Wood Chips from Hedgerows – Biomass Potential for On-Farm Mulching and Bioenergy?

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Key words: agro-eco-systems, soil protection, landscape, bioenergy

Abstract

Hedgerows are landscape features with ecological value and agricultural benefits which are appreciated in organic farming. Biomass from periodical cutting down of hedgerows is often unutilized litter. The study assesses different ways how to use wood chips from hedgerows, and quantifies the biomass potential for either mulching arable land with wood chips or, alternatively, for bioenergy use. The calculations are based on experiments at the experimental station for organic farming Kleinhohenheim and on literature. The yield of wood chips was clearly too low to mulch the total arable land of the model farm. Hedgerows on an area equal to 1% of the farm area yielded wood chips for 0.05 ha if 160 m^3 ha^{-1} were applied. This layer significantly reduced weeds. Hedgerows covering 5% or 20% of the farmland would provide wood chips for about 0.2 or 1 ha for mulching or, used as firewood, they would cover the corresponding fuel oil demand of more than one average household. Compared to poplars in short rotation coppice on the same area, the energy output is low. Since an energy use of wood chips is ecological and economical inefficient, mulching seems a reasonable way to use wood chips from cutting hedgerow, in spite of low yields. Wood chips should be applied to thoroughly selected areas, such as slopes (protection from soil erosion), crops with wide inter-row-distance or to perennial, high-value crops.

Introduction

Hedgerows have many functions and benefits in agricultural systems (Baudry *et al.* 2000). Organic Farming standards explicitly state the relevance of hedgerows for a sound agro-ecosystem. From time to time, usually in a period of 10–15 years, hedgerows have to be cut back to maintain the functions of a hedgerow. The material is mostly chopped to wood chips, and then often left on site unutilized. Safeguarding hedgerows would be facilitated if the "by-product" wood chips would produce some profit. Since the majority of the material is twigs and small stems with a high proportion of bark and moisture, the efficiency of wood fuel from hedgerows seems to be low. An alternative is mulching, e.g. for weed control, as presently done in ornamental gardening, in orchards or urban landscapes (Ferguson *et al.* 2004; Rathinasabapathi *et al.* 2005). Very little is known about the use of wood chips for mulch on arable land, and about the amount of biomass which can be produced by semi-natural hedgerows on a farm. The University of Hohenheim has established a long-term experiment to examine effects of wood chips mulch from hedgerows in an organic cropping system. Among multiple aspects of the experiment, the current paper focuses on productivity and should 1. assess the size of the hedgerow area which is needed to produce sufficient quantities of biomass for mulching a certain area of arable land; 2. discuss the alternative use of wood chips for bioenergy instead for mulching; 3. exemplarily

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contrast the productivity (biomass and energy yield) of hedgerows with the productivity from short rotation coppice (SRC). Simple linear scenarios based on the experimental station Kleinhohenheim as a case study should assess the biomass potential of hedgerows both for mulch and bioenergy, and point out approaches how to use wood chips from hedgerows best.

Materials and methods

Size and structure of the experimental station for organic farming Kleinhohenheim, Stuttgart, Germany, were adopted for this study, completed by additional data from literature for scenario calculations. The farmland is structured with hedgerows along the main field lanes, and at some field boundaries. Hedgerows are composed of autochthonous hardwood species. A section of the hedgerows is routinely cut down every year in a rotation of about 10 years, and the stems and twigs < 5 cm diameter are chopped by a disc wheel chopper. A part of the wood chips is then used in a field trial for mulching, and the rest is left on site. The total farmland is 60 ha, 40 ha of which is arable land. Wood chips were applied on arable land in an amount 80 m^3 ha^{-1} and 160 m^3 ha^{-1}. Several characteristics of the wood chips were determined in own experiments (Tab. 1). Further data on productivity of hedgerows and SRC were taken from literature. Simple scenarios were calculated to describe the productivity of hedgerows and of SRC from a calculative area. Wood chips would be used for energy only outside the farm, and the ash would not be returned to the fields.

Tab. 1: Basic data for calculation and discussion

Data from own experiments [1]		Literature data [2) 3) 4)]	
1 m^3 wood chips	= 0.4 t FM	Mean biomass production by hedgerows	5 t FM ha^{-1} a^{-1}
Water content of wood chips	36%	Mean biomass production by short rotation coppice	13 t DM ha^{-1}*a
C:N ratio of w. chips	47	Width of hedgerows	4 m
Bark weight of wood chips	25% of FM	Caloric value of wood chips from hedgerows	12.6 MJ kg^{-1} DM
Wood chips mulch applied	80 or 160 m^3 ha^{-1} a^{-1}	Caloric value of wood chips from SRC	18.5 MJ kg^{-1} DM
Application of N_t by mulch	4 kg m^{-3}	Caloric value of fuel oil	11.4 kWh l^{-1}
Application of C_t by mulch	189 kg m^{-3}	Energy consumption /household	3000 l fuel oil

1) Gruber et al. (2008), 2) Rösch 1996 (annual mean), 3) Boelcke (2006): 3-years rotation; FM: fresh matter, 4) calculated after Kaltschmitt et al. (2000); DM: dry matter, FM: fresh matter.

Results

A percentage of 1% hedgerows (Scenario 1, Tab. 2) on the total model farm area would equal to 0.6 ha, or a hedgerow length of 1.5 km. The wood yield from these hedgerows would be sufficient to mulch a maximum of 0.05 ha of arable land (recipient area) each year if 160 m^3 wood chips ha^{-1} were applied. The recipient area would be twice as much if 80 m^3 ha^{-1} were applied. Scenario 2 with 3 ha of hedgerows (7.5 km) would produce wood chips for a maximum of 0.23 ha recipient area, and in scenario 3, hedgerows on 12 ha land (30 km) produced biomass for mulching 0.94 ha. As a comparison, the annual energy yield of the same hedgerows ranged from 7 to 134 MWh, corresponding to a fuel oil equivalent of approximately 600–12,000 l. If the same area would be planted with poplars in SRC instead of hedgerows, the energy yield ranged from 35 to 700 MWh, corresponding to 3,000 to 60,000 l fuel oil.

Tab. 2: Maximum area per year for mulch application (recipient area) and annual energy yield of wood chips produced from hedgerows in three scenarios, in comparison to poplars in short rotation coppice (SRC) on the same calculative area of land; mulch application: 160 m^3 ha^{-1}.

Scenarios % of farm area for hedgerows	Hedgerow area (ha) or length (km)	Mulch Recipient area (ha)	Bioenergy Energy yield (MWh)		Fuel oil equivalent (l)	
		Wood chips	Wood chips	SRC	Wood chips	SRC
Scenario 1: 1%	0.6 (1.5)	0.05	7	35	590	3,000
Scenario 2: 5%	3.0 (7.5)	0.23	33	174	2,900	15,200
Scenario 3: 20%	12.0 (30.0)	0.94	134	696	11,700	60,100

Discussion

The annual biomass yield of hedgerows is not enough to mulch all arable land, independently from whether 80 m^3 ha^{-1} or 160 m^3 ha^{-1} are applied. Since only an application of 160 m^3 mulch ha^{-1} was significantly weed-suppressing (Gruber *et al.* 2008), planting semi-natural hedgerows specifically for mulch production is not useful. Though the biomass produced in scenario 2 and 3 is enough for the energy supply of one to three households, using the hedgerow area alternatively for SRC would result in a 5-fold higher production of bioenergy. Poplars are fast-growing trees and genotypes are used which are specifically selected for SRC thus explaining the higher yield of SRC compared to hedgerows. Semi-natural hedgerows are mainly composed of autochthonous shrub species with low capacity for biomass production and often grow on marginal land, e.g. field clearing cairns which additionally reduces yield. The biomass production of hedgerows may highly vary by the composition of species and the management, but at present, little reliable information is available about yields. However, today's primary purpose of hedgerows is to provide ecological benefits (Baudry *et al.* 2000). Under this assumption, wood chips are a by-product that emerges if the ecological value of a hedgerow is maintained by periodical cutting. Using wood chips from hedgerows for combustion seems not reasonable due to high proportions of bark (Tab. 1), which means a high ash content of more than the 6-fold than from pure wood (Hartmann 2005), so that combustion could cause technical difficulties. Recycling of nutrients, input of C_{org} and soil cover by mulch promise to be more beneficial for the agro-ecosystem. Therefore, in spite of low biomass production, the by-product wood chips should be used for mulch rather than for combustion in organic farming. The area and the crops the mulch is applied to have to be selected thoroughly. Wood chips should be applied with decreasing priority to: 1. erodible areas (slopes, silty soils) 2. crops with wide inter-row distance (faba beans) 3. perennials with high economic value (raspberries, black currant). As an alternative, farms could offer organic wood chips for sale to private consumers for gardening. Though this means an export of nutrients, a direct profit from hedgerows is provided. All scenarios and alternative uses have to be evaluated economically in detail in further approaches. Basically, a semi-mechanised process of harvesting and chopping, as usual for cutting hedgerows, causes twice as much costs as a wood combine harvester used in SRC (Textor 2008). Presuming the ecological value is high at low cutting intensity and in wood with diverse structure as recommended by Hinsley & Bellamy (2000) for protecting birds, hedgerows cut in a rotation of ca. 10 years would be more beneficial than SRC in a 3-years-rotation.

Conclusions

To safeguard hedgerows and their ecological benefits, possible economical incentives should be considered and used. The amount of wood chips produced from hedgerows is only sufficient to mulch a very small area of arable land. A use for energy is possible but not efficient in comparison to SRC, and in terms of possible technical difficulties. Co-combustion with other fuels could be taken into consideration. The best solution seems to be the application of wood chips mulch on sensitive areas or to specific crops. Another solution to make economical use of the hedgerows could be the production of "Organic Wood Chips" for sale to private consumers. Though a replacement of hedgerows by SRC is not intended, the ecological effects of both should be compared directly in further studies. To maintain ecological values of hedgerows, only a part of it should be cut back per year.

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