Research and Development Protocol for Agroforestry for Free-Range Pig Production in Denmark

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Contents

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1 Context

The AGFORWARD research project (January 2014-December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to the second objective. It contributes to the initial research and development protocol (Milestone 5.3 (MS22) for the participative research and development network focused on the use of agroforestry in free-range pig production systems.

2 Background

Integration of trees with crops and/or livestock production (agroforestry) has been identified as a sustainable way to increase the productivity of land and to provide a number of ecosystem services and environmental benefits compared to disaggregated agricultural and woodland systems (Smith et al., 2011). When combined with livestock production it is expected to improve animal welfare i.e. because the crops provide the pigs a more natural and stimuli-rich environment with good possibilities for seeking shade in hot seasons as well as shelter in cold seasons (Horsted et al. 2012).

Agroforestry for livestock production is still only very rarely implemented in Denmark. Whereas agroforestry systems for free-range poultry are relatively common, agroforestry in free-range pork production is still very scarce. Only two organic pig producers have established energy crops (willow and poplar) in paddocks for lactating sows. According to farmers and farm consultants, one important reason for this is lack of knowledge of how to establish a profitable agroforestry system with pigs (Kongsted 2014ab). A synthesise of existing knowledge of 'best practice' is needed to support implementation of agroforestry in free-range pig production.

Free-range pig production as currently practiced in Denmark with relatively high stocking densities and large inputs of N from concentrate is associated with high risks of nutrient leaching, especially in farrowing paddocks (Eriksen et al. 2006). The risk of nutrient leaching in these systems is amplified because it is difficult to maintain plant cover due to the pigs' inclination for rooting.

We have previously found indications of a reduced risk of nutrient leaching from integrated production of free-range growing pigs and energy crops compared to the current pasture-based system (Sørensen et al., 2010). This is possibly caused by the deep root system of energy crops with large nutrient uptakes across a long growing season (Jørgensen et al. 2005). However, a more fundamental quantification of the environmental consequences when integrating energy crop and pork production is lacking. Especially the reduction of nutrient leaching when establishing energy crops in paddocks for lactating sows needs to be thoroughly quantified.

On this background two activities are implemented: 1) synthesizing knowledge of best practice and 2) estimating impact of trees on N- leaching and animal welfare for farrowing sows. The second activity is carried out as an extension of another project which is funding the establishment of Suction cups for estimating N- leaching.

3 Synthesise existing knowledge of 'best practice'

3.1 Objective

The objective is to identify and communicate 'best practice' in relation to design and manage an agroforestry system for free-range pig production. Guidelines on integrating trees and/or shrubs in free-range pig production systems will be produced, e.g. with regards to tree species, tree density, animal density and design and management of the system.

3.2 Materials and methods

Data, information and experiences gathered at commercial farms and research plots will be combined with theoretical knowledge. Five steps will be carried out as shown in Table 1.

Table 1. Collection of data, information and experience

Step	Activity	Time
Literature review	Literature from Denmark and abroad will be reviewed. Existing knowledge will be analysed and discussed.	Until May 2016
Interviews	Interviews of pork producers, consultants and forestry/horticulture experts will be carried out	Jan-April 2016
WP5 skype meeting	Meeting with partners from USC and VEN	May 2016
WP5 workshop	Workshop with partners from USC and VEN to compile collected knowledge from Spain, Italy, and Denmark	May 2016 (General Assembly)
Publication	Producing report	August 2016

4 Nitrate leaching with integration of energy crops and free range pigs

4.1 Objective and hypothesis

The objective is to evaluate nutrient emissions, crop damages, crop yields and animal behaviour in a combined energy crop and pig production system.

We hypothesize that integrated production of free-range pigs and trees will reduce nutrient leaching and simultaneously improve pig welfare compared to the present pasture based system.

4.2 Materials and methods

A comparative study including paddocks for lactating sows will be carried out on a commercial organic farm in South West Jutland, Denmark from May 2015 to April 2016 (Table 2).

Table 2. Description of the site, soil, tree, livestock, and climate characteristics.

Site characteristics	
Area (ha):	
Co-ordinates:	55°34'38.1''N; 8°59'36.5''E
Site contact e-mail address	anneg.kongsted@agro.au.dk

Soil characteristics	
Soil type (WRB classification)	Podzol
Soil depth	
Soil texture (sand%, silt%, clay%)	Mixture of coarse and loamy sand.

Tree and understorey characteristics	
Tree species	Poplar (*Populus* spp.) established in 2009.
Understorey species	Grass clover

Livestock characteristics	
Livestock species and breed	Pig: Landrace x Yorkshire sows

Climate data	
Mean monthly temperature	8.3°C
Mean annual precipitation	744 mm
Details of weather station	

The experimental design is illustrated in Figure 1. In each of four farrowing batches, 21 ringed sows (Landrace x Yorkshire) will randomly be assigned to 21 individual paddocks (10 m x 33 m) with a) grass clover and a zone of poplar trees where the sows have access to the trees, b) clover grass and a zone of poplar where the sows have no access to the trees or c) solely clover grass (Table 3).

Table 3. Description of the treatments (1 pig for each of 7 replicates of each treatment).

Treatments		
Solely clover and grass	Clover and grass bordered by poplar (with access provided to the trees for one sow and piglets)	Clover and grass bordered by poplar (with no access to trees for the sow)

The experimental paddocks with trees are arranged in a line. The 14 paddocks will be blocked in 7 with two adjacent paddocks within each block. Each of the two combinations of +/- access to trees will be randomly allocated to one of two paddocks within each block. The paddock with trees include two rows of poplar trees established 2009. The control paddocks with grass clover without trees are situated on another area on the farm. All paddocks will be supplied with an insulated hut with straw and a space allowance of approximately 4 m^2.

The sows stay in the paddocks approximately 1 week before farrowing until weaning after 7-8 weeks of lactation. After weaning of each farrowing batch, the paddocks will have a 'recovery' period of four weeks before the introduction of the next farrowing batch. A list of measurements is provided in Table 4. Carbon sequestration will be estimated by harvesting randomly chosen poplar trees in the experimental paddocks to quantify the additional biomass production from the area.

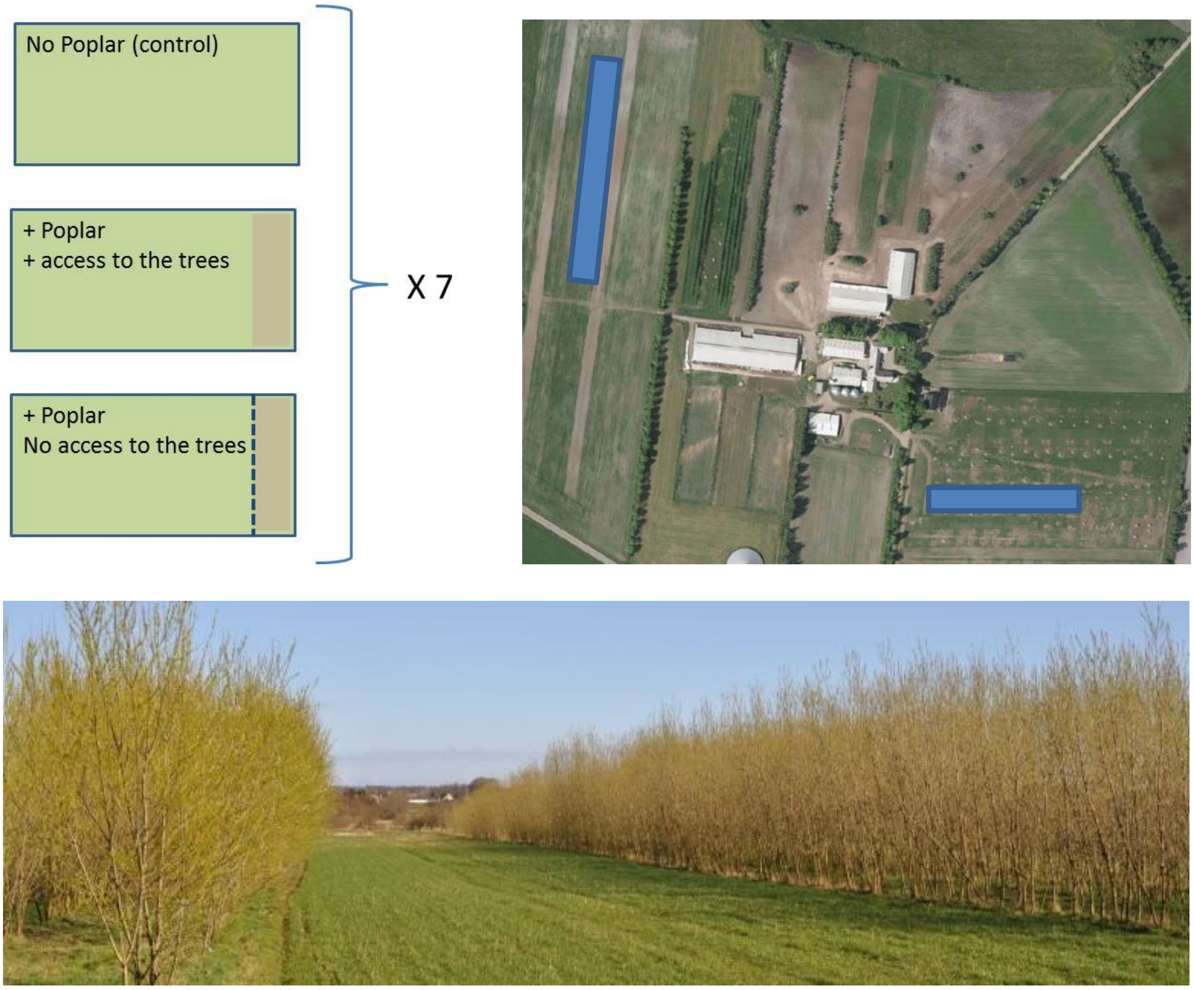

Figure 1. Experimental design, a map of the farm and the experimental paddocks *with* trees (left box) and the control paddocks *without* trees (the right box) and below a photo of the experimental area

Table 4. List of measurements

Variable	Measurements
Nutrient leaching	• Distribution of faeces/urine: all-occurrence samples of excretory behaviour[1)]
	• N and P in soil water: suction cups installed in each paddock at two distances from the poplar trees (one suction cup is installed in the poplar zone and one suction cup approximately in the middle of the grass area), regular collection of soil water every 14th day (except for very dry periods)[2)]
	• Inorganic N in soil: collection of soil at various depths[3)]
	• Overall nutrient load: calculated as input in feed and pigs minus the output in pigs[2)]. The weight of feed allocated to the individual paddocks will be estimated based on random control weighing of total amount of feed allocated to all the experimental paddocks combined with 'visual estimate' of the allocated feed to the individual paddock every 14th day.
Animal welfare	• Behavioural scan samples combined with all-occurrence sampling (sows and piglets): resting, general activity, exploration (rooting, grazing, pawing), stone-chewing, play, hyperventilating, frequency and length of suckling etc. [2,3,4)] • The paddocks will be divided into subzones and the location of the pigs will be recorded for each behavioural element.
	• Clinical observations[5)]
Crop damages	• Visual evaluation of crop damage (trees and grass sward) will be carried out regularly • Behavioural observations of sows and piglets (Biting off, rooting or chewing plant materials (branches, leaves and roots) from poplar crops)[1)]
Poplar biomass growth	• Stem growth: estimated by stem diameter changes on selected trees
Climate	• Air temperature, precipitation, wind speed etc. will be automatically • recorded every hour at an adjacent meteorological station

1) Horsted et al. 2012; 2) Eriksen et al. 2006; 3) Sørensen et al. 2010; 4) Kongsted et al. 2013, 5) Thomsen et al. 2012

5 Acknowledgements

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