disseminated and taught in folk-playhouses and camps.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Diversification; sustainable, tree, sheep, wild pear, wool, handcraft, sustainable lifestyle, back to rural

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HIGHLIGHTS

Silvopastoral systems are harmonious and balanced livestock farming systems, which could provide animal and plant products at the same time (eg. wool, wild food products). Beside the revitalization of our gastro-cultural heritage, agroforestry and in particular silvopastoral systems allow to enjoy and experience a modern and environmentally aware livestock-keeping and slow lifestyle, to be handed down to next generations.



Artistic board game with woolen pieces – handcraft wool product from the wood pasture of Vácza-kő Major, Bakony region, Hungary
Andrea Vityi

FURTHER INFORMATION

Vácza-kő Major (Farm) is small, family owned, restored and managed wood pasture and farm in Bakony region. Most typical trees of their wood pasture wild pear and wild apple and mainly grazed by sheep. Owners are produce artisan wild fruit and wool products.

Wood pasture & Gastronomy, film introduce herders and families, who manage wood pastures in different ways in Bakony and Balaton region in Hungary, with English subtitle. It was made by Gasztróangyal (Gastroangel), Marcsi Borbás.

Dénes Andrea, Papp N, Babai Dániel, Czúcz Bálint, Molnár Zsolt (2012): Wild plants used for food by Hungarian ethnic groups living in the Carpathian Basin. *Acta Societatis Botanicorum Poloniae*, 81: 381-396.

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ADVANTAGES AND DISADVANTAGES

Nature and market-based lifestyle co-producti on

In relation to the efforts made to establish a slow and nature-based lifestyle, a cornucopia of opportunities offered by nature is explored, allowed by the specific observations made as a result of a lifestyle continuously conducted close to nature and the implementation of new ideas derived from such observations. Local traditions inevitably turn up when new ideas are discussed and by their re-consideration they foster the potential of improving the quality of life. Preparation, consumption and marketing of non-pasteurised, beneficial vinegar from wild fruits established in wood pastures has gained more popularity besides fruit jams and juices. Their own sheep's wool used for training activities and the development of unique products such as personal effects and jewelleryes. It is a high standard starting material, being also environmentally sound as a local product. Wild fruit products were part of the traditional and local gastronomy, the recovery of their production could be recognised as good example for slow food production. As regards the disadvantages, the scarce availability of time for both the occupation of the primary producer and of the folk artisan that allows a low volume production, albeit high quality output has to be mentioned. Wool, produced by many hours of labour is prohibitively expensive for prospective customers, thus – the same way as the products made from wild fruits, or even more so – can be marketed and sold with strong difficulties. In spite of the huge amount of interest it raises and superior quality and specificity of the products, it is not nowadays competitive in terms of price with the cheap imported products usually associated to petrol processing.

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NOVEMBER 2018

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BEEF CATTLE IN AGROFORESTRY SYSTEMS

Acorns, wild fruits, winter pasture and more:
Innovation in beef cattle breeding

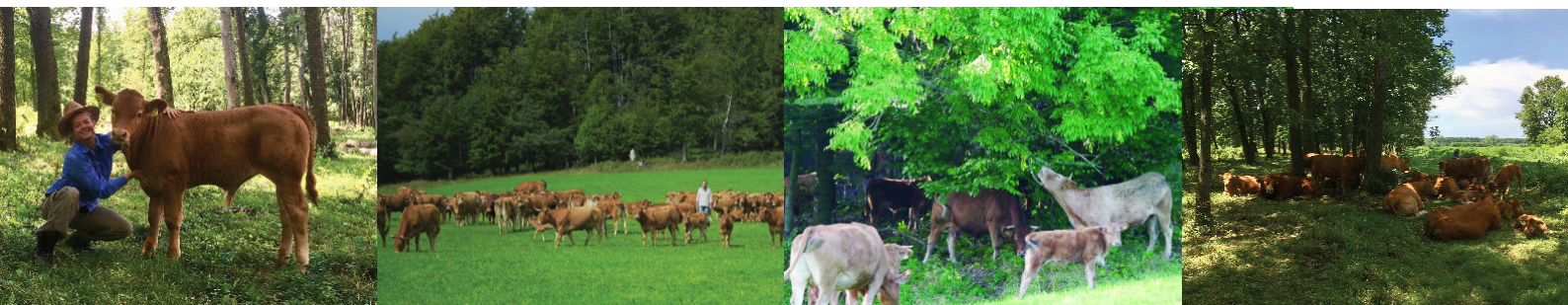


THE WHAT AND WHY

How you could improve your beef cattle keeping?

One of the difficulties to sustainably maintain livestock based on grasslands is to provide appropriate solution for feeding the animals throughout the year. By the end of the pasture growing season, the nutritional value of the grass is low as a result of the summer drought. Under current climate change conditions, the risk of unpredictable and adverse weather conditions is increasing. Moreover, open mountainous pastures which don't offer protection from cold and wind increase animal stress, decrease animal

health and reduce feeding efficiency of livestock, whilst strengthening the risk of soil erosion. These negative effects can be prevented by planting trees or using already existing woodlots. Acorn, wild fruit (apples, pears), herbs or foliage contribute to the diversity of food supply and thus to animal welfare. In addition trees create nesting places for birds that, according to farmers, reduce nuisance and harmfulness of flies for animals. All these promote the creation of healthy and good quality livestock.



Limousine cattle at Mozsi Ranch (Hungary): acorns are used as a type of alternative forage (a). OIKOS farm (Poland): naturally grown herbal leys, willow leaves and wild fruit deliver nutrients for cattle. (b). Mozsi Ranch, Sellye, Hungary (a), Kawka Studio, Poland (b)

Having rest in the forest (a), Grazing in woodland (b). In both cases, woodlots constitute an important and organic part of the pasture land in order to enhance the various aspects of animal welfare.

Mozsi Ranch, Sellye, Hungary (a), Kawka Studio, Poland (b)



watch video



watch video

HOW IS THE CHALLENGE ADDRESSED

Discover your forest patches and change policy

Farmers need to act creatively when they want to implement agroforestry systems in their land under the current environmental and policy conditions. For instance, the introduction and use of small patches of woodlands/shrublands as a source of feed for animals is usually connected with a reduction in land eligibility by the CAP (see also: AFINET Factsheet no. 20: Agroforestry

practice in agricultural lands). The best resources to research the most suitable farming methods to renew an abandoned area are formal or informal interviews with local elder farmers, land use history documents, and monographs on the local region. Existing opportunities, such as grazing within forests or woodlands may be blocked at policy level, in some cases even prohibited by law.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Diversification; sustainable, tree, alternative feeding resources, limousine, extensive livestock keeping, Hungary, Poland

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HIGHLIGHTS

- Grazing of woody perennial areas is of paramount importance for the purposes of animal welfare.
- When applying for agricultural subsidies and developing agrarian policies, the use of forested or even wooded land might be still a disadvantage.
- Farmers on forested or wooded land need to work more per unit of land, but raising healthy and high quality livestock implies higher profits as well.



Agroforestry systems of Mozsi Ranch (a). Hiding under tasty willow bush at OIKOS Farm (b). Mozsi Ranch, Sellye, Hungary (a), Kawka Studio, Poland (b)

ANNA VARGA1 JÓZSEF MOZSGAI (MOZSI MAJOR) ANDREA VITYI1 ROBERT BOREK2

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ADVANTAGES AND DISADVANTAGES

Unpredictable conditions

Grazing diverse pastureland usually results in beef of higher quality than that produced in farming systems where animals are maintained in stables. For the purposes of animal welfare, it is very important that cattle are able to rub themselves against trees, enjoy the shade on hot days, or shelter during windy cold days. This is absolutely necessary if you are to raise good quality livestock. Woody areas on Hungary's Mozsi Ranch are first grazed at the end of summer and beginning of autumn. However, these wooded areas mainly function as the winter pasture, though during long periods of snow cover even these pastures become inaccessible. On this and other grass-fed beef farms, such as OIKOS Farm in Poland, areas are grazed via a rotational system, to maximise efficiency of pasture growth and maintain fodder quality.

Open wooded pastureland offers both nutritious grass and shade. Understorey in more closed-canopy forest patches is often rather shrubby, or weedy, including species like blackberry and hawthorn. Such habitats are also necessary for animal welfare. Cattle can hide in these bushes during the summer to minimize harm from mosquitos and gadflies. These areas also provide wood—a renewable fuel, which can help to cover the price of any thinning required to establish or maintain wood pasture. Grassland, like any land cover type, can be diversified spatially in terms of soil quality. Pastureland is often vulnerable to soil erosion, so practical knowledge about farm soil management, including management of tree-covered areas, is essential.

One of the main disadvantages of including woody vegetation as part of a grassland area is related to payment restrictions associated with agricultural subsidies. These subsidies fail to recognize that wooded pasture areas, far from being neglected, are properly managed grazing plots. Additional difficulties follow from the fact that some current national legislation does not endorse the grazing of woodlots which qualify as forest.

Wood pasture management is more complex than that of treeless pastures, as often grass harvesting cannot be carried out among the trees by large farm machinery, since the trees do not grow at regular intervals. Thus, silvopastoral systems require greater human labour inputs for their management than homogenous, open pastureland. This presents the largest contemporary challenge to wood pasture maintenance, but the resulting diversity produces advantages to livestock welfare quality, and ecosystem services.

FURTHER INFORMATION

Mozsi Ranch, Sellye, Hungary, updated videos and pictures from Mozsi Ranch at their Facebook page:

Silvopasture: Integrating Trees, Forage, and Animals in a Farm Ecosystem Varga & Vityi (2017) Lesson learnt: Wood pastures in Hungary

In Polish:

<https://cookitlean.pl/z-wizyta-u-oikos/>

http://www.drrenaeristastories.com/wp-content/uploads/TS2018_Bracia_ostateczna_mala.mp4

<https://targpietruszkowy.pl/project/oikos/>

EDIBLE HOMEGARDENS

Innovations and challenges for mimicking nature in temperate climates



THE WHAT AND WHY

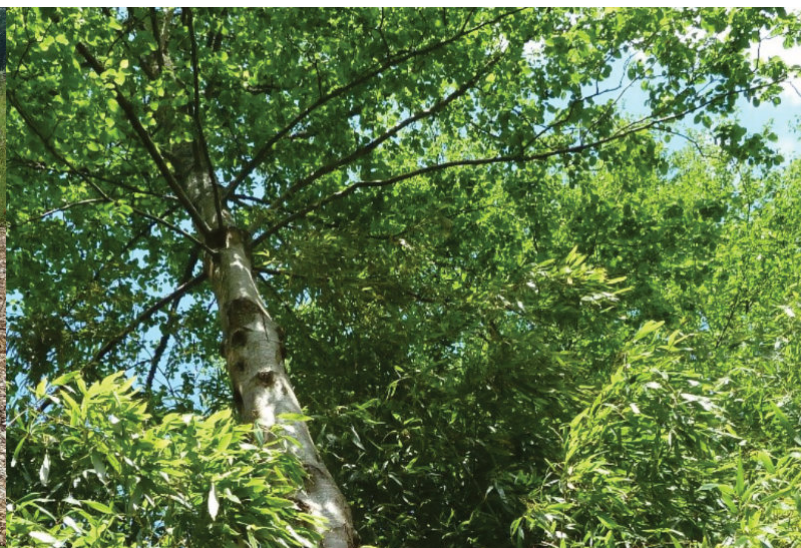
Homegarden or food forest?

Homegardens are primarily or entirely perennial polycultures, containing at least three identifiable vertical layers of food-bearing plants including trees, shrubs and perennial herbaceous understory. They are characterized by a multitude of sizes, shapes and habitats, from rural to urban, from wooded landscape to dense forest (Jacke and Toensmeier 2011). Examples of homegardens can be found in all continents, mostly in the tropics. Apart from a number of environmental

and social advantages, their economic benefits range from high value from new crops to improving income from marginal soil. Homegardens aim to be self-maintaining, increase self-sufficiency of households. Edible food in homegardens are used widely by the permaculture movement and are increasingly adapted to temperate regions, based on local conditions, suitable species and creativity (Mollison 1979, Jacke and Toensmeier 2005, Crawford 2010).



Newly designed and planted homegarden
João Palma



Multi-layer vegetation in a homegarden
Jo Smith, ORC

HOW IS THE CHALLENGE ADDRESSED

Towards diversity, complexity and balance

The first edible homegarden in Europe was established in UK by Robert Hart in 1981; this inspired large numbers of followers in temperate climates. Homegardens are characterized by: a large number of species, giving great diversity in vertical structure and within guilds; the inclusion of plants which increase fertility, such as nitrogen fixers; the use of deep rooting plants as “nutrients pumps”; the use of plants that attract predators of common pests; the use, where possible, of pest and disease resistant varieties;

the role of tree cover and leaf litter in order to improve nutrient cycling and drought resistance. Recommendations also include using seasonal succession of plants in the lower layer and restricting tree pruning (Crawford 2010). However, local conditions may require specific patterns of homegarden design; from homegardens in existing woodland through a managed edge of woodland to suburban community gardens and intercropped orchards.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: food forest, edible forest, homegarden, alternative food, diversity, complexity, balance, permaculture

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Apart from a number of environmental (e.g. resilience to climate change) and social advantages (as a community resource), their economic benefits range from high value from new crops to improving income from marginal soil and diversifying income streams. Homegardens aim to be self-maintaining and increase the self-sufficiency of households.



Homegarden in Poland
Monika Podsiadła,
"Permaculture gardens"
Foundation

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Crawford M. (2010) Creating a Forest Garden. Green Books

Morel et al. (2018) Permaculture. *Encyclopedia of Ecology*, 2nd edition, <https://doi.org/10.1016/B978-0-12-409548-9.10598-6>

ADVANTAGES AND DISADVANTAGES

Learning limitations and possibilities

Homegardens can be used to exploring the potential of novel species, although ecological, economic and cultural impacts of new species should be assessed before and after introduction. However, the use of native species, already adapted to local conditions and of traditional ecological knowledge is recommended. Advantages from growing plants are provided through their interaction at horizontal level (including allelopathy) and at vertical levels (proper design of shade-tolerant crops in seven layers, based on Crawford (2010)). Under conditions of Central Europe, the tallest layer (medium to large canopy trees >10m) need to be considered with caution, due to competition for light, but for example widely spaced limes *Tilia* or sycamores *Acer pseudoplatanus* may be sources of honeydew, nectar and lime tea/sycamore syrup. Small trees and large shrubs (4-9m) consists of fruit trees or nut trees (e.g. hazel *Corylus avellana*). Mountain-ash *Sorbus aucuparia*, shadbush *Amelanchier* or white mulberry *Morus alba* might be high trees but these three are also forgotten sources of nutritious fruits (and of leaves in the case of *Morus*). Siberian peashrub *Caragana arborescens* is another under-appreciated species; it is a leguminous plant, enriching the soil in nitrogen, and has edible pods and seeds. The layer of shrubs <3 m might include nitrogen-fixing plants (e.g. sea buckthorn *Hippophae rhamnoides* and Russian olive *Eleagnus angustifolia*), and edible-fruit bushes (e.g. *Vaccinium*, honeyberry *Lonicera caerulea*, quince *Cydonia* and *Chaenomeles*). The layer of herbaceous perennials and evergreen plants (0-3m) is good for cultivation of leaves (e.g. edible comfrey *Simphytum*, horseradish *Armoracia rusticana*, shepherd's purse *Capsella bursa-pastoris*, wild garlic *Alium ursinum*, winter rocket *Barbarea vulgaris*), culinary herbs (less common spices can be peach-leaved bellflower *Campanula persicifolia*, yarrow *Achillea millefolium*, *Nigella arvensis* or cabbage thistle *Cirsium oleraceum*) or shade-tolerant medicinal herbs (e.g. lungwort *Pulmonaria officinalis* or heath speedwell *Veronica officinalis*). Other layers include ground cover plants (e.g. with strawberries, ground-ivy *Glechoma hederacea*), climbers (with *Actinidia*, *Hablitzia* or *Vitis vinifera*) and underground layer with edible roots and tubers (e.g. marsh woundwort *Stachys palustris*, nut grass *Cyperus esculentus*, Japanese hedge parsley *Torilis japonica*).

PRUNING OF FRUIT TREES

Managing trees for the production of fruit in Northwestern Europe



THE WHAT AND WHY

Fruit production in agroforestry systems

For centuries, in Northwestern Europe, the production of fruit has been integrated in agroforestry practices. Several traditional systems were widespread over Europe whereby fruit trees were combined with cattle (e.g. "pré-vergers") or with arable cropping (e.g. "streubstäcker"). Up till present, the landscape of several regions such as Haspengauw (Belgium) or the Regional Nature Reserve of Avesnois (France) is still characterized/dominated by orchards with high standard fruit trees. Thereby, apple, pear,

plum and cherry are the main types of produced fruit. Ascertaining and maintaining good production of fruit trees requires adequate management. Particular attention should be paid to the consistent pruning of the fruit trees throughout their lifecycle. During the first years after plantation, pruning determines the development of the desired tree shape. In later years, this directly affects both the quantity of fruits produced as well as their quality (e.g. size, color, taste).



A traditional agroforestry system in large parts of Northwestern Europe whereby sheep graze in fruit tree orchards.

(c) Bert Reubens - ILVO



Tree shape with 3-4 equivalent main branches.

(Consortium Agroforestry Vlaanderen)

HOW IS THE CHALLENGE ADDRESSED

Selection of the tree shape and subsequent pruning

The different stages throughout the lifecycle of a fruit tree require a different pruning regime.

Right before or after planting, the main branch(es) which will constitute the lasting basis of the tree are selected and withheld. Thereby, either 3-4 equivalent side branches can be selected and growth of the central leader is suppressed by pruning it to approximately the same height as the side branches to create a wide crown. Alternatively, the central leader can be selected as a single main branch to create a smaller (and higher) tree.

In a second phase, starting from the plantation year until the start of fruit production, yearly formative pruning is required as the number of lateral branches increases to further establish a desired crown form.

In the third and final phase when trees start to bear fruit (approximately after 10 years in most parts of Northwestern Europe, depending on the species), maintenance pruning (e.g. every 5 years) is conducted to preserve the tree shape and produce sufficient quantities of high-quality fruits.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Orchard, Pruning, Fruit trees, Yield, Quality, Apple, Pear, Tree management

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HIGHLIGHTS

- Pruning of fruit trees is indispensable for the production of enough quantities of high quality fruit.
- The selected tree form affects both quality of the fruit and management activities.
- Trees may either be pruned to maintain 3-4 equivalent side branches or one central apical branch.



Tree form with one central apical branch.
(Consortium Agroforestry Vlaanderen)



watch video

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www.agroforestryvlaanderen.be [accessed 18/12/2018]

Personnal communication Paul van Laer & Jan van Bogaert

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SEPTEMBER 2019

ADVANTAGES AND DISADVANTAGES

Effect of pruning and selected tree shape on fruit production

By pruning, the light availability in the tree crown is modified, with increased light resulting in more flower buds and sweeter fruit of larger size and better color. As a rule of thumb, it is advised to eliminate maximally 20 % of the crown volume in already pruned orchards. To avoid a large number of fruits of undesirable small size, part of the flower buds can be eliminated by pruning which results in a larger average size of the remaining fruits.

The light availability in the tree crown is further affected by the tree shape whereby the type with one apical branch generally results in a higher quantity of sweet fruit of higher quality when compared to the type with 3-4 main branches. In the latter type, the fruit on the inner branches receives less light and high quality fruit is mainly located at the outside of the tree. As a result, use of this tree form often necessitates more pruning to deliver high quality products

Besides the increased proportion of high quality fruits, additional advantages of the tree shape with one apical branch is the shorter period before the tree starts to bear fruit (already after 3-4 years). It should, however, be noted that not all cultivars are equally easy to prune to this tree form. The narrower tree shape furthermore results in an easier use of agricultural machinery, which may be of particular importance in a silvoarable agroforestry context. Alternatively, trees may be planted in higher densities.

A disadvantage of the tree shape with one single main branch is the increased height, which may impede pruning of the upper branches and harvesting of the upper fruits (if conducted manually). In addition, in an agroforestry context where trees are often planted at lower densities than in conventional permanent crops systems, they may be relatively exposed to extreme events such as storms. Thereby, higher trees may be more susceptible to wind damage. Therefore, the use of seedlings with a taproot is strongly advised as a rootstock when compared to rootstocks originating from vegetative propagation.

Pruning activities can be conducted in winter which stimulates branch formation in the subsequent growing season. Alternatively, e.g. in case of water sprouts, pruning in summer can be advisable to avoid regrowth. The timing of pruning may furthermore affect susceptibility to diseases. For example, in case of pome fruit, no pruning should be conducted between October and December, since during this period mold spores are highly active resulting in a high infection risk through the pruning wounds. Faster covering of the wounds may occur during summer, further decreasing the risk of contamination.

ROTATIONAL CATTLE GRAZING IN TRADITIONAL ORCHARDS

Diversification of production for smallholder farms in Central Eastern Europe



THE WHAT AND WHY

Traditional organic orchard with cattle grazing

Traditional orchards are valuable elements of rural landscapes and sources of income for smallholders. Almost 3000 local apples varieties still exist in Central Europe alone. They are naturally resistant to frost, diseases, pests and each provides a unique taste and healthy values. Value-added income can be improved by integrating livestock grazing activities. Grazing can contribute to the diversification of production and extending the timing of cash flows. Although sheep are preferred to cattle in most fruit production systems

because they cannot browse as high, under certain market and cultural conditions, sheep/lamb meat, milk or wool production might be not profitable. For example, in Poland there is a long tradition of grazing cattle and high demand for beef in the domestic market means farmers prefer cattle instead of sheep. Furthermore, the first successful trials dealing with grazing in orchards by using electric fences to facilitate rotating animals between paddocks, showed that trees have not been affected by cattle browsing.



Cattle resting in old traditional apple orchard. The grazing realizes the productive potential of environmentally valuable areas.

Andrzej Majerski



High electric fencing prevents browsing trees. Simmental-Limousine hybrid cattle can provide high-quality beef as an additional income for smallholders.

Andrzej Majerski

HOW IS THE CHALLENGE ADDRESSED

Controlled cattle grazing in the management of traditional orchards

Before planting a traditional orchard, site factors and local varieties should be carefully considered and a supply of good quality trees is crucial. A traditional apple orchard of different varieties is grown on a spacing pattern 7-10m x 5-8m, depending on soil texture, plot location and needs. A north-south row orientation is preferred due to uniform distribution of sunlight to tree crowns. Controlled grazing with a 1.4m high electric fencing allows intensive grazing of a portion of orchard without tree damage. Paddock

rotation and paddock size varies, depending on weather, season or sward cover. Water access should be provided. A mowing-grazing regime is considered as the best, with grazing practiced until the harvest of fruits. A holding open-air area is needed for animals when they are removed from the orchard. The trees are fertilized each year with liquid manure approx. 25-50 l/tree. The system is very flexible and requires the farmer to have systematic control and good knowledge of the sward productivity and cattle herd needs.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Organic farming, beef cattle, traditional orchard, orchard grazing, silvopasture, smallholder farms

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HIGHLIGHTS

- Combined production of traditional apple varieties and feed grass can be an additional income for smallholder farms.
- Grazed orchards provide shade for animals, reduce mowing needs, enhance nutrient cycling and biodiversity.
- Traditional fruit varieties and beef expand the culinary product portfolio of the region.
- Silvopastoral traditional orchards help to save the cultural identity of the region and countryside heritage.



Each traditional apple variety has different taste, aroma and use. This offers a great many possibilities for creating unique combinations of fruit products depending on customer preferences.

Andrzej Majerski

FURTHER INFORMATION

More information in English on management of traditional orchards:

<https://www.agricology.co.uk/resources/traditional-orchards-wildlife>

http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE07_NAT_D_000236_LAYMAN.pdf

<http://publications.naturalengland.org.uk/publication/19007>

In other languages:

<https://www.esto-project.eu/index.php-id=87.html>

ADVANTAGES AND DISADVANTAGES

Increase management effectiveness and enhance biodiversity

The size of many farms in Central-Eastern Europe does not allow them to enjoy equal access to the market. The fragmented agrarian structure of lands characterized by distance from other parcels forces smallholders to look for ways to intensify and diversify production. Controlled cattle grazing in traditional orchards is one of the methods for significantly increasing income, however usually this does not enable them to be self-sufficient. Manufacturing and sale of high-quality apple juice from their own traditional orchard, encompassing different local varieties (expected average yield 20–50 t ha⁻¹) is considered as a profitable farm operation. Additional production of grass feed in an orchard can provide animal gains similar to those from open pastures and finally raise the production of increasingly sought products (i.e. beef) that improves farm cash flows. Grass yield in well managed young and old thinned orchard does not differ significantly from the yield harvested in traditional open pastures. In other habitats, plant viability and grazing usage might be decreased. Grazed orchards offer shade and shelter for animals, limit fuel use by reducing the need to mow, and enhance nutrient cycling and soil fertility. Traditional orchards provide mosaics of different habitats for beneficial invertebrates, rare birds (European pied flycatcher or Icterine warbler), bats and lichens. Grazing prevents dispersion of pests and diseases from fallen leaves and fruits and reduces mole activity. Last, but not least, cultivation of several traditional fruit trees varieties contributes to a rich landscape and restoration of cultural heritage. The region of Łącko is famous for traditional fruit products but subject strongly to emigration of the rural population. In the circular economy approach, combined and nature-based farming systems including silvopastoral orchards are needed to develop sustainable bioeconomy models on peripheral rural areas featuring complex land use structures. However, it is not an easy process, but it is one of the few opportunities to save the cultural identity of the region and the touristic values of the landscape.

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JULY 2019

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APPROPRIATE VARIETIES FOR FRUIT OR NUT PRODUCTION IN AGROFORESTRY

Which criteria and options?



THE WHAT AND WHY

Fruit and nuts in agroforestry systems: a valid option

When establishing agroforestry plots, quite often a combination with high standard fruit or nut trees is chosen these days. Think of apple, pear, cherry, peach, apricot, medlar, almond nut, walnut, hazelnut, chestnut and so many other options. The economic added value of these trees is not the wood production but the added value the fruit or nuts can offer. The harvested fruit is often processed into fruit juice, cider, syrup, wine, jelly, or jam. Also, nuts can be either sold

fresh or processed before selling as walnut oil or chestnut flour for example. However, making the most suitable species and variety choice when establishing a new agroforestry plot with this type of trees is not an easy thing to do. Various factors play a role in this decision process, and the right choice determines the success of the outcome. In this factsheet, we briefly list the options and most important criteria.



Fruit and nut tree variety choice: a wealth of options.

Bert Reubens - ILVO



Improved fruit or nut trees generally are grafted onto a rootstock of another variety or species. For high standard trees in between the rootstock and the selected variety there is often also an intermediate stock.

Bert Reubens - ILVO

HOW IS THE CHALLENGE ADDRESSED

Picking the right tree for the right place and goal: which criteria to consider?

For fruit and nut trees, various factors play a role in the selection process. These are important ones to consider:

- The benefits of more diversity (biodiversity and genetic diversity);
- The economic added value of the future harvest of these fruit and nut trees, largely determined by how the farmer intends to market the fruit, nuts or processed products;
- Soil and microclimate conditions, which help to determine which types of fruit or nut trees you should (not) plant on the plot;
- The individual properties of the different varieties (taste,

harvesting time, properties for storage, processing, pest and disease resistances, etc.);

- The timing in the harvesting and consumption season according to the objectives of the harvest;
- The mutual (necessary) cross-pollination.

Finally, when you have to make a choice between different, equivalent varieties, it is best to opt for regional varieties.

Improved varieties generally are grafted onto a rootstock (and often also intermediate stock) of another variety or species. Properties of these, such as growth speed, resistance, soil preferences, are also determining the outcome.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Diversification; orchard; added value; cultivar; selection

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HIGHLIGHTS

- High standard fruit or nut trees are a valid option when establishing agroforestry.
- Success is determined by the right species and variety choices for your place & objective.
- Important criteria to consider are taste, flowering & harvesting time, properties for storage, processing, pest & disease resistances, soil preferences, etc.
- The characteristics of rootstock and intermediate stock are also important.



Walnut varieties: besides taste, colour and size, also budding and harvesting time, properties for storage, processing, pest and disease resistances, and soil condition preferences are important selection criteria.

Bert Reubens - ILVO

FURTHER INFORMATION

More information (in Dutch) on fruit and nut trees in agroforestry systems can be found at

<https://www.agroforestryvlaanderen.be/NL/Kennisloket/Boomspecifiekeinfo/tabid/9776/language/nl-BE/Default.aspx>

For Belgium, several lists with traditional and regional varieties exist, such as this “brochure hoogstamfruitbomen” for West-Flanders and the “fruitfiches” for Limburg. Also the variety list of Gembloux is worth checking.

Interesting English websites are the National Fruit Collection and Orange Pippin, respectively for Wallonia and the UK.

ADVANTAGES AND DISADVANTAGES

Late budding walnut: a variety choice example for temperate zones

In the last few years, walnut trees have become a popular choice for agroforestry systems because of their highly valued timber and fruits. Variety choice is often solely based on nut production properties of the tree, especially quantity and quality. The importance of budding, blooming and leafing period in temperate climates like Belgium is often overlooked. Most Southern European varieties are not suited for temperate climates. Until 15th of May, spring night frost is not unusual in the whole of Flanders. Bud breaking and blooming of every commonly used cultivar in France occurs well before half May and bud growth of nearly all commonly used cultivars used in Belgium (Broadview, Buccaneer, Coenen, Rita, NO.16, Plovdivski, Proslavski, Axel, Hansen) starts before the risk of frost is gone. In Flanders, on average you must take substantial losses (due to frost) into account once every 2 years when using very early cultivars (March) in temperate climates, once every 4 years using early cultivars (beginning of April), once every 10 years using middle cultivars (end of April – beginning of May) and once every 15 years using late developing (half May) cultivars. With very late cultivars (late May – early June) this risk is reduced to zero, allowing a more consistent nut production throughout the years (of great importance for marketing). On top of that, a late leafing period also has some interesting implications when used in alley cropping agroforestry system. Intercrops, like winter wheat, get maximum light during most of their growth period as tree leaves are still absent. Drier growing conditions could also make the intercrops less vulnerable to fungal diseases. First observations also indicate that the late budding walnut varieties are less vulnerable to walnut blight and chestnut weevils. Hence, late budding varieties open up a lot of opportunities for smart combinations in alley cropping systems. Very late varieties are relatively rare, but they exist. About 2% of seedlings fall into this category. Optimal growing conditions and management are crucial for these varieties due to the short growing season. Knowledge on them (nut production, pollination, resistance, shape) is however still limited and they are not yet commercially available, but more research on this promising topic has been initiated in Belgium by local walnut experts cooperating with research institutes.

VALORIZATION OF WALNUTS IN FLANDERS

What possibilities do walnut trees offer? Case study of the agroforestry farm 'Buxusberg'



THE WHAT AND WHY

Versatile trees and promising business in Flanders

Walnut trees (*Juglans regia*) are a good choice as tree species in agroforestry systems in Flanders (Belgium) because of their ecological characteristics. Moreover, walnuts are gaining popularity fast among consumers making it a promising business. That is why recently there has been a relatively strong increase in the number of walnut plantations in Flanders. However, to maximize profit and get the most out of your system, it is important to think in advance on what products you will put on the market and how. You can increase profitability by

valorizing as many parts of the tree as possible and processing waste products where possible. When planting walnut trees in an agroforestry system the choice is usually made to produce either timber or nuts. Although it is more complex in terms of profitability, a combination of both goals is possible with certain varieties (for example Coenen) or by planting seedlings (usually faster growing). Nevertheless, there are also a lot of innovative business models concerning various other plant parts of the walnut tree waiting to be discovered.



Walnuts as the main product from walnut trees.
Buxusberg



Shaking walnuts from the trees (left) and sorting them by size (right).
Buxusberg



HOW IS THE CHALLENGE ADDRESSED

What products do walnut trees have to offer?

The walnut tree is a multifunctional tree species. Fruits, wood, roots, bark, leaves, husks, nut shells, tree sap,... all can be used. This results in a whole range of products: nuts, timber, oil, litter, dyes, liquor, tea, energy,... The first two are considered the primary products. Timber (often used as veneer wood) is highly valued and prices in Flanders range between 250 and 500 € per m³. Prices for dried nuts in our region are about 4 € per kg. Wood production has an impact on nut production. For each 50 cm of height you add to the branch-free stem length by pruning in the first years, the first

profitable nut production is delayed 1 year. Higher stems also mean higher tree crowns, increasing the labour intensity and costs for harvesting nuts. Profitability of your system can be significantly improved if you valorize 'waste products': the internal nut partition membrane can be used to make tea, nut shells as biomass for energy, the press-cake after oil production as cattle feed or in human consumption (chocolates, cookies), husks to make dyes, tannins from the bark as preservative, leaves as fodder for goats and sheep or litter in stables.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Product diversification; walnut plantation; profitability; waste products; processing

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HIGHLIGHTS

- Being a good tree species to implement in an agroforestry system and consumers loving its healthy nuts, walnut plantations are increasing in Flanders.
- The walnuts and/or wood is the main product coming from the walnut plantations.
- Profitability of the system can significantly increase by valorizing waste products such as the husks, nutshells, press-cake, damaged nuts...



The agroforestry plantation combining walnut trees and box (top), walnut liquor (bottom left) and freshly harvested unripe nuts to produce liquor (bottom right). Buxusberg

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More information (in Dutch) on the usage of walnut trees in agroforestry systems can be found on <https://www.agroforestryvlaanderen.be/NL/Kennisloket/Boomspecifiekeinfo/tabid/9776/language/nl-BE/Default.aspx>

More information (in Dutch) on the case study farm Buxusberg (and other farms) can be found on <https://www.agroforestryvlaanderen.be/NL/Toepassersahwoord/tabid/9160/language/nl-BE/Default.aspx>

ADVANTAGES AND DISADVANTAGES

Case study: walnut plantation 'Buxusberg' in Flanders

On the flanks of a hilly part in Flanders lies the farm 'Buxusberg'. The farmer is a practitioner of agroforestry and combines walnut trees (for nut production) with the cultivation of box (Buxus) in between rows on 4 hectares. The farmer used the box to overcome the non-productive first years of his trees. Now that his walnut trees are becoming more productive, he plans to stop cultivating box and focus on his 10 hectares of walnut plantation. At the beginning, the farmer sold the harvested green nuts in their husks straight to retailers, but by now he is processing them himself.

His main product is fresh walnuts. From late September until early November, walnut fruits for direct consumption are harvested by shaking them from the trees and picking them up with an automatic sweeper with a capacity of 3000 kg nuts per day. After mechanically scraping off the husks (pulp is re-used as fertilizer in his plantation) and sorting them by size, nuts are shipped almost directly to the store and sold as fresh walnuts. Fresh walnuts don't require a lot of processing and storage room. Moreover they are heavier than dried ones (drying causes 60% of weight loss) and are a niche product with high prices per kg and a demand exceeding the supply. All this makes them very interesting in terms of profitability.

Early July, the farmer also harvests some unripe green nuts in their husks (a lot of flavour is in the husks) to produce walnut liquor or walnut flavoured lambic beer. Around 500 kg of nuts (including husks) is enough to produce about 10000 litres of liquor. For this he cooperates with a local distillery and brewery. The farmer produces his own brand of walnut liquor that is now sold in the region.

While before, the smaller and/or damaged nuts (refused by retailers) used to be composted, they are now dried, cracked and sold as dried, peeled nuts. This processing requires more time and equipment, however, making them less profitable in comparison with the fresh walnuts. The farmer is now experimenting to use the dried nuts for walnut oil and to make the processing efficient and profitable. 100 kg of his dried nuts yielded up to 60 litres of oil when using an adjusted olive oil press. Prices for cold pressed walnut oil in Flanders go up to € 40 - 50 per litre. A possible valorization of the remaining press-cake and the nutshells is not yet explored on this farm but will be in the future.

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JULY 2019

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USE OF FAST GROWING TREE SPECIES IN A CROP ROTATION

Case study: Crop rotation of corn and black locust in an arable agroforestry system



THE WHAT AND WHY

Be comfortable with the low productivity from your land?

In a medium or poor-yielding corn-growing area, short rotation tree plantations can be incorporated into a crop rotation in order to improve the soil conditions and to increase the production of the system. One possibility for such agroforestry systems is to plant trees for biomass at high planting density. The establishment of such plantations is justified where the use of other techniques is limited or where higher sales revenues

can be achieved through the delivery of special products. For example, a medium-yield maize growing area can be used to produce poplar or black locust (*Robinia pseudoacacia*) in high yields, the biomass of which is marketable as fuelwood or usable for private purposes. Short rotation coppicing is followed by a transition to arable cropping. In this way, the tree plantation is included in the crop rotation.



Black locust plantation at the age of 3 years planted at 0.5 x 1.5 m spacing

Photo by B. Marosvölgyi

Black locust energy tree bales

Photo by B. Marosvölgyi

HOW IS THE CHALLENGE ADDRESSED

Soil and yield improvement with black locust - crop rotation

Black locust can be renewed by coppicing, so it can be harvested three or five times, totaling a plantation life of up to 10-20 years. (Ref 3) As leguminous plant, it can fix nitrogen from the air into the soil, up to 50 kg ha⁻¹ year⁻¹. Also the foliage falling every year and root die off increases the mineral content (K, Ca, Mg) and thus the microbiological activity of the soil as a result of the input of organic matter. The roots of trees penetrate much deeper (2-5 m) than conventional agricultural plants. The channels made by the roots improve

the soil water infiltration capacity and the conditions to avoid water loss through run-off. Therefore, dense tree plantations can have a positive effect over a long period of time, including the improvement of soil fertility and thus the yield of the subsequent crop. Crop and wood products (timber, woodchip, stumps, roots etc.) of short rotation coppice (SRC) provide regular income for the farmer. The extracted wood can be shredded or baled locally, stored after chopping and used for industrial or private purposes. (Ref 2)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: crop rotation, black locust, energy, plantation, fast growing

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HIGHLIGHTS

The main advantage of alternating black locust as SRC crop with annual crops such as maize in a crop rotation is that the former produces renewable energy for local use, whilst significantly increasing soil quality and total biomass yields. The cultivation of black locust for energy purposes gives reasonable yields in poor production areas. Its high energy density and good burning properties make it easy to use.



Strongly spiked stem of a single year black locust in plantation
Photo by B. Marosvölgyi

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ADVANTAGES AND DISADVANTAGES

Advantages and disadvantages of SRC in rotation with crops

The SRC plantation incorporated as part of a rotation with annual crops is advantageous from various aspects. During the period of SRC production, marketable wood products such as wood chip can be produced either for the producer's own purposes, or the sale of wood chip fulfilling a contract or the sale of them in a free market.

The disadvantage is that methods of evaluating the indirect benefits of the inclusion SRC as part of a crop rotation- such as determining the value of a positive change in the quality of the soil - have not been developed yet. This requires further research. Moreover, as the inclusion of SRC as part of crop rotation applies over a long period of time, both policy and macroeconomic changes as well as economic stability may pose a high risk.

Another risk element is climate change, which can affect biomass yields and the selection of the most suitable tree species.

After the final SRC harvest and before the following maize is sown, the stumps must be removed. Switching from SRC to crop production may also be necessary if the economic conditions become unfavorable for the maintenance of the tree plantation. In this case the area can be returned to agricultural production with suitable technology within 1 year.

The main advantage of the system is that it delivers renewable energy for local use (e.g. heating), at the same time as significantly increasing soil quality and biomass yields whilst reducing the amount of N-fertilisation required for the tree and the subsequent crops due to the presence of leguminous trees. Due to its high energy density and good burning properties, the wood of black locust is easy to use after any mechanical processing (crushing, compacting, baling).

The results of studies from Germany show important benefits concerning drought tolerance, resilience and water use efficiency of black locust. (Ref 1) These qualities of the species are the basic conditions for effective management of an agricultural system under recent climate change extremes.

In areas with low yields, it is justifiable to use black locust to replace agricultural crops where black locust can even achieve higher yields than poplar plantations. Though, due to the specificity of the species (strongly spiked) only fully mechanized technologies can be used.

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MULTIPURPOSE USE OF HEDGEROWS AND WINDBREAKS

Productive family farm with multipurpose use of green belts



THE WHAT AND WHY

Protect your land and build a productive system

It can be a challenge to build up a self-sustaining organic family farm operated on some ten hectares in an intensively managed agricultural area. As this case study implies, it is a work-intensive project but can be successful with proper planning and management. The family farm introduced in this case study is established on 12-hectares of land in Hungary. Their land has some unfavourable properties (drought-prone area exposed to wind and soil erosion) and is subject to many negative effects

caused by human activities carried out on the neighbouring land. Based on their knowledge of the fact that linear green belt systems have age-long history in some European countries, for protecting fields, people, and livestock and improving productivity by altering wind flow and regulating climate, the farmers built their concept on a well-considered plan of a structured system of hedges, windbreaks and shelterbelts as well as a combination of different agroforestry practices.



Mowed orchard (right) protected by windbreaks (left) – one of the several ways agroforestry is practiced at Valaha-Tanya, Vértessacs, Hungary

Photo by A. Vityi



European Economic and Social Committee thematic session on the CAP.

European Economic and Social Committee (EESC).

HOW IS THE CHALLENGE ADDRESSED

Protection and diversity

The farm is located in an exposed location, surrounded by big, intensively cultivated agricultural monoculture parcels which has the effects of increasing weed abundance and contamination from agrichemicals. In order to avoid any negative effects from the surrounding agriculture, planting of protective green belt around the farm was one of the first steps taken by the farmer. Due to this, within 2–3 years there has been a significant decrease in spray drift and wind pressure. To further reduce the exposure and the evaporation loss the area has been sectioned

with tree and bush lines, perpendicular to the prevailing wind direction. The hedgerow around the farm is mixed species. The aim of using multilevel vegetation and wide variety of indigenous or adaptive species and varieties in the windbreaks is to increase biodiversity (can be considered as a gene bank), support protective functions and ensure its multipurpose use (food, wood, bee pasture, forage etc.). Diversity and a mix of land use practices provide the basis for the profitability and sustainability of the farm. (Fig1 and 2)



watch video



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Hedgerow, windbreak, diverse, wood, food, sustainable, productive, Hungary

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HIGHLIGHTS

Farmers often experience that farming adjacent to large-scale, intensive agricultural areas has a negative impact on their productivity. In such cases, planting windbreaks and hedgerows to separate the farms also has the effect of altering wind speeds and regulating climate, as well as providing a range of products and services and thus have a key role in protecting the farm and improving productivity.



Lovely, unique and delicious products of the multipurpose windbreaks and orchards at Valaha-tanya

Reference: Valaha-Tanya

ADVANTAGES AND DISADVANTAGES

Make it worth the effort!

The use of diverse windbreaks and hedges in and around the farm reduces wind speed and regulates the climate, which prevents soil erosion and supports higher productivity. Increasing species diversity of windbreaks, hedgerows and shelterbelts can make the production more stable and thus the farm sustainable through a variety of products.

As disadvantages, protective green belts require space and thus the farmer has to withdraw a part of the area from cultivation of annual and perennial crops. Furthermore, for trees and bushes planted for flower and fruit purposes (e.g. in the case of elder), the farmer has to leave at least two metres from the boundary of the area in order to make the bushes accessible for harvest. Though this loss of area might generate a negative impression, practically, it doesn't influence or even increase the total productivity as these areas still remain productive, but in a different way, providing a range of food and non-food products and services in the global farm. Farmers must also ensure by pruning that the branch height on the adjacent agricultural area of the protective belt is adequate and fit to agricultural machines.

In total, the higher diversity of land use practices applied and proper management of green belt systems require more work compared to intensive monocrops or low diversity systems, but it results in more sustainable farming, which provides both livelihood for the farmer today and in the future for the next generations.

FURTHER INFORMATION

More detail about the farm is available here:

http://www.eurafagroforestry.eu/afinet/rains/agroforestry-action/Vmultifunctional_agroforestry_organic_farm_in_hungary

<https://www.facebook.com/valahatanya/>

<http://valahatanya.hu>

http://www.eurafagroforestry.eu/afinet/rains/agroforestry-action/Vmultifunctional_agroforestry_organic_farm_in_hungary

POST FIRE MANAGEMENT OF CORK OAK FOREST (*QUERCUS SUBER*)

Promoting sustainable management practices for recovery of burnt areas



THE WHAT AND WHY

The importance of the cork oak tree in the Mediterranean Basin and its vulnerability to fire

Cork oak (*Quercus suber*) forest stands and the ecosystems in which these are included have a great socioeconomic and ecological relevance in the western Mediterranean Basin, where they occupy more than 2 million hectares. The cork oak tree has a unique feature that sets it apart from all other Mediterranean hardwood species: a bark (cork) that can reach 30 cm thick. This has been used for thousands of years as a renewable natural resource and a versatile, valuable raw material. Nowadays, world cork market exports represent about EUR 1.6 billion per year. Due to its commercial value, cork is periodically harvested, usually every 9 to 15 years. Beyond this commercial use, these areas are also usually used as

silvopastoral areas. Cork oak ecosystems have also a remarkable ecological value, supporting high biodiversity, including several endemic species, and providing a habitat for endangered ones. Despite being so valuable, these stands have been facing many problems which threaten their sustainability. One of the biggest problems is the occurrence of forest fires which have affected many stands in the last decades in several of the Mediterranean regions. Although cork oak trees are frequently considered to be the most fire resistant and resilient trees among the native trees of this region, factors like cork harvesting can change that, making it paradoxically one of the most vulnerable tree species.



Cork oak stand in an agroforestry system (Credits: Filipe Catry).



Cork oak trees growing from their stumps about two years after a fire (Credits: Filipe Catry).

HOW IS THE CHALLENGE ADDRESSED

Post-Fire Management: Setting Goals, Assessing Damage, and Planning Restoration Actions

It is important to define management goals after a fire and plan for restoration. Usually the most common objective for burnt cork stands is to recover their cork production as soon as possible. Post-fire management alternatives will largely depend on the fire severity, and so, firstly one should make a multidisciplinary damage assessment to identify direct and indirect economic and ecological impacts and risks. After a fire, a strong negative commercial impact should be expected. Burnt cork loses its value and the productivity decreases. The severity of the damage to the trees will depend on many factors, but one of the most important is usually cork thickness. It will take about 40 years minimum to start re-harvesting good quality cork from the site if the trees have died (good quality cork is the one that

can be used for wine corks). These will need to be replaced. It will take about 30 years before harvesting from those surviving trees with high canopy mortality, and 10 years from those trees with high canopy regeneration. In terms of the ecosystem the most common consequences are a decrease on tree cover and vigour, decrease on acorn production, reduction on the regeneration and food availability for livestock and wildlife, decreased carbon retention, nutrients and water and an increase in soil erosion. All these economic and environmental aspects should be taken into consideration when planning post fire forest management. Inadequate management will risk increasing fire damage with seriously negative consequences in the mid and long terms.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: cork oak tree; fires; sustainable management; post fire recovery; cork harvesting; mortality; resilience; natural regeneration

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HIGHLIGHTS

- Cork oak forest stands have a great socio-economic and ecological importance in the Mediterranean Basin.
- Fire has a severe and lasting impact on these stands and is one of the main threats to their sustainability.
- In the short term right after a fire, the priorities should be to prevent soil erosion, the presence of large domestic or wild herbivores, pruning and cork harvesting.
- When improving the burned area one should favour natural regeneration wherever possible



Canopy regeneration of a burnt cork oak
(Foto: Filipe Catry).

FURTHER INFORMATION

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AUGUST 2019

ADVANTAGES AND DISADVANTAGES

Sustainable management: measures for better recovery of burnt areas

For security reasons dead and severely damaged trees should be cut when they pose a risk of falling over, to improve plant health (if plant pests are present), and to promote natural regeneration (from the tree stump). This is especially important when their canopies are dead or their trunks are badly damaged. The decision to cut should be well considered and in some countries, such as Portugal, you need to ask for permission before cutting. Cuts should be close to the ground and the resulting timber/cork can be sold. In some cases one's management choices may include leaving these trees standing or on the forest floor to favour biodiversity. Machinery use should be minimised to avoid destroying natural regeneration, soil erosion and compaction.

Cork harvesting and tree pruning with canopy regeneration should not be made in the first few years after the fire since trees will be weak. Several specialists recommend waiting 2 or 3 years until canopy recuperation has reached about 75% of its pre-fire volume and cork is about 2 to 3 cm thick. Cork harvesting should be done carefully using experienced workers, leaving the cork on the trees whenever it does not come off easily as to not hurt the trees.

In a lot of cases, and mostly if cork had not been harvested recently before the fire, trees will regenerate from the canopy or the stump. If the canopy is regenerated in a uniform way there will be no need for intervention. Otherwise, tree stump regeneration is a good, rapid way of regenerating forest stands, and easier and cheaper than sowing or planting. Frequently there will be many shoots originating from the base of the tree trunk, and thinning may be needed. In such cases up to 3 shoots should be left, choosing the most well developed and shaped ones. There is little information on this matter, but it seems to indicate it is better not to be thinning the trees during the first few years.

During the first year after a fire, larger herbivores should not access the stand, whether that might be livestock (goat, sheep and cow) or wildlife (e.g. deer) to allow for natural regeneration to occur and reduce soil compaction. If most of the trees have died, are regenerating from the stump or stand density is being increased, these animals should be kept away for several years. It is also important to take every action that improves fire resistance and resilience.

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DESIGNING A PROFITABLE AGROFORESTRY SYSTEM WITH POPLAR

Investigating agroforestry potential with double rows of poplar in arable systems



THE WHAT AND WHY

Agroforestry on cropland as an alternative solution to meet the poplar demand

Today, the decrease in new poplar planting is a very worrying factor for the industry. Over the past twenty years, the rate of poplar replanting in France has decreased from 2.3 million plants per year in the early 1990s to less than 600,000 plants per year in 2013. Today in France, more than one in three parcels is not reforested. This has become very insufficient to ensure the future supply of processing industries.

The first signs of supply stress are already being felt such as poorer quality and quantity of log. At the same time, an increasing demand for export in Europe (Italy, Spain), South-East Asia and India adds to this stress. If the rate of replanting

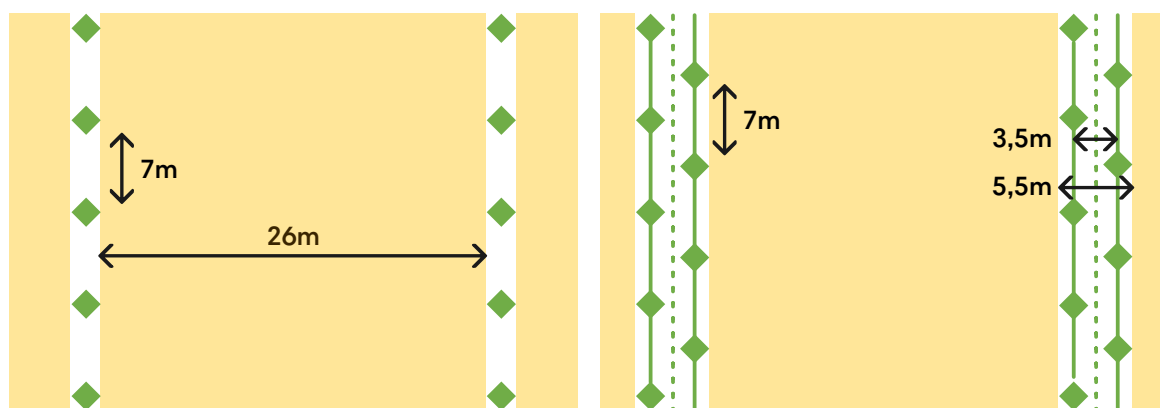
does not increase, and an evolution of the poplar sector is not quickly engaged, the industries are expected to experience a break in their supplies at the beginning of the 2020s.

In this context, agroforestry is seen as an alternative source of raw material for the poplar industry, and a good opportunity of diversification for farmers. However, agroforestry on cropland faces a major issue of competition between trees and crops for light, water and nutrients which can strongly affect the profitability. Proper design has to be implemented to allow effective complementarity between both components of the system.



Agroforestry system of poplars and maize in Haute-Garonne, France.

Credit: Philippe Van Lerberghe © CNPF



From single-rows to double-rows of trees in poplar alley cropping, a way of maximizing the profitability of agroforestry systems.

Credit: Association Française d'Agroforesterie.

HOW IS THE CHALLENGE ADDRESSED

Optimizing line spacing and density with a multiple row design

Arable crops and trees, when present simultaneously on a same field, partly share the same resources: light, water and nutrients. Light has already proved to be one of the main limiting factors to the growth of arable crops in alley cropping agroforestry systems, due to the shading effect of the tree canopies. The wider the crop strips between the tree lines, the lower the impact of shade, hence the expected yield reduction. In general, the minimum distance recommended between tree lines is 20m.

On the other hand, the production of quality timber requires a spacing of 5 to 6m between trees (distances to be adapted to the context and plot characteristics). As a consequence, if poplar lines are more widely spaced, tree density, and thus timber volume production per hectare is reduced. To optimize the tree density, to the level of 100 trees per hectare, it is possible to plant trees in a double-row design. This way both light needs of the crop and a good tree production potential are ensured.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: design; profitability; yield; arable crops

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HIGHLIGHTS

- Poplar is a high value, fast growing tree species, and an increasingly scarce resource for the industry. Its integration in agroforestry systems could help increase profitability in the mid-term, if implemented with an appropriate design.
- In agroforestry, wide spacing between trees rows are often advised to mitigate crop yield reduction and allow for the use of large agricultural machinery. Tree lines composed of double-rows appear to be a promising solution to keep a sufficient tree density on the plot, while preserving crop production.
- Based on modelling, double-row designs in poplar agroforestry systems appear to be more profitable than single row layouts.
- Further research is necessary to fine-tune the model developed, especially regarding crop yield reduction, but also to evaluate its applicability to other tree species and crops.



Several rows of poplar are established between agricultural plots sown with maize in Verdun-sur-Garonne, France.

Credit: French Agroforestry Association



watch video

FURTHER INFORMATION

¹Fang et al. 2005. Poplar in wetland agroforestry: a case study of ecological benefits, site productivity, and economics. Wetlands ecology and management.

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ADVANTAGES AND DISADVANTAGES

A lot more to be tested on the field

Double-row design is a common practice in China where poplar agroforestry is well-known. A chinese study published in 2005 compared several layouts of double-rows poplar agroforestry systems to monoculture, and claimed an increase of 46% on the cost/benefit ratio for a 30m-apart double-row layout after 7 years¹. However, this practice is not well-known in Europe, and more references and experiments are needed to fine-tune recommendations and advice for temperate climates.

The **French Agroforestry Association** worked on a technical handbook² to guide practitioners in the implementation of poplar agroforestry systems, both in crop and livestock. In this document, economic modelling shows that a double-row poplar system would outperform a single-row design. With a design of 93 trees/ha (vs 54 trees/ha for the single row), the double-row system would get a EBITDA of 151€/ha and year against 72€/ha and year for the single-row considering a 1.3m³ log of wood per tree after 20 years. This is mainly explained by scale economies and the fact that a quincunx double-row is considered to have no or little impact on wood production (poplar growth) .

However, it is currently not possible to estimate the impact of each design on the crop yields, and this needs to be further investigated on the field to understand better the potential of double-row agroforestry systems. A research need is also to validate the different possible configurations, with regard to spacing in the row, between rows and crop types. In a new project, adapted varieties will be selected and tested based on the work of the French poplar experimental network, coordinated by the **National council of forestry owners (CNPF)**.

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24 JUNE 2019

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AGROFORESTRY WOODCHIP FOR COLLECTIVE HEATING FACILITIES

Maintaining the landscape by using woodchip for fuel



THE WHAT AND WHY

Pruning the hedges is not just a cost, it also produces fuel resources

Hedges are very important elements of the French landscape, especially to maintain the “bocage” (pastureland divided into small hedged fields interspersed with groves of trees). However, since the 70s, trees and hedges are seen by farmers and town representatives as a liability and a cost rather than a resource. Hence, hedges are not well maintained, and sometimes even pulled out. To keep these hedges healthy and managed, so that they can keep providing their ecological and agronomical services (e.g. biodiversity havens, protection against weather,

erosion prevention), it is crucial to turn them into economic resources.

A serious lead for the valorisation of hedge products is wood-fuel for collective heating systems. Several actions are needed to truly develop a wood-fuel value chain: promote hedge restoration and replanting, train farmers on good hedge management practices, help small-scale woodchip-processing companies to find suppliers and promote installation of heating systems for city infrastructures, enterprises or farms.



watch video

A collective heating facility using woodchips in Sin-le-Noble, France, supplying heating to apartment buildings, a school, a high-school, a hospital and even a shopping mall.

Source: La voix du Nord newspaper, photo by Johan Ben Azzouz



Shredding branches after the pruning of a hedge.

Credit: Collectif Bois Bocage 35

HOW IS THE CHALLENGE ADDRESSED

Building up the woodchip value chains

Making woodchips for fuel is not a new practice, it has been used way before gas, oil or electricity, and the process is apparently very easy (just shred the pruning residues). However, it is a quite technical and expensive operation for a farmer, and to make it profitable is sometimes a real challenge. This is possible only thanks to well-structured value chains and a good demand. Today, both are lacking in many places to really develop agroforestry woodchip. Over the past few years several local organisations in France took up the challenge.

In Northern France, the **Regional Natural Park of Avesnois** launched an initiative in 2012 to promote the establishment of heating systems in the area, in partnership with an association that sources and processes woodchips **Atelier Agriculture Avesnois Thiérache**. Now, more than 88 individual and 24 collective heating systems have been

installed, and more than 458 tons of woodchips have been delivered. This represents an equivalent of 700 households powered with the exploitation of 600km of hedges.

Another good example is the **Bois Paysan** initiative, which is held by a group of 30 farmers in the Ariège department of South France. It began its actions by restoring existing hedges and then evolved to promote new agroforestry planting and knowledge transfer. Thirty-five hectares of land were converted towards agroforestry from 2015, creating several km of new hedges. Nowadays, ten of the farmers are gathered into a distribution company to process and sell directly high-value products from this “farmers’ wood”, aggregating direct value from a locally available resource. This company already signed 20 offtake contracts with gardening and hardware stores for products like mulch (ramial chipped wood), charcoal, and timber.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Woodchip; energy; bocage; tree hedges

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HIGHLIGHTS

- In terms of cost per kWh, woodchips sourced locally are 10 times cheaper than electricity
- For a 260m² house, a woodchip heating system has a higher cost of installation (12,500€ more) but allows savings of 150€/month on raw material.
- 100m of tree hedge can supply the equivalent of 2,500kg of gas or 30,000kWh of electricity in 10 years.
- Sustainable sourcing practices must be guaranteed for the woodchips to prevent hedges depletion.
- The local woodchips value chain can promote the creation of local jobs, 3 or even 4 times more than classic oil or gas value chains.



An open-air warehouse for woodchip storage.

Credit: Scierie Abies-Bois



watch videos

FURTHER INFORMATION

¹Data from the PEGASE statistics, French Ministry of Ecology, Sustainability and Energy

²Case study made by the association Bois Energie Bretagne in 2010, France.

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24 JUNE 2019

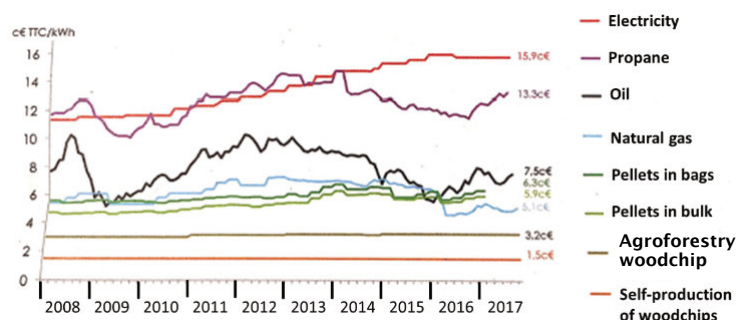
ADVANTAGES AND DISADVANTAGES

A profitable alternative, that requires sustainable management practices on the field

With the increase of fuel prices, wood-fuel now appears as a valuable energetic alternative. It can significantly decrease the cost of heating (1.5 ct€/kWh against 15.9 ct€/kWh for electricity or 5.1 ct€/kWh for natural gas¹) for collective buildings (e.g. schools, hospitals, offices). However, the installation cost for a woodchip heating system is higher than one powered by fuel or propane. For example, to heat a 260m² house, the total installation cost for a fuel heating system would be around 8,500€, against 26,000€ for a biomass heating system. The savings while using a biomass facility would be around 150€/month, and the overcost of installation paid in only 5 years².

Promoting the local woodchip value chain is also a way of supporting the creation of jobs locally (3 or even 4 times more than gas or oil value chains). More than 22 SMEs processing and selling woodchip from pruning hedges were created these past years in France³. Moreover, this heating alternative is also a way of decreasing CO₂ emissions, especially because the woodchips are sourced locally, reducing the transport footprint compared to gas or fuel.

This new opportunity could also have drawbacks, though. When demand increases, there are always risks that sourcing is done without sustainable practices, depleting hedges and eventually leading to their destruction. Traceability is a key factor to avoid this situation. Several initiatives in France are tackling this issue and are promoting quality labels to guarantee best sourcing practices of the raw material.



Price evolutions of various sources of heating energy in France

Source: French Ministry of Ecology, Sustainability and Energy

LEARNING BY DOING AND SHARING, A WAY TO IMPROVE AGROFORESTRY KNOWLEDGE CREATION AND EXCHANGE AMONG PRACTITIONERS

The example of the Agr'eau programme, an initiative designed for and by farmers in France



THE WHAT AND WHY

Purely academic approaches do not allow a full learning of agroecology principles

Knowledge transfer is one of the key axes for the development of innovative practices such as agroforestry. Agronomy, ecology, tree management, etc. are already particularly complex fields of expertise when undertaken separately, so composite subjects such as agroecology or agroforestry require an even deeper understanding of interdependent varying factors and interactions between components at the system level. Theoretical approaches cannot provide the whole set of skills needed; it can lead to forgetting crucial points for sustainable agroforestry

development at plot, farm, and landscape scale. Knowledge creation and exchange therefore must be implemented in a context-specific approach and be farmer-centered. One such example is the methodology used within the **Agr'eau regional development programmes** and implemented at a water catchment level in France. The aim of this initiative is to encourage collaborative development of optimal farming practices, taking a landscape approach to soil, water, and resource management.



Field trip to Jérémy Auzeral's farm, Lot-et-Garonne, France, 2018.
Credit: Association Française d'Agroforesterie



Students in Agricultural sciences visiting Michel Nedellec's farm, Gers, France, 2018.
Credit: Association Française d'Agroforesterie

HOW IS THE CHALLENGE ADDRESSED

Mixed trainings and on-farm events to optimize sharing and emergence of ideas

From the beginning, the Agr'eau programmes were designed to build a community of practitioners and experts, and foster exchanges between the different stakeholders evolving in and around the agricultural sector (farmers, foresters, natural resource managers, decision makers, scientists, teachers, etc.). Since the launching of the first pilot programme in 2013 (established in the Southwestern Adour-Garonne water catchment), more than 1,000 events were organized, gathering around 30,000 people in total. In the same time, nearly 700 farmers and advisors were trained

with a mixed methodology of digital learning, lectures, field trips and technical days. The main focus of the Agr'eau programmes is on training the practitioners (lifelong learning), but partnerships with agricultural colleges are also an important objective. Resources are regularly published online as newsletters and in the press through technical magazines. Last but not least, open days at innovative farms from the Agr'eau network are a good opportunity to reach an ever wider audience and encourage a reconnection between producers and consumers.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Learning; teaching; pedagogy; training; knowledge

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HIGHLIGHTS

Agroforestry practices are being (re)invented in the field every day, based on local observations and sharing of site-specific experiences among practitioners. The Agr'eau programmes, implemented at a catchment scale in the four corners of France, are aiming to foster this "learning by doing" process allowing for collaborative grassroots development of improved farming practices, while taking a landscape approach to soil, water, and resource management. Farmers, advisors, natural resource managers, researchers, teachers, and even the agri-food sector are now involved in this continuous improvement process encouraging a faster and more appropriate sustainable farming transition at regional level.



Technical day at Pierre Pujos' farm, Gers, France, 2018.
Credit: French Agroforestry Association

FURTHER INFORMATION

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Balaguer, F. 2017. Agr'eau: developing a resource-efficient, ecofriendly climate-smart agriculture across the Adour-Garonne basin (South-West France). French Agroforestry Association; power point presentation for the Agroforestry 2017 Conference – Cranfield University, 22 June 2017.

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ADVANTAGES AND DISADVANTAGES

From Fork to Fork - Towards market integration for agroforestry and agroecology

In the past two years, Agr'eau has started to build on its network of farmers and stakeholders to involve the rest of the value chain (cooperatives, industries, wholesalers, collective catering companies, etc.) in the agroforestry/agroecological transition.

There has long been felt a need to create an entity that could play the role of a platform able to integrate vertically the major players of these new production/processing/distribution chains, and to reach out horizontally to a wide range of consumers. This is the main mission of the movement **Pour une Agriculture du Vivant** (PADV), created in 2018 to gather private companies in direct relation with national farmers associations and assisted by local organisations and advisory offices specialising in agroecology/agroforestry development. PADV is laying the foundations in France for an integrated and ambitious agroecological production-distribution approach on a large scale, from corporations in the private sector and high-level political commitment, to engagement from farmers.

As PADV provides services to food companies by helping them create sustainable distribution chains and identifying producers that fit specified agroecology and agroforestry standards, the additional value is being reinvested in applied research and assistance to farmers for implementing permanent soil cover, low soil disturbance, low phytosanitary interventions and tree reintroduction in landscapes. By bringing the subject to the wider audience (consumers), this project is a major opportunity to involve every citizen in agroforestry development and to reach beyond practitioners or specialised researchers.

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4 JULY 2019

"TREES IN THE FIELD" AS A SELLING ARGUMENT

Getting higher value for agroforestry products through dedicated marketing



THE WHAT AND WHY

Using agroforestry as a differentiation argument to get better market penetration and price

Agroforestry, being still a marginal form of farming nowadays in France, is not yet well-known by the consumers. However, we now know that this way of producing food, combined with a global agroecological approach, leads to more sustainable systems. Agroforestry goes beyond simple food production, providing ecological and social services. Various studies also suggest that those changes in practices tend to lead to higher quality products (taste and nutrition), improving the health and pleasure of the consumers.

Taking into account these characteristics, agroforestry products can be marketed as such, so as to provide added

value for the farmers and, probably as important, raise awareness among the wider audience. Some producers have already taken this opportunity and added to their marketing strategy an adapted story-telling to explain and display their practices. Today, a significant part of the market share is occupied by educated and increasingly demanding consumers who look for quality and meaningful purchases. This is a clear opportunity for agroforestry products that, if well-marketed, can comply with both expectations. In France, this marketing trend is adopted by both individual farms and the larger food value chain.



Ducks browsing shrubs at Péres family farm, Gers, France.
Source: fermedelapattedoie.fr

HOW IS THE CHALLENGE ADDRESSED

Taking advantage of agroforestry and put its services forth

The Péres family are French farmers producing ducks in Gers, an area that is well-known for its famous foie gras, a delicacy valued all over the world. However, the products from **La Ferme de la Patte d'Oie** are not like all the other ones: they come from a full-agroforestry environment with a long-term strategy of reintegrating trees in the farming landscape. The family planted wild cherry, walnut, linden, ash and many other species on their 20 ha of free-range plots, and circled them with diversified hedges. They did so to improve a lot of aspects of their business, but what they tirelessly repeat is that the presence of trees on the farm truly increases the global quality and value of their products. As Philippe Péres says himself: *"It is undeniable, products from agroforestry systems have better nutritional quality and taste. Yes they are ducks, but agroforestry ducks!"*. These practices are a real advantage that customers highly value, whether at farmers' markets or directly at the farm shop.

The marketing potential of trees on farms and agroforestry can



Example of two labels using agroforestry as a marketing argument in pig systems.

Source: noirdebigorre.com and gascondemontaut.fr



HIGHLIGHTS

- Agroforestry can be a selling argument and help differentiate products on the market.
- Today a significant share of the consumers demand more sustainable and meaningful food products, which is an opportunity for agroforestry farmers.
- Story-telling needs to be clear and easy to understand since agroforestry is still little known by the consumers.
- A lot of quality labels are now existing on the market, so it is important to get fully involved in raising awareness and popularizing the sustainable practices behind agroforestry, rather than just relying on a label.



The Bigorre Black Pig has now become a symbol for high-value agroforestry systems in France.

Source: porcnoir.fr

FURTHER INFORMATION

¹ 2018 annual report of the evolution of the organic market in (in French)

More information on the Bigorre Black Pig label initiative (in French): www.noirdebigorre.com and www.porcnoir.fr

Information on French agroforestry products (in French): Les produits agroforestiers, des paysages à déguster des valeurs à partager, 2015, Arbre & Paysage 32.

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ADVANTAGES AND DISADVANTAGES

Getting a better product differentiation and stimulate interest, but avoiding confusion

Taking the example of the organic market in France, with a double-digit growth every year (+15.7% in 2018 reaching 9.7 million euros¹), it is clear that an ever growing portion of the consumers are moving toward more sustainable and meaningful products. More generally, an efficient story-telling can bring more to the consumers than just the benefits of the product. It helps them understand how the product was made and feel closer to the producer. These two factors are key to differentiate one's product, an important advantage in nowadays market, flooded with homogenized goods.

However, these past few years, numerous labels appeared on the market, official and unofficial, bringing some confusion and scepticism to the consumer's mind. Creating an official "agroforestry" label does not seem realistic and could even be ineffective. Agroforestry gathers a whole range of practices to be adapted to each context, and setting fixed technical specifications could make no sense to promote sustainable development on the field.

Only a consistent and clear marketing strategy involving all the actors of the value chains can have good results for a large scale change, together with individual approaches using the direct sale channel.



watch video

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24 JUNE 2019

FERTILISATION IN AGROFORESTRY SYSTEMS

Increasing the productivity of agroforestry systems



THE WHAT AND WHY

Fertilisation and productivity of agroforestry systems

In the agroforestry systems the short-term production is often limited due to an inappropriate soil fertility management. The use of inorganic and organic fertilizers can enhance the soil fertility at the same time that the productivity of the agroforestry systems (of both the understory and the woody perennials) is increased. The main difference between inorganic and organic fertilizers is the amount of fertilizer that should be added into the soil to fulfil crop needs that is usually higher with organic fertilizers due to the lower nutrient content they have compared with the main

inorganic fertilizers. One option adopted in many countries around the world is the use of manure or sewage sludge as organic fertilizers due to their low cost compared with mineral fertilizers and their specific organic matter and macronutrient content, particularly nitrogen. Moreover, the use of this type of residue as fertilizers contribute to the Circular Economy strategy adopted by the European Commission, which proposes that when a product reaches the end of its life, it should be used again to create further value.



Pasture production in silvopastoral systems established with *Pinus radiata* D. Don in acidic soils of Galicia (NW Spain) fertilised with dairy sludge
Santiago-Freijanes, JJ

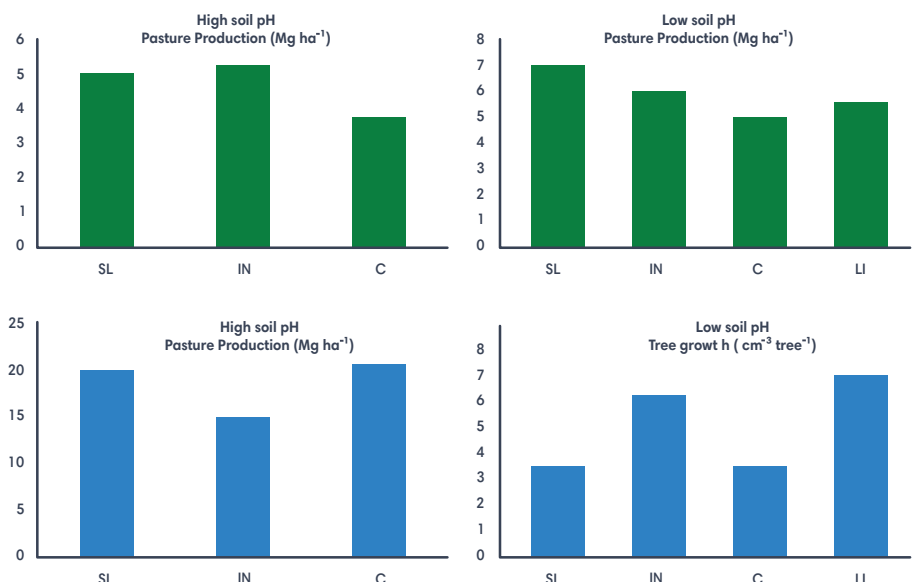


Figure 2. Pasture production and tree growth after sewage sludge (SL), inorganic fertilizer (IN) and lime (LI) applications compared with the control treatment (C) in soils with high and low pH. Mosquera-Losada, M.R.; Ferreiro-Domínguez, N.

HOW IS THE CHALLENGE ADDRESSED

Impact of fertilisation on the crops and tree production

In the agroforestry systems the impact of inorganic and organic fertilizers on crops and tree production mainly depends on the type of soil. Inorganic fertilizers are usually associated to soil acidification as it promotes the extraction of cations. In acidic soils, organic fertilizers generally increase soil pH of acidic soils due to its high level of cations and the long term nutrient release increasing both pasture and tree production. In agroforestry systems established in soils with water pH close to 7, mineral fertilisation tends to increase the pasture production that is in detriment of tree growth. However, when organic fertilizers such as the sewage sludge are applied both tree and pasture increase

their growth due to the inputs of nutrients and organic matter to the soil (enhance of the water holding capacity). In very acidic soils, the fertilisation with mineral usually enhances tree growth but not pasture production which increases when the organic fertilizers are applied because this type of fertilizers reduce soil acidity that make possible for the pasture to use the applied nutrients. In silvopastoral systems, the inorganic and organic fertilizers also modify the pasture biodiversity as those pastures with increased production have a higher proportion of monocots (grasses) than those where pasture production is low, which has a higher proportion of dicots.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Soil fertility, production, biodiversity, inorganic fertilizer, organic fertilizer

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HIGHLIGHTS

- The fertilisation increases the productivity of agroforestry systems
- The use of organic fertilizers (e.g. sewage sludge, manure) allows the adoption of the circular economy concept in the agroforestry farms
- The impact of inorganic and organic fertilizers on crops and tree production depends on the type of soil
- The integration of trees in agricultural areas could be a solution to the problem of excess nitrogen in the environment due to the addition of organic and inorganic fertilizers to soils



Silvopastoral system established under *Fraxinus excelsior* L. and fertilised with different types of sewage sludge (anaerobic, composted and pelletized).

Fernández-Paradela, P.

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JUNE 2019

ADVANTAGES AND DISADVANTAGES

Aspects to bear in mind

When the inorganic and organic fertilizers are applied in agroforestry systems several aspects should be considered:

Agronomic aspects: in the agroforestry systems, both organic and inorganic fertilizers provide plants with the nutrients needed to grow. However, each type of fertilizer supplies these nutrients in a different way (organic fertilizers are characterized for a slow release of nutrients) and therefore its effect on the components of agroforestry systems is also different.

Environmental aspects: environmental restrictions play a role in the practical application of inorganic and organic fertilizers because an application rate that exceeds the crop needs could result in nitrate contamination of the ground-water by leaching. However, in agroforestry systems the nitrate-leaching risk tends to be lower than in areas with conventional agricultural systems due to the different localisation of tree and crop roots which enhance nutrient uptake. Therefore, the integration of trees in agricultural areas could be a means of addressing the problem of the excess of nitrogen in the environment resulting from the addition of organic and inorganic fertilizers to the soils. Moreover, when the sewage sludge or other types of residues are used as fertilizers, their heavy metal concentration must be considered to avoid an increase in inorganic soil pollutants. Indeed, this heavy metals concentration, mainly Zn and Cu, is higher than normal levels in soil and it is regulated by the European Directive 86/278/EEC.

Economic aspects: one of the main disadvantages of the use of inorganic fertilizers in the agriculture is their price which has increased in the last years as consequence of the lack of resources of some of them (Phosphorous) but also the high economic and environment cost they have (Nitrogen). For this reason, the inorganic fertilizers are promoted to be replaced by organic fertilizers (e.g. sewage sludge, manure) which provide a cheaper source of main nutrients (N, P) as well as organic matter. Moreover, it is important to be aware that in the agroforestry systems the amount of fertilizer needed is generally lower than in conventional agricultural systems due to the recycling of nutrients through trees which reduce the production costs of the farms. Moreover, the use of organic fertilizers such as sewage sludge allows the adoption of the circular economy concept in the agroforestry farms in order to achieve a more sustainable consumption and production.

Management aspects: inorganic fertilizers offer the advantage of coming in several easy to use formulations, which also makes them much easier to transport, storage and spreads than organic fertilizers like sewage sludge or manure. These organic fertilizers have a high proportion of water which can be reduced by 98% through thermic treatments, thus facilitating its management through the production of pellets.

SHADE TOLERANT GRASSES AND LEGUMES

Forage use



THE WHAT AND WHY

How you could improve understorey forage production in silvopastoral systems?

Silvopastoral systems are designed to simultaneously produce timber/fruit/wood biomass in the long term and high-quality forage resources and efficient livestock production thus ensuring short-term and continuous cash flow. These current income sources should be explored by careful selection and management of livestock and forage components to be developed under the trees. The choice of appropriate forages will depend on particular characteristics of the site and the aim. Locally adapted

perennial crop species, productive under shade stress and tree competition conditions must be considered by farmers operating in Atlantic and Continental European climates. Farmers may want to choose grass genotypes/species or mixtures of grasses and legumes to provide feed with improved palatability, nitrogen content, protein yield and digestibility. There are several promising species for Atlantic and Continental climate silvopastoral systems that could be recommended as a forage.



Agroforestry systems of the Mozsi Ranch. Ref : Mozsi Ranch, Sellye, Hungary
Cattle grazing at a silvopastoral farm, Poland, Ref: OIKOS Farm, Krzywa, Poland

Orchardgrass (*Dactylis glomerata*), an ideal grass to be used in silvopastoral systems

Caucasian clover (*Trifolium ambiguum*) has developed many adaptations to shade conditions.

HOW IS THE CHALLENGE ADDRESSED

Discover the best forage species for your system

Agroforestry farmers in Atlantic and Continental climates should focus on shade-tolerant forage species with higher palatability and percent of crude protein, protein yield and feed value but also plant species with higher performance under shaded conditions compared to sunny open places. Such species are more likely to maintain biomass and quality as trees grow and canopies close (Pang et al. 2017). Many of the top shade-tolerant species described for North America have been found to be adapted to shade in Continental Europe as well and some of them are recommended as forage shade-tolerant species by extension services or seed companies. The most promising cool season forage grass species are to be: orchardgrass (*Dactylis glomerata*) (also tested as an excellent shade-tolerant species in Galicia); tall fescue (*Festuca arundinacea*); red fescue (*Festuca rubra*) and reed canary

grass (*Phalaris arundinacea*) (the last one is considered an invasive plant, be careful). Among leguminous crops, Caucasian/kura clover (*Trifolium ambiguum*), crimson clover (*Trifolium incarnatum*) and red clover (*Trifolium pratense*) were recommended. Some cultivars of perennial ryegrass (*Lolium perenne*) (Prończuk and Prończuk 2008) and Kentucky bluegrass (*Poa pratensis*) show satisfactory adaptability to shade. However, typically a species/cultivars mixture is used in order to ensure stability and optimal quality of the sward. This means that grass and leguminous species, varieties and cultivars have enough plasticity to grow under shade and in open sites. Usually, grass species are better adapted to shade than leguminous species that are generally more temperature and light demanding than grasses. Therefore, it is very important to evaluate the varieties/cultivars better adapted to local conditions.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727872.

Keywords: Silvopasture; shade tolerance; feed value; crude protein; yield; site adaptation

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HIGHLIGHTS

- Appropriate legume and grass species, varieties and cultivars should be selected to be sown under shade under given conditions
- Shade delays the best moment for grass/legumes to be harvested extending the growing season
- Grasses are usually better adapted to shade than leguminous species



Experimental plots in a silvopastoral system established in Galicia (NW Spain).

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Content editor: Maria Rosa Mosquera-Losada (USC)

SEPTEMBER 2019

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ADVANTAGES AND DISADVANTAGES

Optimize forage quantity and quality

Interaction of agroforestry components

Trees can protect forages against winds, frosts and summer drought by reducing evapotranspiration, allowing an extended grass growing season. Increased botanical diversity is observed when both underneath and far away from tree canopy habitats are considered, compared to open grasslands. Impact of tree shade on forages may be negative in soils with strong water restrictions, as trees can consume large amounts of water, which might limit the growth of the forages, particularly on sandy soils; they can delay maturity of understorey plants and have an impact on general resistance of plants against stress conditions as well. Moreover, in some cases, with high humidity, shade may improve conditions for the growth of shade-tolerant weeds and fungi infecting crops, and this can lead to severe yield losses under wet climate conditions. Some of these fungi are able to produce alkaloids that may cause animal poisoning. For instance, tall fescue has a mutualistic association with an endophytic fungus being a source of the ergovaline toxin. In this regard, although top performing shade-tolerant species should be planted under the trees, a mix of site-appropriate high-protein and disease-resistant species including legumes is recommended.

Shade-tolerant grass species recommended for mixtures in silvopastoral systems

Orchardgrass (*Dactylis glomerata*)

Highly competitive under shade conditions. Very resistant to cold. Tolerant of acid and poor fertility soils but not growing on wet areas. Very valuable forage plant for beef and sheep.

Tall fescue (*Festuca arundinacea*)

Grows well on acid soils. Adapted to wet areas and does not tolerate dry soils. Resistant to cold temperatures and droughts. Due to deep roots, may be used in eroded areas.

Red fescue (*Festuca rubra*)

It prefers well-drained soils but tolerates poor fertility and periodically dry stands. Good winter hardiness. Resistant to animal trampling. Good plant for controlling erosion.

Shade-tolerant leguminous species recommended for mixtures in silvopastoral system

Caucasian clover (*Trifolium ambiguum*)

Persistent perennial plant. Tolerates continuous heavy grazing. Adapted to acid soils and soils where phosphorous is limiting. Resistant to pests and diseases. It is very tolerant of cold conditions and drought.

Crimson clover (*Trifolium incarnatum*)

Annual plant. Continuous grazing pressure at a moderate stocking rate may be beneficial to the plant as it limits fungal diseases. Deep rooting. Not tolerant of heavy acid and alkaline soils.

Red clover (*Trifolium pratense*)

Short-lived perennial plant (2-4 years). Recommended light rotation grazing since trampling destroys crowns. Deep rooting. Grows on a wide variety of soils, optimal soil pH above 6 with adequate Ca. Drought tolerant.

Fertilization

Fertilization of grasslands should be carefully considered, and phosphorous and potassium should be provided in sufficient amounts to cover the demands of the grassland mixture. Leguminous are especially dependent on phosphorous and potassium as this family is considered a “luxurious consumer” of potassium. Moreover, nitrogen inputs should be restricted if an adequate proportion of leguminous is expected. A high nitrogen level in soil is associated with legume development, while in grass dominant swards soil nitrogen is low.

Protein yield and digestibility

Digestibility of grasslands is usually negatively associated with the ageing of grasses and generally positively associated when the legume proportion in the grassland is increased. However, some dramatic problems may appear when an excess of legumes appears in the grassland due to the delay of the flowering caused by the shade. On the other hand, flowering delay could increase the intake of protein by livestock reducing the needs of external inputs such as concentrates. Digestibility is depending as well on the share of individual grass species in grassland and selection of best yielding and quality cultivars mix under given conditions.