Investing in Short Rotation Coppice – Alternative Energy Crop or an Albatross around the Neck?

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Abstract—

Short Rotation Coppice (SRC) for bioenergy generation becomes increasingly important and is regarded as a promising new income source for farmers. The present study compares the profitability of SRC in line with a typical crop rotation. For comparison of profitabilities investment analysis is applied to account for the time value of money. Results show that the net present values for the regarded cropping activities vary widely. Although SRC can reach profitability the regarded crop rotation turns out to be the better option in periods with high market prices for agricultural commodities. Since SRC is related with long-term specific investments and break-even is achieved after 8 years, investment decisions have to be scrutinized.

Keywords— *Short Rotation Coppice, investment analysis, profitability*

1. Introduction

There is a growing consensus that energy crops have the potential to reduce the greenhouse gas emissions substituting fossil fuels. In order to tackle climate change the European Union set ambitious targets for the promotion of renewable energies. In 2020, at least 20% of the EU's primary energy consumption is to come from renewable energies. Following this the German Biofuels Roadmap outlines ambiguous targets and aims for a 20% share of fuels from biogenic origin. Concern about increasing fossil fuel prices due to rising world wide demand for energy and depletion of fossil fuels sources has contributed to the increasing interest in renewable energy sources, particularly for those that can be sourced from domestic agriculture. Agricultural biomass can be used to produce a broad spectrum of fuels for transport, in power stations or in heating systems. Energy supply is expected to be increasingly locally due to rising transport cost and an increasing effort of developed nations to become more independent from fossil fuels.

To meet the demand for heat generation and second generation fuels (Btl) the production of woody biomass becomes increasingly important and may open new sources of income for farmers by growing short rotation coppice (SRC) with willow and polar cultivars.

SRC have more in common with agricultural or horticultural crops than forestry. In addition, woody biomass can be produced over differing time scales and provides considerable flexibility to fit the production of energy crops with the demand of other farming activities (Tuby and Armstrong 2002). As substitute for fossil fuels, woody biomass crops have the potential to reduce the carbon dioxide emissions compared to conventional arable crops as they require reduced chemical input. Thus, investing in broadleaved energy crops may be a tempting option of biomass production for farmers. However, the cultivation of tree-plantations is linked with long-term and production specific investments. The paper discusses the profitability and incurred risks of SRC in comparison to conventional arable crop rotations.

2. Short Rotation Coppice - Establishment and Management

Short rotation coppice are high density plantations of fast growing and high yielding trees for rotation (Herrick and Brown 1967). Coppicing is considered to increase biomass production and is an inexpensive alternative for replanting trees (Verwijst 1996). To achieve a high productivity, willow and poplar cultivars are widely used because they are among the fastest growing temperate trees and can be cultivated at many types of sites, i.e. poplar and willow can be grown on a wide range of soils but very wet or very dry conditions are not suitable. Trees are easy to propagate through vegetative cuttings (Dickmann 2001).

The woody perennial crop is generally planted by pushing cuttings approximately 20 cm long and 1 cm in diameter, into the cultivated soil (Tuby and Armstrong 2002). The shoots are left to grow and will be harvested on a 2-4 year cycle with specialised machinery. The stools remaining in the ground produce more shoots that grow another 2-4 years until the next harvest. Several cuttings are possible before yield declines and the crop is replaced.

The establishment of SCR requires a high capital expenditure and thus can be compared with perennial horticultural crops. A high standard of land preparation and establishment is of utmost importance to achieve high yields. Sites should be ploughed in the late autumn or early winter to 25-30 cm. Harrowing immediately before planting operations start is recommended to support the formation of a healthy root system. Before planting it is important to plan for future operations and to select a planting and spacing design which is well suited for the harvesting system (Forestry Commission 1995).

Planting is suggested between February and March, as soon as soil conditions allow. Depending on the tree species planting can be done on different mechanization levels. For commercial planting of willow the most commonly used machines are "step planters", which are designed as to cut willow rods of about 20 cm and insert it into the soil. Around 15,000 cuttings per hectare is the current standard planting density using this planting technique (DEFRA 2000). For the cultivation of poplar modified cabbage planters or specialized machines are used because the cuttings have to be manually processed to ensure the presence of the apical bud. The planting density is generally lower than that of willow and averages out at 10,000-12,000 cuttings/ha.

Harvesting takes place on a 2-4 year cutting cycle and is generally carried out during winter after leave fall and before bud burst. The type of harvesting machinery used depends on the end-user´s requirements. There are two basic harvesting systems for SRC. Crops can be cut and the stems left intact. Chipping is carried out at a later date as a separate operation. Alternatively, the crop can be cut and chipped in one operation (direct-chip harvesting). After the final harvest follows the site reinstatement. Poplar coppice stools are removed with forestry mulchers. Finally the site is cleared with a cultivator.

3. Methodology

The comparison of the profitability of annual and perennial crops must not only take the average revenues into account but also their time value. Consequently, an investment analysis is performed to examine whether short rotation coppice is a suitable production alternative for agricultural enterprises. The most important objective of investment analysis is to assess the effects an investment will have on the economic success of farm enterprises. This assessment is based on the farmer's current income portfolio and on a projection of his future financial performance assuming the investment is implemented. In other words, will farm enterprises earn sufficient returns on their equity investment to justify making the investment the SRC requires? The most straightforward decision criterion in investment analysis is the "Net Present Value" (NPV), which is typically explained as the present worth of the incremental net benefit or the incremental cash-flow stream. (Gittinger 1982).

The mathematical formulation of the NPV is as follows:

$$NPV = \sum_{t=0}^{N} (R_t - C_t) q^{-t} \qquad (1)$$

R_t = revenues in each year

C_t = costs in each year

q^{-t} = $\frac{1}{(1+i)^t}$ = discount factor for each year

N = number of years

i = interest rate

Profitability is given if the NPV > 0. A negative NPV would mean that the present value of the benefit stream is less than the present value of the cost stream, at an assumed discount rate; that is inadequate to recover investment.

Additionally the average annuity (A_t) of SRC is calculated, a methodology which is commonly used in pomiculture. It can be interpreted as average revenues on annual basis including the time value of money. The formal mathematical statement is given below:

$$A_t = \sum_{t=0}^{N} PV_t \frac{i(1+i)^N}{(1+i)^N - 1} \qquad (2)$$

PV_t = present value at time t

N = number of years

i = interest rate

The results show the break-even point of the investment and the amount paid annually or received in case cropping would be stopped at a particular year during crop lifetime.

To show whether growing SRC is profitable the NPV as investment criteria is calculated for poplar and compared with the NPV of a conventional crop rotation assuming a given period of 20 years. In Germany, the cultivation of SRC is still in its experimental stage and only little reliable production and yield data for the regarded region is available for willow. The following therefore will focus on poplar. Basic data for the exemplary cash-flow calculation is given in Table 1.

Table 1: Input and Output Data for Poplar SRC

General Data		
Interest rate	**%**	6
Rotation length	yrs	4
Crop lifetime	yrs	21
Planting density	cuttings/ha	10,800
Biomass yield per harvest	dry t /ha	40
Total biomass yield	**dry t /ha**	**200**
Biomass price at farm gate	€/t*	75.00
Total revenue	**€/ha**	**15,000.00**
Establishment		
Land preparation (plow, harrow, herbicide)	€/ha	120.55
Planting stock	€/cutting	0.20
Planting stock	€/ha	2,160.00
Planting cost	€/cutting	0.01
Planting	€/ha	140.40
Total establishment costs	**€/ha**	**2,420.95**
Harvest and Transport		
Harvest (field chopper)	€/dry t	15.00
Harvest costs	€/ha	600.00
Transport costs (distance up to 4 km)	€/ha	169.76
Harvest costs per rotation (operating costs)	**€/ha**	**769.76**
Stock removal	€/ha	1,400.00
Production costs and revenues		
Total production costs	**€/ha**	**7.669.75**
Total revenue	**€/ha**	**7.330.25**

Source: KTBL (2006, 2008), LVLF (2008) *containing 35% moisture

General inputs for SRC are rotation length, expected biomass yields and biomass price at farm gate. Costs include establishment, harvest, transport and poplar crop removal. The crop rotation of the alternative investment analysed includes rapeseed wheat and barley.

On the basis of data on a typical cropping scheme on a specific land category suitable for arable farming and SRC in the Federal State of Brandenburg, information about crop prices, yields, input use per crop, variable costs per activity and area payments were used (LVLF 2008).

Due to the recent price fluctuations on agricultural commodities market prices from the last three cropping years are taken into account. These are calculated on the basis of time series data from ZMP (2008) and shown in Table 2.

Table 2: Market prices for crops within the observation period

	Cropping season		
	2005/2006	2006/2007	2007/2008
Rapeseed [€/t]	22.57	25.40	38.50
Wheat [€/t]	10.62	14.70	22.90
Barley [€/t]	10.38	12.10	20.80
Poplar [€/t]*	60.50	68.35	75.00

Source: ZMP (2008) * containing 35% moisture

The typical interest rate for investment appraisal in agriculture of 6% is taken into account.

4. Results

Growing SRC requires high initial investments related to the establishment costs. Inflows depend on the cutting cycle and growing scheme. At the end of the cropping cycle stocks are removed, causing cost and reducing the revenues of the final harvest. Figure 1 illustrates the present and discounted cash-flows of the SRC model calculation. Break-even is achieved after 8 years. The financial analysis shows that the NPVs are positive for both cropping alternatives and scenarios.

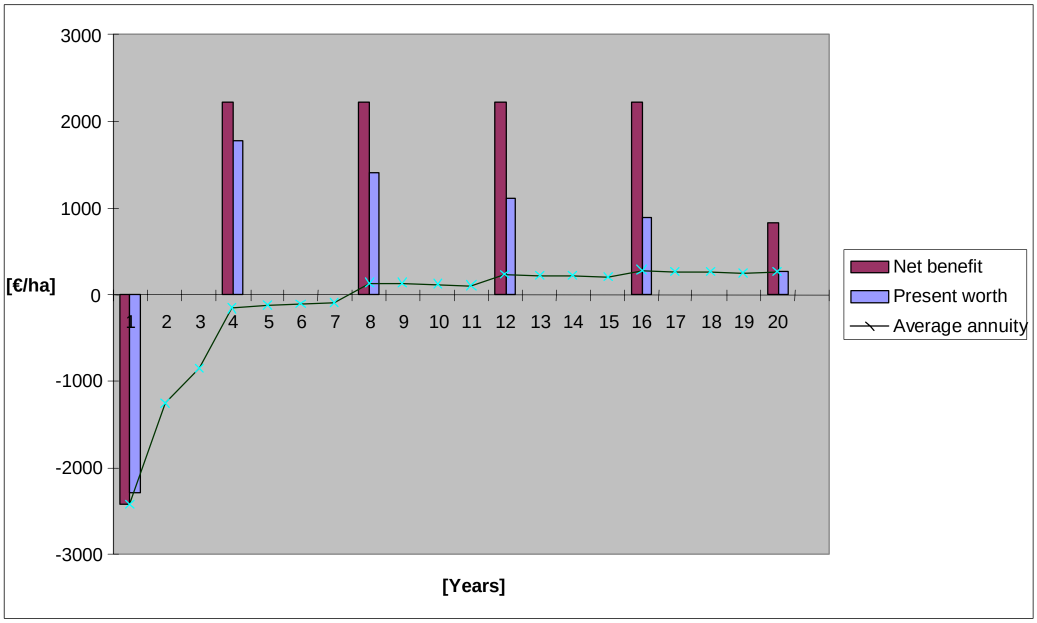

Figure 1: Yearly cash-flow and average annuity of poplar SRC in €/ha

Table 3 illustrates the different NPVs depending on changing market prices. In the cropping season 2005/06, SRC is the favorable investment with a higher NPV because the market prices for agricultural commodities were extremely low (cp. Table 2). However, with rising market prices for rapeseed, wheat and barley the NPVs increase and the crop rotation turns out to be the better option although biomass prices for poplar increased as well. Thus, the profitability and investment decision of growing SRC highly depends on market prices and profitability of alternative cropping activities.

Table 3: NPVs$_{(n=20;\ 6\%)}$ depending on market price changes

	Cropping season		
	2005-2006	2006-2007	2007-2008
Crop Rotation [€/] (rapeseed-wheat-barley)	937	2,510	7,588
Poplar SRC [€]	1,554	2,393-	3,315

Own calculations

5. Conclusions

In the past SRC were promoted as sustainable form of land-use and new income source for farmers' alternative to food production. This has encouraged some farmers to establish SRC. Good reasons for growing SRC are the environmental aspects such as reduced chemical input use and increased biodiversity. However, from the economic perspective current prices for agricultural commodities are a strong argument against cultivating SRC because long-term specific investments require a stable economic environment. Once a SRC is established the invested capital is tied up until break-even is achieved. If alternative crop rotations turn out to be the more profitable during this time SRC can be become an albatross around the farmers neck. In contrast conventional arable cropping is more flexible in terms of crop rotations and thus can more easily be adapted to market developments.

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