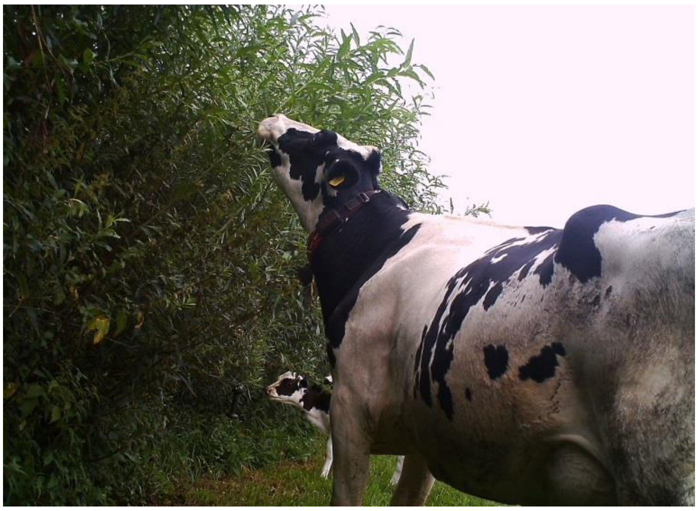

Lessons learned - Agroforestry for ruminants in the Netherlands

Project name	AGFORWARD (613520)
Work-package	5: Agroforestry for Livestock Farmers
Specific group	Agroforestry for ruminants in the Netherlands
Deliverable	Contribution to Deliverable 5.14: Lessons learned from innovations related to agroforestry for livestock
Date of report	15 August 2017
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Approved	John Hermansen and Paul Burgess (27 September 2017)

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 Objective 2 in that it focuses on the field-testing of an innovation within the 'agroforestry for livestock systems' participative research and development network. It is part of Deliverable 5.14: Lessons learned from innovations in agroforestry systems.

2 Background

Agroforestry systems with dairy cattle used to be common in the Netherlands but such systems are now relatively rare. Trees and shrubs in and around pastures used to be important landscape features, created a range of habitats promoting biodiversity, and played a functional role on farms. Dairy farmers in the Netherlands interested in agroforestry identified animal welfare and animal health as the most important positive aspect of trees for ruminants (Luske 2014). Furthermore, it is known that trees contribute to soil fertility and water drainage, while tree leaves could also serve as fodder (Hejcman et al. 2014; Vandermeulen et al. 2016).

To address the nutritional aspects of tree leaves for ruminants a test site was developed at an organic dairy farm (Luske 2015; Hermansen et al. 2015). On the test site willow (*Salix viminalis*) and alder (*Alnus glutinosa*) trees were planted in a trial field, which dairy cows (at intervals) could use for three dimensional grazing. As tree leaves can contain higher levels of macro and micro elements, browsing of leaves might be a natural supplement for cows (Luske and Van Eekeren 2014). The test site was used for monitoring the preference of the cows for different tree species and to estimate how much the cows would eat from the trees (Luske 2014). Additionally, the intake of macro and micro elements was calculated and soil characteristics under the tree rows were measured after several years after planting. Based on this background we present the lessons learned from the experiment.

More background information about the test site can be found in the system description report (Luske 2015 and Appendix A), and the research and development protocol (Luske et al. 2015).

3 Method

3.1 Preference test

In 2015, the trial field was used to monitor the preference of the cows for willow and alder leaves and twigs. From 1 May 2015 until 29 September 2015, the cows were allowed to enter the trial field and to browse from the fodder trees every alternate day. The trees were inspected for browsing marks three times during the growing season (on 27 May, 9 July and 19 November).

3.2 Browsing simulation

In 2016, the trial field was used to quantify browsing by a selected number of dairy cows. In February 2016 all trees were pruned at knee height and several exclosures were made where the cows were not able to browse from the trees. From 1 May 2016 until 30 September 2016 (150 days), on average of 2.5 dry cows were kept in the enclosure with the fodder trees where they could graze grass and browse from the fodder trees (except for the exclosures). On 14 September 2016, the browsing marks from three-dimensional grazing by dairy cows on the fodder trees were carefully studied in the enclosures. Subsequently, browsing was simulated in two exclosures by pruning the twigs that were at browsing height and of an appropriate browsing thickness, as observed in the enclosures. The simulated browsing samples were collected per metre of hedgerow (one browsing side of the tree row). Twigs and leaves were separated in the laboratory and the fresh weight of leaves and twigs was determined. Dry weight was determined by drying all samples at 70°C for 24 hours in an oven.

3.3 Calculate the potential intake of macro and micro elements

By combining the simulated browsing quantity and data on nutritional values of tree leaves (which were collected in 2013), we estimated the potential intake of macro and micro elements by three dimensional grazing on fodder trees by dairy cows.

3.4 Soil developments under trees

In December 2016 soil samples (20 cm x 20 cm x 20 cm) were taken at the site in the tree rows and in the grass-clover strips in between for soil biota (earthworm biomass and earthworm abundance). For all treatments (willow, alder and grass-clover) five samples were taken. A second round of mixed soil samples were taken in the tree rows and the grass-clover strips with an auger (25 cm deep) in January 2017. These samples were used for lab analyses to define soil organic matter levels, water saturation and nutrient levels (soil organic matter, N-total and P-total). One mixed sample was taken per treatment.

4 Results from experiments

4.1 Preference test

By studying the results of the summer season of 2015 we observed the following:

- More browsing marks were found on the willow cultivars willow (*Salix* L.) than on alder trees (*Alnus glutinosa*). Alder was hardly browsed by dairy cows.
- Between the two willow clones/cultivars, the number of browsing marks differed:
    - Wide growing willow trees had more edible twigs at browsing height. Almost all twigs within reach of the cows were browsed during the growing season.
    - In the case of the tall, fast growing willow cultivars, twigs at browsing height were primarily only present in the trees that had been pruned.

4.2 Browsing simulation

Measurements to quantify browsing were done on the wide growing willow clone (Table 1).

- In the enclosure all twigs within reach of the cows were browsed. We found on average 21 browsing marks per metre of willow hedgerow (on one side of the tree line).
- As a reference: In the exclosure, there were on average only 8.8 twigs that could be browsed. This shows that browsing (or pruning) of twigs stimulates the development of more new edible shoots.

Table 1. Browsing marks by dairy cows documented in the enclosures

	Range (min-max)	Average (± St. dev.)
Browsing height (cm)	80-190	139 ± 33.3
Twig diameter (mm)	2-9	4 ± 1.7
No. browse marks/running m fodder tree	8-35	21 ± 7.4

- Browsing simulations resulted in an average browse intake of 216 g of leaves and twigs per metre of fodder trees (fresh weight on one side of the tree row). In dry weight this corresponds to about 99 g of leaves and twigs. Transformation of these numbers gave the dry matter intake of fodder trees per animal per day (Table 2).

Table 2. Estimated intake of fodder trees per running meter hedgerow, transformed into g DM cow/day, assuming an average browse intensity of 2.5 dry cows for 150 days, with 280 m of hedgerow (both sides)

	Intake per running metre (g DM)	Browse intake (g DM/cow/day)
Leaves	53	40
Twigs	47	35
Leaves and twigs	99	75

4.3 Calculated potential intake of macro and micro elements

Crop analyses of willow leaves were completed on three occasions in the growing season of 2013 (16 June, 29 July and 10 September). Additionally, a literature study was completed on the levels of macro and micro elements in willow (Table 3).

Table 3. Average composition of willow leaves and twigs according to on site measurements and literature of different willow species (Azim et al. 2001; Becker and Nehring 1965; Douglas et al. 2001; Oppong et al. 2001; Kemp et al. 2001; Lavin et al. 2015; González-Hernández et al. 2003; MacWilliam et al. 2005; Moore et al. 2003; Nijboer & Dierenfeld 1996; Nijman 2002; Oppong 1998; Pitta et al. 2005; Pitta et al. 2007; Rahmann 2004; Robinson et al. 2005; Smith et al. 2012; Wroblewska 2009).

	unit per kg DM	Leaves (measured on site)	Leaves (literature data)	Leaves and twigs (literature data)	Twigs (literature data)	Grass (measured on site)
Dry Matter	g	304	373	399	464	267
Crude Ash	g	73	85	71	46	60
Digestible Organic Matter	%	52.2	70.1	58.2	49.2	60
Na	g	0.4	15	4	9	0.4
K	g	17.4	16.4	14.8	3	22.7
Mg	g	4.2	3	2.4	0.9	1.8
Ca	g	13.2	18.9	6.4	10.7	4
P	g	4.8	2.4	2.8	1.2	2.9
Mn	mg	301	215	82	40	83
Zn	mg	462	273	55	146	32
Fe	mg	119	94	84	36	85
Cu	mg	7.2	30.6	12.3	8.3	5.8
Co	µg	144	310		500	40
Se	µg	76	65		300	31
S	g	4.9	4.3		0.7	2.1
Mo	mg	1.6	1.4		0.1	4.7

By combining the data of the browsing simulations with the nutritional values of willow leaves, the potential intake of macro and micro elements per cow per day was calculated. The calculated intake of macro- and micro elements by browsing was compared with the daily requirements of macro- and micro elements for dry cows (12 kg DM/day) and lactating cows (19 kg DM/day) (CVB 2005) (Table 4). These calculations show that although the intake of browse material by the dairy cows was low, the intake of macro and micro elements was supplemented. In the case of sodium (Na), zinc (Zn), manganese (Mn) and iron (Fe) the intake reached up to 2-9% of the daily requirements.

Table 4. Intake of macro- and microelements per cow per day (for leaves based on site measurements, for twigs based on literature levels).

	Units	Leaves (40 g)	Twigs (36 g)	*Total (76 g)*	Proportion of daily requirement for dry cows (%)	Proportion of daily requirement for lactating cows (%)
Na	g	0	0.3	*0.3*	4	2
K	g	0.7	0.1	*0.8*	na	1
Mg	g	0.2	0	*0.2*	1	0
Ca	g	0.5	0.4	*0.9*	na	1
P	g	0.2	0	*0.2*	na	0
Mn	g	11.9	1.4	*13.3*	3	2
Zn	mg	18.3	5.1	*23.4*	9	5
Fe	mg	4.7	1.3	*6*	2	4
Cu	mg	0.3	0.3	*0.6*	0	0
Co	mg	5.7	17.5	*23.3*	2	1
Se	µg	3	10.5	*13.5*	1	0
S	µg	0.2	0	*0.2*	na	na
Mo	g	0.1	0	*0.1*	6	3

na: not available; daily requirements are unknown

4.4 Soil developments under trees

Soil sampling and observations on vegetation succession showed the effects of the trees on soil characteristics. Soil organic matter increased after three years for alder (0.3%) and willow trees (0.5%). No change of soil organic matter content was observed for grass-clover (Figure 1). Due to the limited number of samples (one mixed sample per treatment), no statistical analyses were done.

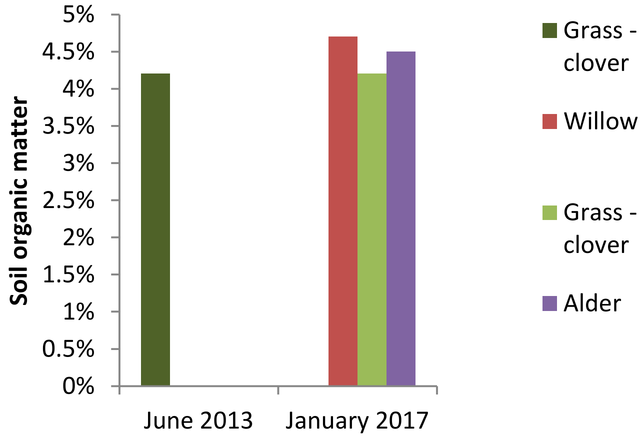


Figure 1. Effects of trees on soil organic matter (%), three years after planting

Soil moisture content was similar between willow and grass-clover. Alder showed the highest soil moisture content out of the three vegetation types (Figure 2). However, the soil samples were collected in January, and the soil was very wet, making it difficult to interpret the results. Additional measurements would be necessary to conclude this.

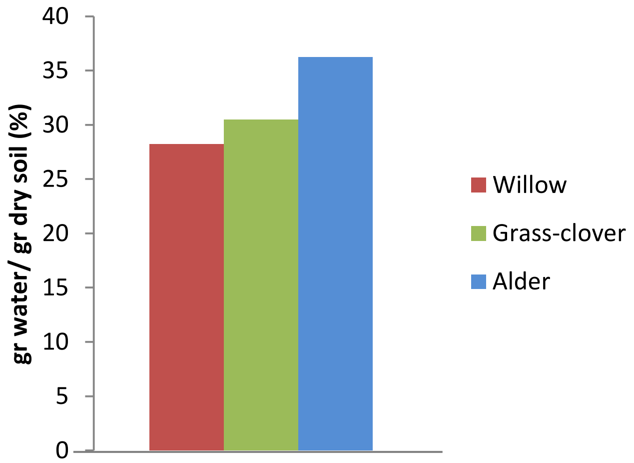


Figure 2. Moisture content of the upper soil, three years after planting (January 2017)

Total nitrogen soil content did not differ between grass-clover and trees (willow, alder) (Figure 3a). However, during summer nettles (*Urtica dioica*) were only dominantly present under the alder trees, which indicates relatively nitrogen- and phosphate rich conditions (Pigott and Taylor 1964). Higher P-PAE (availability of phosphate in the soil) was found for both trees, in comparison to grass-clover. A large increase was found for willow (65%) and a moderate increase for alder (13%; Figure 3b). Due to the limited number of samples no statistical analyses were completed for total nitrogen levels and available phosphates in the soil.

Figure 3. Total nitrogen level (a) and plant available phosphorus (b) level in the upper soil, three years after planting under the willow and alder trees, and the grass-clover in 2017

Earthworm biomass (g/m^2) and earthworm abundance (nr/m^2) under different vegetation was assessed in December 2016. After transformation of the data, the mean earthworm biomass was significantly ($p<0.05$) lower under willow trees than under alder trees (Figure 4a). The same applies for earthworm abundance (Figure 4b). We can conclude that the use of trees in general does not directly result in increased earthworm biomass, as it depends on the tree species. Alder has a positive effect compared to willow. This might be an indirect effect due to increased mineralization under alder trees (due to nitrogen fixation in root nodules) or dry soil conditions under willow (or both).

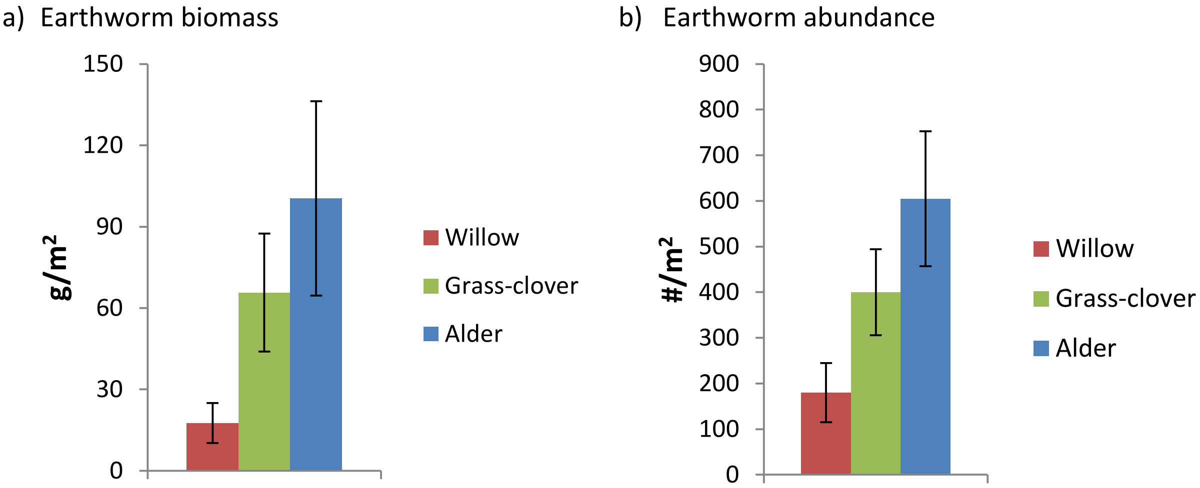


Figure 4. Earthworm biomass (a) and earthworm abundance (b) under willow and alder tree rows and grass-clover, three years after planting. Error bar display SEM.

5 Main lessons

- Dairy farming in the Netherlands is mostly a combination of spring/summer grazing, grass silage with the addition of maize silage and concentrates. The use of concentrates has increased from 0.8 to 2.06 tonnes per cow per year resulting in doubling of the average milk production per cow (Van den Pol-van Dasselaar et al. 2015). Mineral supplements are used to fulfil the daily requirements of macro- and microelements. Therefore, we investigated the potential of trees to supplement macro and micro elements requirements.
- Our measurements confirm earlier reports about the fact that tree leaves contain higher macro and micro element levels than grass (Rahmann 2004; Luske and van Eekeren 2017).
- The levels of some important macro and microelements in willow for dairy cows are promising. As expected, the intake rate of browse material is low: 0.6 and 0.4% of the required dry matter intake for dry and lactating cows respectively. Nevertheless, the intake of for instance sodium (Na), zinc (Zn), manganese (Mn) and iron (Fe) is reaching up to 2-9% of the daily requirements in this case study.
- We suspect that the rooting systems of trees reach deeper soil layers than grasses and therefore trees are able to take up more macro- and microelements, which become available for livestock via the leaves. The extent by which trees play this functional role is species specific (Luske and van Eekeren 2017).
- Due to the low intake rate, the risk for toxic levels of macro or microelements from fodder willow is negligible, also on clay sites where willow leaves can contain very high levels of some microelements (Luske and van Eekeren 2017).
- Dairy cows prefer willow (in general) over alder trees for browsing in this trial. Just a couple of browsing marks were found on the alder trees, where in some rows all willow twigs within reach of the cows were browsed.
    - However it should be noted that the alder tree rows were not in the best condition, as the leaves were eaten by beetles of the species *Agelastica alni*. This probably affected the palatability of the leaves and twigs.
- Tree morphology (affected by cultivar and management) defines whether or not a willow tree can be used for three dimensional grazing by dairy cows.
    - Not all willow cultivars are suitable as a fodder tree for dairy cows. Cultivars especially selected for biomass production grow too fast and soon the new shoots become too thick at browsing height.
    - Willow cultivars with a wider tree morphology are best suited as fodder tree for three dimensional grazing. These willow cultivars require less intensive management than willow cultivars with a tall straight tree morphology, to be able to use them as a fodder tree. As dairy cows have many twigs within their reach, they can browse them and prune the twigs in a natural way.
    - Fast growing willow cultivars need to be managed as a ‘fodder hedgerow’, instead of a ‘fodder tree’. They need more intense management, but may have multiple uses in that way: as a fodder hedgerow and for biomass production. Harvesting the tree biomass every year promotes the development of new palatable shoots, twigs and leaves within browsing reach of dairy cows.
- The soil samples show that tree species significantly affects soil parameters like organic matter content, earthworm biomass and soil water content and also nutrient levels (P).

In general, we can conclude that trees and shrubs play multiple functional roles on dairy farms in the Netherlands. Apart from shade and shelter (animal welfare) and landscape aesthetics, we learnt that the trees tended to increase soil organic matter and available phosphorus levels in the upper soil. Alder tends to increase total nitrogen levels. Furthermore we measured significant differences in earthworm biomass and earthworm abundance under willow and alder trees. Under alder trees we found higher earthworm numbers and higher earthworm biomass. As earthworms stimulate soil mineralization, this indicates that alder trees play a functional role for increasing soil fertility. Furthermore, we measured the potential of willow to serve as a fodder resource. We learned that this potential is not about huge quantities of fodder biomass, but it shows that (in this case study) willow can add essential macro- and microelements to the dairy farming system like Na, Zn, Mn and Fe; elements which are often fed to dairy cows in grass fed dairy systems through mineral supplements.

6 Acknowledgements

The AGFORWARD project (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD, Theme 2 - Biotechnologies, Agriculture & Food. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

7 References

Azim A, Khan AG, Ahmad J, Ayaz M & IH Mirza (2001). Nutritional evaluation of fodder tree leaves with goats. Asian-Australasian Journal of Animal Sciences 15: 34-37.

Becker M, Nehring K (1965). Handbuch der Futtermittel 2. Band. Verlag Paul Parey, Hamburg und Berlin.

CVB (2005). Handleiding *Mineralenvoorziening*. Rundvee, Schapen, Geiten. Commissie Onderzoek Minerale Voeding centraal veevoederbureau. ISBN-10:9072839439 228 pp.

Douglas G, Foote A, Kemp P, Oppong S (2001). Browse yield and nutritive value of two Salix species and Dorycnium. Agroforestry Systems 51: 1–21.

González-Hernández MP, Karchesy J, Starkey E (2003). Research Observation: Hydrolyzable and Condensed Tannins in Plants of Northwest Spain Forests. Journal of Range Management, 56(5): 461-465. doi:10.2307/4003837

Hejcman M, Hejcmanová P, Stejskalová M, Pavlů V (2014). Nutritive value of winter-collected annual twigs of main European woody species, mistletoe and ivy and its possible consequences for winter foddering of livestock in prehistory. The Holocene 24(6): 659-667.

Hermansen JE, Kongsted AG, Bestman M, Bondesan V, Gonzalez P, Luske B, McAdam J, Mosquera-Losada MR, Novak S, Pottier E, Smith J, van Eekeren N, Vonk M, Burgess PJ (2015). Agroforestry Innovations to be evaluated for Livestock Farmers. Milestone 5.2 (MS 21) for EU FP7 Research Project: AGFORWARD 613520. 10 pp.

Kemp PD, Mackay AD, Matheson LA, Timmins ME (2001). The forage value of poplars and willows. Proceedings of the New Zealand Grassland Association 63: 115–119.

Kuzovkini YA (2015). Checklist for Cultivars of Salix L. (willow). International Salix Cultivar Registration Authority FAO -International Poplar Commission.

Lavin SR, Sullivan KE, Wooley SC, Robinson R, Singh S, Stone K, Russell S, Valdes EV (2015). Nutrient and plant secondary compound composition and iron-binding capacity in leaves and green stems of commonly used plant browse (Carolina willow; *Salix caroliniana*) fed to zoo-managed browsing herbivores. Zoo Biology 34:565-575. DOI: 10.1002/zoo.21244.

Luske B (2014) Agforward Initial Stakeholder Meeting Report. Louis Bolk Institute, Driebergen, NL

Luske B (2015) System report: Agroforestry for ruminants in The Netherlands. Contribution to Deliverable D5.13 (5.1): Detailed system description of a case study system Contribution to Milestone 28 (6.3): Database for description of agroforestry systems of EU FP7 Research Project: AGFORWARD 613520. 9 pp

Luske B, Vonk M, Bestman M (2015). Research and Development Protocol for Agroforestry for Ruminants in the Netherlands. Milestone MS22 (5.3) Part of experimental protocol for WP5 of EU FP7 Research Project: AGFORWARD 613520. 6 pp.

Luske B, van Eekeren N (2014). Renewed interest for silvopastoral systems in Europe: an inventory of the feeding value of fodder trees. p. 811-814. In 4th ISOFAR Scientific Conference. Istanbul, Turkey. 13-15 October 2014.

Luske B, van Eekeren N (2017). Nutritional potential of fodder trees on clay and sandy soils in the Netherlands. Agroforestry Systems, submitted.

McWilliam EL, Barry TN, Lopez-Villalobosa N, Cameron PN, Kemp PD (2005). Effects of willow (Salix) versus poplar (*Populus*) supplementation on the reproductive performance of ewes grazing low quality drought pasture during mating. Animal Feed Science and Technology 119: 69–86.

Moore KM, Barry TN, Cameron PN, Lopez-Villalobos N, Cameron DJ (2003). Willow (Salix sp.) as a supplement for grazing cattle under drought conditions. Animal Feed Science and Technology 104: 1–11.

Nijboer J, Dierenfeld SE (1996). Comparison of diets fed to Southeast Asian Colobines in North American and European zoo, with emphasis on temperate browse composition. Zoo Biology 15, 499-507.

Nijman M (2002). Bomen en struiken als Veevoer- Een alternatief voor het voeren van mineralen en sporenelementen aan biologische melkkoeien. Afstudeerscriptie Hogeschool Delft bij Louis Bolk Instituut.

Oppong SK (1998). Growth, management and nutritive value of willows and other browse species in Manawatut, New Zealand. PhD Thesis, Massey University, Palmerston North.

Pigott CD, Taylor K (1964). The distribution of some woodland herbs in relation to the supply of nitrogen and phosphorus in the soil. Journal of Animal Ecology 33: 175-185.

Pitta DW, Barry TN, Lopez-Villalobos P, Kemp PD (2005). Effects on ewe reproduction of grazing willow fodder blocks during drought. Animal Feed Science and Technology 120: 217-234.

Pitta DW, Barry TN, Lopez-Villalobos P, Kemp PD (2007). Willow fodder blocks - an alternate forage to low quality pasture for mating ewes during drought? Animal Feed Science and Technology 133: 240-258.

Rahmann G (2004). Gehölzfutter – eine neue Quelle für die ökologische Tierernährung. In: Landbauforsch Völkenrode Somderheft 272: 29-42. Bundesforschunsanhalt für Landwirtschaft (FAL).

Robinson B, Mills T, Green S, Chancerel B, Clothier B, Fung L, Hurst S, McIvor I (2005). Trace element accumulation by poplars and willows used for stock fodder. New Zealand Journal of Agricultural Research 48: 489-497.

Roder W (1992). Experiences with tree fodders in temperate regions of Bhutan. Agroforestry Systems 17: 263-270.

Smith J, Leach K, Rinne M, Kuoppala K, Padel S (2012). Integrating willow-based bioenergy and organic dairy production - the role of tree fodder for feed supplementation. In: Rahmann & Godinho (Ed) (2012). Tackling the Future Challenges of Organic Animal Husbandry. Proceedings of the 2nd OAHC, Hamburg/Trenthorst, Germany, september 12-14, 2012.

Van den Pol-van Dasselaar A, Aarts H, De Caesteker E, De Vliegher A, Elgersma A, Reheul D, Verloop J (2015). Grassland and forages in high output dairy farming systems in Flanders and the Netherlands. Grassland Science in Europe 20: 3-25.

Vandermeulen S, Ramırez-Restrepo CA, Marche C, Decruyenaere V, Beckers Y, Bindelle J (2016). Behaviour and browse species selectivity of heifers grazing in a temperate silvopastoral system. Agroforestry Systems: DOI 10.1007/s10457-016-0041-x

Wróblewska H, Kozik E, Czajka M (2009). Content of marco- and microcomponents in willow (*Salix purpureal* L.) grown in substrates with composts of post-use wood waste. Folia Forestalia Polonica 40: 23-30.

Appendix A. Description of the fodder tree test site

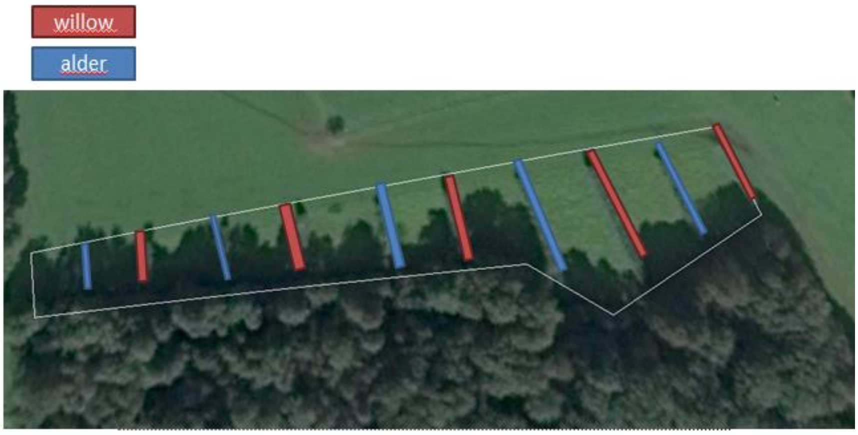
<table>
<tr><th colspan="2">Specific description of site</th></tr>
<tr><td>Area</td><td>Test site consists of 9000 m² with tree rows which is part of the pastures of organic dairy farm ‘De Kerkhoeve’</td></tr>
<tr><td>Co-ordinates</td><td>51°38’15.65”N; 5°12’27.58”W</td></tr>
<tr><td>Map of system</td><td>
Figure 5. Aerial view of the farm with silvopastoral trial site and its’ surroundings


Figure 6. Silvopastoral system design with 5 willow and 5 alder rows (twin rows)</td></tr>
</table>

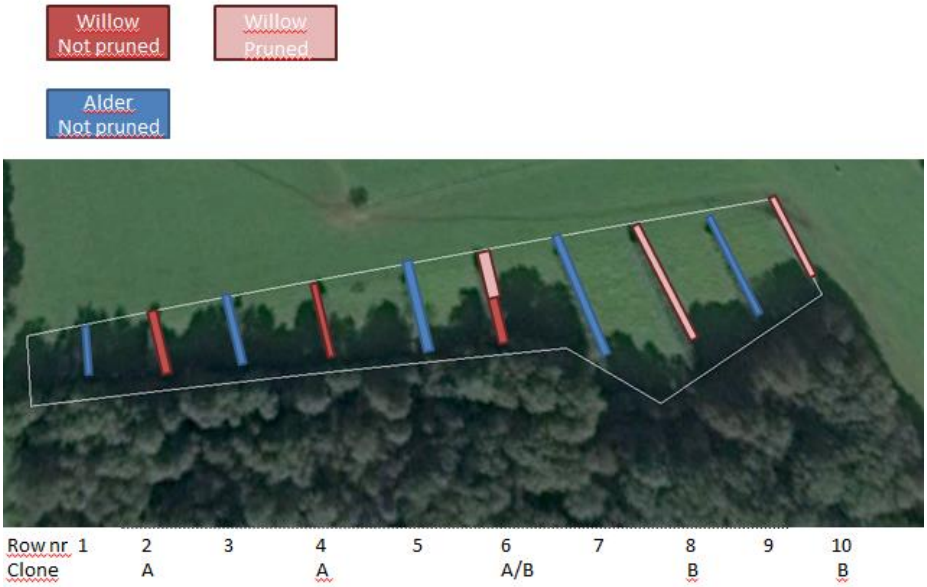


Figure 7. Situation in growing season of 2015

Figure 8. Situation in growing season of 2016 with two exclosures and locations of the soil sampling

Soil type	
Soil type	Sandy soil
Soil texture	Soil measurements have been done on 17th of June 2013: Clay: 3% CEC: 55
Additional soil characteristics	N total: 1710 C/N ratio: 12 PPAE: 2.3 pH: 5.6 Organic matter content: 4.2% Soil is too wet for grazing in autumn and winter period.

Tree characteristics	
Species and variety	Willow *Salix viminalis*: 2 cultivars. Cultivar A is wide growing, cultivar B (Klara), both originally from Sweden. (Kuzovkini, 2015) Common alder (*Alnus glutinosa*)
Date of planting	April 2013
Intra-row spacing	0.25 m between trees 0.7m between twin rows
Inter-row spacing	24m between centre of twin rows
Tree protection	Single line, electric.
Typical tree yield	April 2015: 2.5 twin rows of willow have been harvested at knee height. Yield was not determined. February 2016: All willow tree lines were harvested at knee height. Yield was not determined. March 2017: all willow tree lines were harvested. Yield ranged between 1,5 and 3 kg fresh weight per tree, depending on cultivar.
Crop/understorey characteristics	
Species	Grassland, including perennial ryegrass (*Lolium perenne*) and clover (*Trifolium repens, Trifolium pratense*) Nettle (*Urtica dioica*) developed under the rows with alder trees, probably due to nitrogen fixation by the trees.
Management	Cattle introduced for the first time in April 2015. Regular mowing for weeds.
Typical grass yield	Not determined.
Fertiliser, pesticide, machinery and labour management	
Fertiliser	Cattle grazing
Pesticides	None (organic)
Machinery	Tractor and mower
Manure handling	Not necessary in the field
Labour	Animals checked daily during milking (also by milk robot) or in case of dry cows in the enclosure
Fencing	Test site with fodder trees is next to a small piece of forest (south side), north and west of the test site are pastures accessible to the cows. On the east side are pastures of a different farm. There is electric fencing in between the forest and the neighbouring farm. Twin rows of fodder trees are protected with a single line (first electric, but later non-electric). In 2016 several exclosures were made with an electric single line.
Livestock management	
Species and breed	Holstein dairy cows.
Description of livestock system	Cattle are outdoors from March/April to Oct/Nov depending on weather, soil and water conditions. The animals are part of an organic dairy farm, with dairy cows and milking unit (robot) on the main farm (first building north of the test site). When an individual cow needs to be milked it walks by it self to the milking unit in the stable.
Date of entry to site	From 1st of April 2015, every other day all the cows have access to the fodder trees and the surrounding pastures. The cows could pass by the fodder trees several times a day by walking to the milking robot. In 2016 the test site was seperated from the other pastures and only dry cows were in the enclosure with the fodder trees from the 1st of May 2016.
Date of departure	Until 29th September 2015 (180 days) and 30th of September 2016 (150 days).

from site	
Stocking density	In 2015: 130 cows and calves have access to the trial field and time the surrounding pastures at the same In 2016: on average 2,5 cows were in the enclosure
Animal health and welfare issues	The tree rows were used for shelter from heat in during summer. Especially the young calves (that were kept with the mother cow in the heard the first weeks of their life) used the trees for shelter.
Requirement for supplementary feed	Protein and mineral supplements are provided after milking (half a doses per day, 100 grams of mixture minerals)
Financial and economic characteristics for maintenance	
Costs	- Management cost for mowing the grass of the trial field was slightly higher, because it took some more time to mow around the tree rows (1 hour per year) - Costs for weed management were slightly higher (2 hours per year) - Grass yield was the same or even higher as the old situation. Before, the grass was hardly grazed due to wet soil conditions of the trial field. In the new situation the pasture between the tree rows is a popular for grazing (and browsing). The calves used the tree rows for laying down beneath them.