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Integrating willow-based bioenergy and organic dairy production – the role of tree fodder for feed supplementation –

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Abstract

Silvopastoral systems that combine livestock and trees offer two main advantages for the animals. First, trees modify microclimatic conditions which can have beneficial effects on pasture growth and animal welfare. Second, trees also provide alternative feed resources during periods of low forage availability. This paper reports on research carried out within the Sustainable Organic and Low Input Dairying (SOLID) project to investigate the multifunctional potential of a novel integrated willow-based bio-energy/organic dairy production system in the UK, especially the role of tree fodder for feed supplementation in organic dairy systems. The nutritional value of two ages (1st and 2nd year re-growth) of short rotation coppiced willow was assessed in two seasons (late spring and late summer) in 2011.

Key words: Agro-forestry, silvopastoral, short rotation coppice

Introduction

Agroforestry, the integration of trees and agriculture, is valued as a multifunctional land use approach that balances the production of commodities (food, feed, fuel, fibre, etc) with non-commodity outputs such as environmental protection and cultural and landscape amenities (IAASTD, 2008). The EU Renewable Energy Directive sets a target for Europe to get 20% of its energy from renewable sources by 2020. The need to increase bioenergy production from biomass crops such as *Miscanthus* grass and short rotation coppice (SRC) has led to concerns that there will be increasing conflict for land between food and energy production. Agroforestry systems integrating SRC bioenergy crops and livestock or arable production can help reconcile these conflicting demands. This paper reports on research investigating the viability and multifunctional potential of a novel integrated willow-based bio-energy/organic dairy production system in the UK, especially the role of tree fodder for feed supplementation in organic dairy systems.

An integrated bio-energy and organic livestock production system

Agroforestry systems integrating SRC bioenergy crops and livestock or arable production can help reconcile conflicting demands for land use. Silvopastoral systems that combine livestock and trees offer two main advantages for the animals. First, trees modify microclimatic conditions including temperature, water vapour content or partial pressure, and wind speed, which can have beneficial effects on pasture growth and animal welfare (Bird, 1998; Karki and Goodman, 2009). Second, trees also provide alternative feed resources during periods of low forage availability, particularly in climates with seasonal droughts such as the Mediterranean (Papanastasis *et al.*, 2008). Browse from trees and shrubs plays an important role in feeding ruminants in many parts of the World, particularly in the tropics, and there has been considerable research into the nutritional potential and limitations of many tropical fodder species (Devendra, 1992). However, comparatively little is known about the potential of temperate browse species. The composition of tree fodder varies depending on a range of factors including tree species and cultivars, season, age of growth, climate, and plant part utilized (leaf vs stem).

Materials and methodology

This work is part of an EU FP7 funded project "Sustainable organic and low input dairying" (SOLID, KBBE.2010.1.2-02), which aims at supporting developments and innovations in organic and low input dairy systems to optimize competitiveness while maximising the potential of these systems to deliver environmental goods and biodiversity, and optimising economic, agronomic and nutritional advantages for the development of innovative and sustainable organic and low input dairy systems and supply chains. For more information on the project, see www.solidairy.eu.

This paper reports on research carried out to investigate the role of tree fodder for feed supplementation in organic dairy systems. The nutritional value of two ages (1st and 2nd year re-growth) of SRC willow was assessed in two seasons; late spring (June) and late summer (Sept) in 2011.

Figure 1. Wakelyns agroforestry short rotation coppice willow system with a legume-ley in the 12m wide alleys.

The integrated system is based on an alley-cropping design, with twin rows of SRC willow (*Salix viminalis*) separated by 12m wide alleys of pasture (Fig.1). The tree rows are orientated north/south to minimise shading effects in the alleys. The willow is harvested on a 2-3 year rotation, dried and chipped for use in wood chip boilers. Feed value of the willow is likely to vary depending on the age of re-growth and season of the year, and a better understanding of this variation is necessary in order to identify its potential for contributing to livestock nutrition. We hypothesised that the willow would be of highest nutritional value in spring, declining as plants mature through the summer as fibre and lignin contents and structural carbohydrates increase while crude protein content decreases. We also predicted higher feed value within 1st year re-growth compared to 2nd year re-growth.

Willow samples were collected from Wakelyns Agroforestry, an established silvoarable system in eastern England in June and September 2011. SRC willow was planted in 1998 and is harvested on a 2 year rotation. Samples were collected on 29th June and 14th September 2011 from both 1st and 2nd year re-growths of willow. Samples were taken from 5m long plots, with 4 replicate plots of each age class (total of 8 plots). The samples consisted of leaves and stems up to 8mm in diameter

as cattle have been shown to eat willow of 4-8mm diameter (Moore *et al.*, 2003). Samples were oven dried at 60°C until a stable weight was reached.

The feed values of the samples were analysed in the laboratory of MTT using standard methods. The digestibility of the samples was measured *in vitro* using a pepsin-cellulase based method (Huhtanen *et al.*, 2006).

Results and discussion

Table 1. Chemical composition and in vitro organic matter (OM) digestibility of willow samples harvested from 1st and 2nd year re-growth in late spring (June) and late summer (Sept) 2011

	1st year		2nd year		Statistical significance		
	June	Sept	June	Sept	Year	Season	Y*S
n	4	4	4	4			
DM[a] (g/kg)	265	378	359	420	**	**	**
In DM[a] (g/kg DM)							
Ash	70.8	72.5	63.6	63.7	*	NS	NS
Crude protein	167	127	125	99	**	**	NS
NDF[b]	573	492	548	503	NS	**	NS
ADF[c]	410	341	395	357	NS	**	*
Lignin	184	136	168	135	NS	**	NS
In vitro OM digest.	0.41	0.38	0.40	0.37	NS	**	NS

* significant at P<0.05 and ** significant at P<0.01

[a] DM: dry matter

[b] NDF: neutral detergent fibre

[c] ADF: acid detergent fibre

There were significant differences in the chemical composition of the different ages and seasons of willow samples (Table 1). As expected, crude protein levels were highest in late spring and higher in 1st year than 2nd year re-growth. We were surprised to find a statistically significantly higher level of lignin in the late spring samples as we expected lignin content to increase as the willow grew through the season. One explanation is that there was a greater proportion of stems in the late spring samples as the early growth stems would be more likely to be smaller in diameter than the 8mm limit. As expected, organic matter digestibility was higher in late spring than late summer, but overall was rather low at 0.38 to 0.41. This compares poorly with values from the research literature which recorded values for willow of up to 0.74 (Pitta *et al.*, 2007; Musonda *et al.*, 2009). Typically dairy cow forages have a much higher OM digestibility (hay 0.47-67; grass silage 0.52-0.67; grazed grass 0.64-0.75 (Ministry of Agriculture Fisheries and Food, 1990)). The similarity of the feed values in the 1st and 2nd year re-growths could be explained by the fact that branches mainly from the current growing season were harvested as the limit of the diameter of the branches collected was 8mm. While it is apparent that the feed value of the willow within this integrated system is limited, willow as a fodder may have a role to play as a buffer feed when grass is in short supply or of poor quality. In addition, low concentrations of secondary compounds such as condensed tannins found in tree fodder can have a beneficial influence by reducing protein degradation in the rumen and increasing the flow of protein and essential amino acids to the intestine (Rogosic *et al.*, 2006) although at high levels, these compounds may reduce digestibility and availability of protein, palatability and intake (Tolera *et al.*, 1997).

Suggestions to tackle the future challenges of organic animal husbandry

The unpredictability and variability in feed supply from organic agro-forestry systems seems to be one of the biggest challenges to their use at present as there are so many different species available

and the seasonal variation is so great. However, fast growing trees provide the potential for a large quantity of material, and can deliver a range of other benefits to animal welfare and the environment, in addition to providing a local renewable resource energy and diversifying farm economies.

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