REFEREED PAPER

A DISCOUNTED CASH FLOW ANALYSIS OF FINANCIAL RETURNS FROM BIOMASS CROPS IN IRELAND

D. Clancy, J. Breen, A.M. Butler, F. Thorne, M. Wallace

The economic case for the production of biomass crops can only be established through a comprehensive analysis of the potential costs and returns of these crops. Using data from Ireland, this paper provides a Discounted Cash Flow (DCF) investment analysis for two of the most common biomass crops, willow and miscanthus. We find that miscanthus consistently generates investment returns greater than willow. Sensitivity analysis is used to examine the effects on the estimates of variation in key physical and financial parameters. The superseded enterprise, establishment grant level, yield level, price level, and length of production lifespan are shown to significantly influence the returns generated by investments in willow and miscanthus. Due to the level of risk involved in growing biomass, widespread adoption in Ireland is only likely when the economic merits of these crops have been proven over an extended period.

Keywords: Willow, Miscanthus, Discounted Cash Flow, Sensitivity Analysis

1. Introduction:

There has been a recent surge of interest in the potential of biomass as an alternative to fossil fuels within the EU. Rising oil and gas prices, concerns about the security of imported energy supplies and Kyoto targets to reduce greenhouse gas emissions have been the principal drivers of government policy to increase the use of biomass in energy and heat production (Department of Communications, Marine and Natural Resources, 2007).

As in other countries, the Irish Government has enacted measures to incentivise the production of biomass crops (Department of Communications, Marine and Natural Resources, 2007). Farmers who diversify into biomass crops can receive establishment grants to offset part of the initial setup costs and they are also currently eligible for an energy crop subsidy of €45 per hectare. In addition, under the recent CAP reforms, EU agricultural subsidy payments are substantially de-coupled from production. This allows farmers a greater freedom to switch to alternative enterprises, such as biomass crop production, without reducing the value of their existing single farm payment entitlements. Consequently, farmers may have an important diversification opportunity which merits careful financial analysis.

From the view point of an individual farmer such analysis is not straightforward. There are important risks associated with adopting an enterprise that does not yet have a proven track record. For example, there are important questions about future demand/prices and the direction of government policy affecting biomass crops over the longer term. There is also uncertainty about potential yields since available data are based on small samples of experimental trials that have been running over a limited number of years. This makes it difficult to establish how yields are influenced by production factors and the extent of variability from site to site and over time. These risks associated with biomass crops are accentuated by their lengthy production horizon compared with traditional enterprises. Consequently, it may not be surprising that farmers are sceptical about the prospect of biomass crops as a viable alternative agricultural enterprise. A recent survey of Irish farmers (Connolly *et al*. 2006) found that only 8 percent of respondents were willing to consider/investigate the production of biomass crops. This study seeks to address some of the information deficit about the economics of biomass crops in Ireland.

Short Rotation Coppice consists of densely planted, high-yielding varieties of willow (or poplar), which is a perennial woody crop. Miscanthus on the other hand is a tall perennial woody grass of East Asia origin. Although willow and miscanthus can be grown in a wide variety of soils, site selection is important to the yield levels the plantations will achieve. Deep heavy soils will produce the best yields for willow, while deep, water retentive limestone soils result in the highest yields for miscanthus. However, due to the fact that willow and miscanthus are sown and harvested in late winter and early spring respectively, the site must facilitate the use of heavy machinery necessary for planting and harvesting the crops. Willow is stick (whole stem) harvested using grass forage equipment with an adapted header. Miscanthus can be harvested with many different machines including a sugar cane harvester, a self propelled precision chop maize harvester and a rotary mower.

The following section of the paper describes the method of analysis and the assumptions employed. Section 3 details the results of the analysis. Finally section 4 summarises the research findings and draws conclusions from the results.

2. Data and Methods

2.1 A Discounted Cash Flow Analysis

This paper employs the well established Discounted Cash Flow (DCF) method to evaluate willow and miscanthus as investment projects. The analysis computes investment returns from the production of biomass as an alternative farm enterprise. It also evaluates the effects of variation in key parameters on the performance of each investment. The paper abstracts from issues of scale of investment in biomass by conducting the evaluations in per hectare terms.

The results of the DCF are presented in terms of both the Net Present Value (NPV) and the Internal Rate of Return (IRR) of each investment. The NPV values an investment as the sum of the project's net cash flows discounted at the businesses' opportunity cost of capital. The investment project is deemed to be 'worthwhile' if it generates a positive NPV.

The IRR is the discount rate that results in a project generating a NPV of zero over its economic life. This is a useful measure of the percentage return from an investment and both the NPV and IRR calculations complement one another in providing a comprehensive assessment of the financial merits of alternative investment projects.

Lewandowski *et al.* (2000) note that the opportunity cost of land has been omitted in some studies when calculating investment returns. In order to address this issue, the opportunity cost of land is accounted through the inclusion of foregone returns from a superseded activity. In the baseline calculations this superseded activity is assumed to be the market rental value for the land used to produce the biomass crop. Approximately 80% of Ireland's agricultural area is grassland (Department of Communications, Marine and Natural Resources, 2007); therefore the average rental value of grazing land is deemed to be the appropriate measure and is used in this analysis. As part of a sensitivity analysis, results are also presented for alternative superseded enterprises such as spring barley, winter wheat and store to finished beef. Thus the results presented in subsequent sections comprise the estimated investment returns from a decision to switch a hectare of land from a conventional enterprise to a biomass crop such as willow or miscanthus.

The DCF approach to calculate the returns from perennial biomass crops such as willow and miscanthus has been used by Goor *et al*. (2000), Heaton *et al.* (1999), Toivonen and Tahvanainen (1998), Rosenqvist and Dawson (2005a) and Styles *et al.* (2008). These papers used sensitivity analysis to evaluate the effects of variation in key parameters such as yield level, discount rate, price per tonne and harvest cycle. Heaton *et al.* (1999) and Toivonen and Tahvanainen (1998) used an annual margin calculated from the crops NPV for comparison with another enterprise. This allowed for an examination of how the crop performed relative to an existing agricultural enterprise and what subsidies would be necessary for the biomass crop to achieve parity. Styles *et al.* (2008) constructed life-cycle cost assessments for the production of willow and miscanthus in Ireland. The gross margins of these crops for alternative harvest and supply strategies were compared with projections of those from conventional agricultural systems using the NPV approach.

Heaton *et al*. (1999) stated that the influence of the discount rate is greater for biomass crops (willow) than for conventional agricultural systems (e.g. sheep production). This is due to differences in the cash-flow profiles. With biomass crops the profits come later in the investment horizon and so are decreased by discounting. Toivonen and Tahvanainen (1998) stated that the required interest from investment in agriculture is usually in the 3-5% range and assumed a 5% discount rate in their analysis. Goor *et al*. (2000), Niskanen (1999) and Styles *et al.* (2008) also assumed a 5% discount rate when examining the economics of biomass crops. Niskanen (1999) argued that the potential to compare results with other profitability studies which use the NPV criteria was an additional benefit from applying a conventional discount rate. Therefore, a 5% discount rate is also applied in this analysis similar to that used in the literature.

2.2. Cost and Return Estimation of Different Crops

The DCF method is capable of comparing investments with different cash flow profiles such as annual versus perennial crops. It can easily accommodate the different harvesting schedules of willow and miscanthus, allowing for the timing of cash flows from year to year over the project life. The capital invested in biomass comprises the start up costs of the willow or miscanthus enterprise in the initial period, less the establishment grant less the average working capital released from the superseded enterprise. The cash margin foregone from the superseded enterprise is deducted annually from the net margin of the biomass crop. It is assumed that productivity of the biomass crops and any superseded enterprise remains constant throughout the project lifespan. Furthermore, by applying sensitivity analysis it is possible to show the economic outcome on a per hectare basis of varying establishment grant levels, yields, prices per tonne and production life spans.

2.3 Data and Assumptions

This section details the assumptions made relating to respective costs and revenues from willow, miscanthus and the superseded enterprises. Figures for willow and miscanthus were compiled from a review of the relevant literature and in consultation with the Teagasc Energy Systems Specialist. Table 1 outlines the cost and revenue assumptions for willow and miscanthus. Table 2 details the gross margins and average working capital released from the superseded enterprises. At the end of the economic life of each biomass crop

Table 1. Model cost and revenue assumptions for willow and miscanthus

	Willow	**Miscanthus**
Maximum Production Period	16 Years	16 Years
Number of Harvest Cycles	7 Harvest Cycles	15 Harvest Cycles
Yield Level[1]	7t/DM/ha 1st Harvest 10t/DM/ha Every Harvest Thereafter	6t/DM/ha 1st Harvest 10t/DM/ha Every Harvest Thereafter
Establishment Grant	€1450 (75% payable in year 1, 25% in year 2)	€1450 (75% payable in year 1, 25% in year 2)
Harvest Strategy	Stick harvested, naturally dried, stored outdoors then chipped	Baled harvest, naturally dried, stored outdoors
Moisture Content	25%	20%
Crop Removal	€562/ha	€225/ha
Price per Tonne[2]	€55	€60

1. All willow yield levels are expressed in annual terms unless otherwise stated.
2. Assumed price levels for willow and miscanthus based on August 2008 market prices.

the cashflow schedules include the estimated costs of crop removal. This comprises the expected costs associated with 'grubbing out' the roots of the biomass crops and restoring the land to its original state prior to establishment.

The grazing land rental value was calculated as the average paid per hectare by farmers engaged in this activity in the Irish National Farm Survey

Table 2. Gross margin and working capital released per hectare for the superseded enterprises

	Grazing Land Rental Value	Spring Barley	Winter Wheat	Store to Finished Beef
Gross Margin[1]	€236	€260	€435	€210
Working capital released[2]	-	€291	€487	€928

1. Gross margin for production enterprises assume average levels of technical efficiency
2 Working capital released is the average capital tied up in stock and variable inputs for each enterprise.

(NFS) from 2005-2007. It was assumed that any rental value less than €20 per hectare was a nominal value and so was excluded from the analysis. To avoid problems of allocation of fixed costs associated with owned machinery, calculations assume contractor charges for all field operations. All machinery and labour costs are therefore assumed to be variable costs. Due to a number of factors, such as policy constraints and the pioneer nature of the crops in Ireland, it is likely that willow and miscanthus will only be introduced to a small proportion of adopting farms overall land base. Thus the superseded enterprise is being reduced and not eliminated. In this context the reduction in fixed costs (e.g. labour) from reducing a conventional enterprise is likely to be quite small.

The contractor prices were obtained from survey data reported in Management Data for Farm Planning 2006/2007 (Teagasc 2007) and inflated using FAPRI-Ireland input cost and price projections until 2009. Obtaining long range forecasts of costs and prices are a formidable task in any farm investment appraisal. In this analysis estimates of input costs assume normal input levels under average production conditions as estimated by enterprise specialists. Average levels of technical efficiency, based on National Farm Survey data, are assumed for the superseded enterprises. Prices for all inputs and the outputs of superseded activities are conservative estimates based on medium term FAPRI projections. The resulting normalised margins for the biomass crops and the superseded enterprises are held constant over the economic life of each project. The level of the establishment grant for biomass crops is the current rate available under the National Bioenergy Scheme (2006 -2009).

Table 3. Baseline investment performance in per hectare terms

	Net Present Value *	Internal Rate of Return	Payback Period (Years)
Willow	-€757	-1.68%	N/A
Miscanthus	€886	10.31%	9

* Discount rate is 5%.

3. Results:

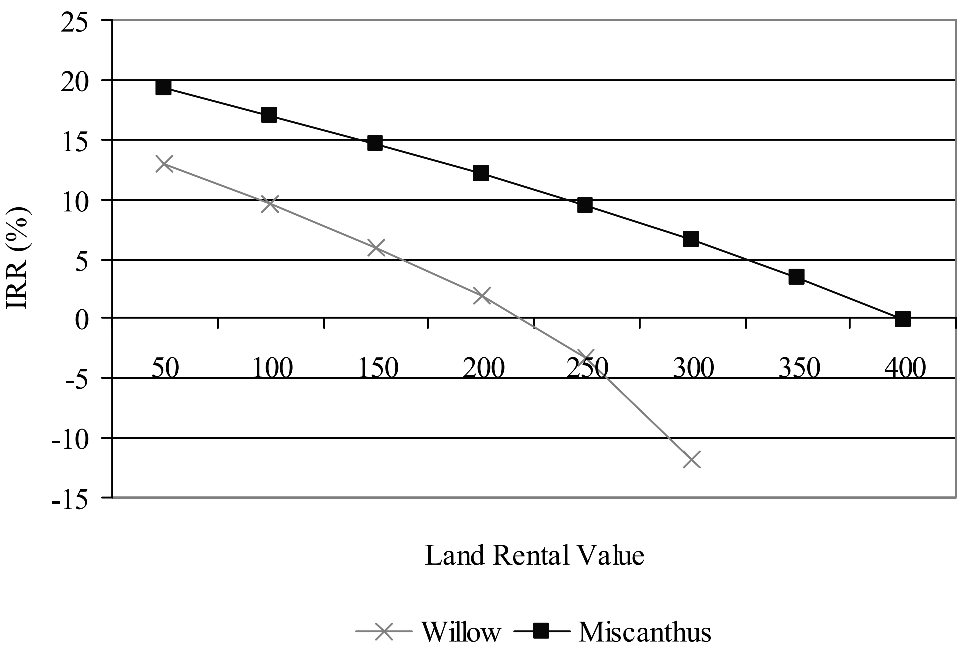
3.1. Baseline results

Table 3 presents some of the key economic findings under the crop costings and economic assumptions that have been outlined above.

The IRR for miscanthus (10.31%) is significantly higher than that of willow (-1.68%). Under the baseline assumptions miscanthus generates a positive NPV (€886) suggesting that it would be a financially worthwhile alternative enterprise. Under the same rationale, the negative NPV for willow (-€757) suggests that this investment should not be made. The payback period is the point at which an investment has recouped its costs and begins to generate a positive return (Ingersoll and Ross 1992). In this analysis it was calculated as the year in which the sum of discounted cashflows becomes positive, which also allows for the incorporation of interest payments in the analysis. The payback period for willow is longer than the project lifespan of 16 years while for miscanthus it takes 9 years to recoup the costs. The discounted cash flows for willow and miscanthus are presented in Appendices 1 and 2.

In the following sections, sensitivity analysis is conducted in order to examine the effects of variation in key parameters on the IRR's generated from investments in willow and miscanthus.

Figure 1. Impact of Land Rental Values on the Internal Rate of Return per Hectare



3.2 Influence of the opportunity cost of land and alternative superseded enterprises

The effect of variation in the opportunity cost of land (rental value for land) on the returns available from willow and miscanthus is shown in Figure 1. The minimum and maximum grazing land rental values from the NFS in the period 2005 – 2007 was used in the estimation of the range of values for the analysis.

The opportunity cost of land in terms of the potential land rental values receivable by the farmer have a significant effect on the decision to invest in willow and miscanthus production. At the baseline land rental value of €236 per hectare willow (-1.68%) generates a negative return while miscanthus (10.31%) generates a positive return. The results show that farmers who could let their land for more than €250 per hectare would be better off doing so than adopting willow production. Any land rental value less than €400 would make miscanthus a more attractive investment than letting the land.

An alternative way of viewing the opportunity costs of growing biomass crops is in terms of the foregone returns from conventional enterprises that

Table 4: Investment performance in per hectare terms with alternative assumptions about the superseded activity

	Net Present Value *	Internal Rate of Return	Payback Period (Years)
Superseded: Spring Barley			
Willow	-€719	-2.68%	N/A
Miscanthus	€924	11.25%	8
Superseded: Winter Wheat			
Willow	-€2338	-20.27%	N/A
Miscanthus	-€694	-1.86%	N/A
Superseded: Store to Finished Beef			
Willow	€436	10.93%	8
Miscanthus	€2080	22.93%	6

*Discount rate 5%.

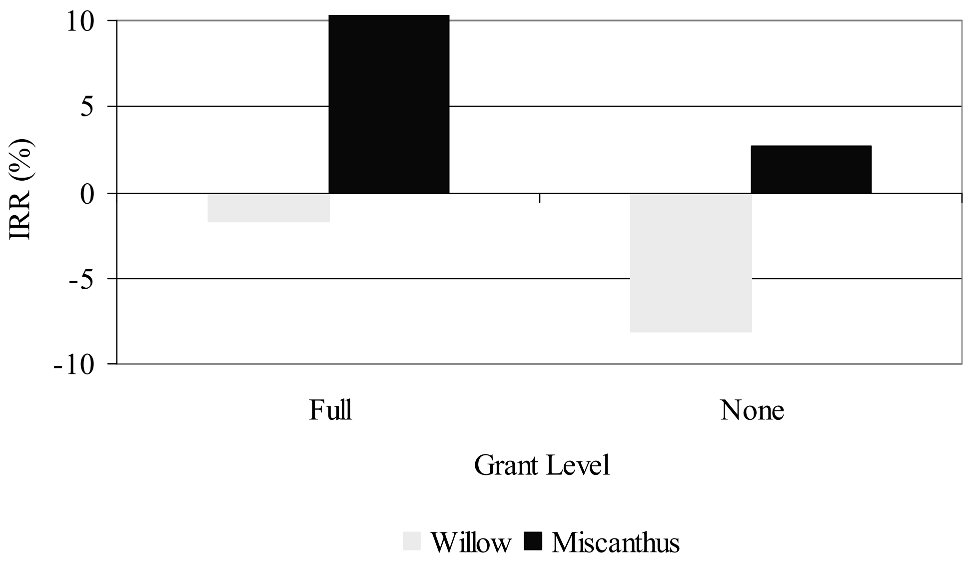
might be replaced by biomass. Three conventional enterprises (spring barley, winter wheat and a store to finished beef) are considered as being superseded by willow or miscanthus (Table 4). In contrast to the baseline assumption in which the alternative was to let the land, the ceasing of an existing production enterprise results in working capital being released from the activity, reducing the net set-up cost for the investment in biomass.

Miscanthus (11.25%) generates a positive IRR when spring barley is the superseded enterprise, while the return from willow (-2.68%) is still negative. However the negative NPV coupled with the low IRR for willow suggest that this investment may not be worthwhile. The payback period for willow and miscanthus is the same as under the baseline assumptions.

Superseding a winter wheat enterprise with either willow or miscanthus (-1.86%) would generate a negative IRR for the investing farmer. The opportunity cost from the higher margin winter wheat activity outweighs the returns available from willow and miscanthus production. The payback period for willow and miscanthus is longer than the project lifespan of 16 years.

A farmer who superseded a store to finished beef enterprise in order to invest in a willow (10.93%) or miscanthus (22.93%) production project would generate a positive return on this investment. The payback period is reached in 8 years for willow and 3 years earlier for miscanthus (year 6) than if a grazing land rental enterprise was superseded. The larger returns generated by a farmer switching from a store to finish beef enterprise to willow or miscanthus is a result of a combination of a lower superseded gross margin and a greater working capital released.

Figure 2. Impact of Alternative Establishment Grant Levels on the Internal Rate of Return per Hectare



3.3 Influence of an establishment grant

A scenario in which no establishment grant is offered was examined in order to assess its impact on the IRR from producing willow and miscanthus (Fig. 2). This was compared with the baseline assumption of an establishment grant being offered.

The removal of the establishment grant has a considerable effect on the

IRR achievable from willow (-8.08%) and miscanthus (2.67%). This is to be expected as the majority of the costs associated with these crops are accrued in the years before the first harvest. Without an establishment grant the IRR from willow is negative, although it remains positive for miscanthus. Even when the establishment grant is removed the level of returns from miscanthus are greater than those of willow with the establishment grant. The payback period for willow is longer than the project lifespan of 16 years and is delayed by 4 years to year 13 for miscanthus when no establishment grant is offered.

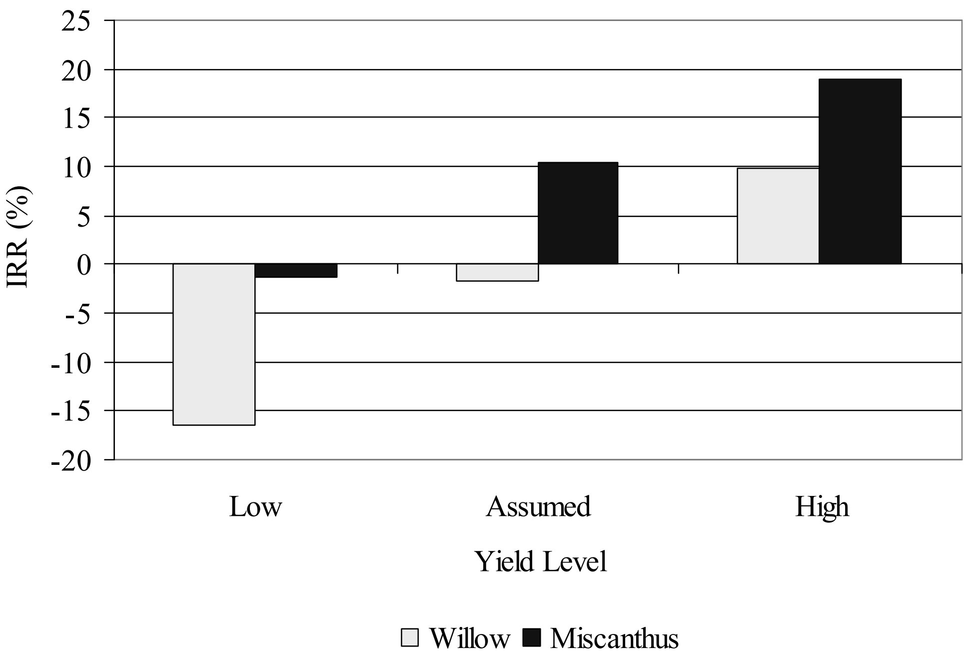
Table 5: Low and high yield level scenarios for willow and miscanthus

	Willow	**Miscanthus**
Low Yield Level	5t/DM/ha 1st Harvest 8t/DM/ha Every Harvest Thereafter	4t/DM/ha 1st Harvest 8t/DM/ha Every Harvest Thereafter
High Yield Level	9t/DM/ha 1st Harvest 12t/DM/ha Every Harvest Thereafter	8t/DM/ha 1st Harvest 12t/DM/ha Every Harvest Thereafter

3.4 Influence of yield level

In order to assess the effect that yield level variation has on the investment return of both crops, a low and high yield level scenario (Table 5) were

Figure 3. Impact of Yield Level Variation on the Internal Rate of Return per Hectare

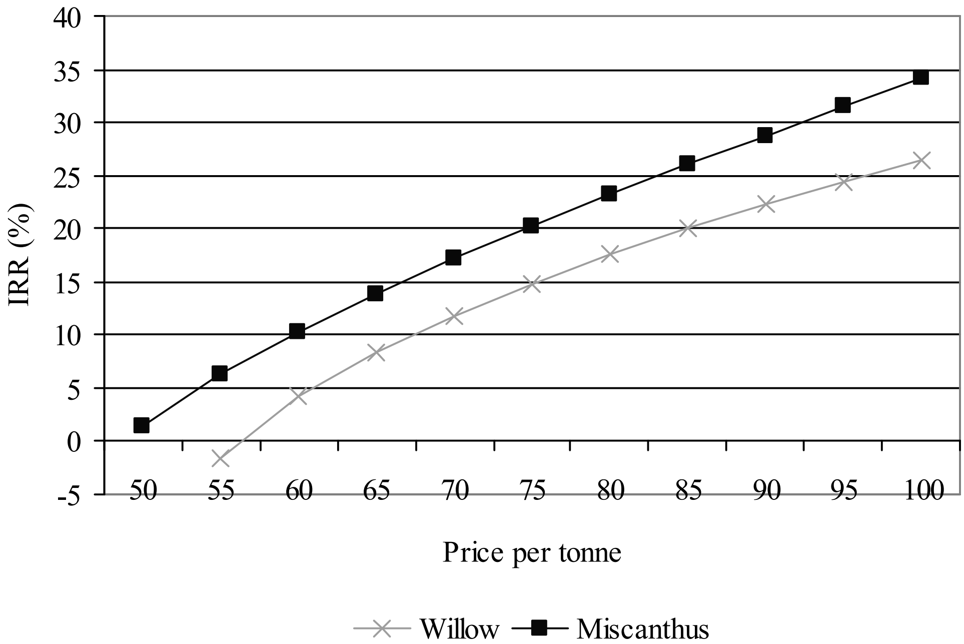


compared with the baseline yield level (Fig. 3).

The high and low yield levels for willow and miscanthus were compiled in consultation with the Teagasc Crops Research Centre and from a review of the literature (Rosenqvist and Dawson, 2005a; Heaton *et al.*, 1999; Toivonen and Tahvanainen, 1998).

Figure 3 shows that, as expected, yield levels have a significant impact in determining the IRR from willow and miscanthus production. The yield levels for these crops have a high variability due to a number of factors such as; meteorological conditions (particularly sunshine and rainfall); location (soil fertility, latitude and sheltering); and harvesting conditions (harvesting losses for miscanthus are typically 10-30% but could be worse under poor conditions) (Finnan, 2008). Both willow (-16.40%) and miscanthus (-1.34%) generate a negative IRR under the low yield scenario suggesting that the investment is susceptible to risk from yield level variation. The payback period is longer than the production lifespan of 16 years for both willow and miscanthus when low yield levels are experienced. Under the high yield scenario the IRR of both willow (9.71%) and miscanthus (19.00%) are significantly higher than under the baseline yield levels. The IRR for willow under the high yield scenario is still lower than that of miscanthus under the baseline scenario. The payback period for willow and miscanthus under the high yield scenario are years 10 and 7 respectively.

Figure 4. Impact of Price per Tonne Variation on the Internal Rate of Return per Hectare



3.5 Influence of price per tonne

The effect that the price per tonne has on the economic viability of willow and miscanthus was examined by varying the price received per tonne (Figure 4).

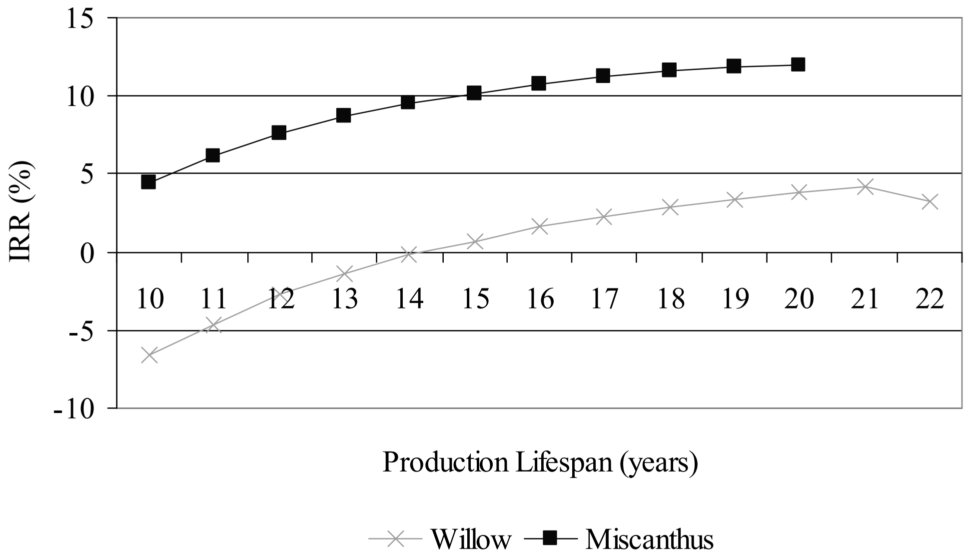
The price per tonne offered has a large effect on the level of returns attainable from willow and miscanthus production. For example, an increase in price from the baseline level to the highest price scenario increased the IRR's of willow and miscanthus by 28.13% and 23.76% respectively. The payback period was reduced to 6 years in the case of willow and 5 years in the case of miscanthus. Under the lowest price scenario the payback period for willow is longer than the project lifespan of 16 years, while it is 14 years for miscanthus. Willow generates a negative IRR under the lowest price scenario as well as at the baseline level. Although miscanthus (1.40%) still manages to generate a positive IRR at this price level, the low level of this return is unlikely to incentivise farmers to switch enterprises.

3.6 Influence of production lifespan

The influence that the length of the production lifespan has on the returns for willow and miscanthus was examined by varying the economic life of both crops. A 10 – 22 year range of project lifespan was examined for willow and a 10 - 20 year lifespan for miscanthus (Fig. 5). Note that in the case of willow the IRR is plotted for two year increments in project length as the crop generates a harvest every other year. It can be assumed that a farmer would only terminate the enterprise immediately after a harvest.

The general consensus in the literature was for a 22 year life-cycle for

Figure 5. Impact of Production Lifespan on the Internal Rate of Return per Hectare



willow (Heaton *et al.* 1999, Rosenqvist and Dawson 2005a, Toivonen and Tahvanainen 1998). Furthermore Rosenqvist and Dawson (2005a) stated that the availability of new and improved planting stock with higher yield potential and/or reduced disease susceptibility may be an important issue in determining the economic life of a plantation. However, Lewandowski *et al.* (2000) highlighted the fact that most trials are under ten years old and the length of time a plantation is productive is untested. Therefore they suggest that 15 – 20 years should be the maximum lifespan assumed. In this analysis a conservative production lifespan of 16 years is assumed as the baseline scenario for both willow and miscanthus.

Decreasing the length of the production lifespan has a significant impact on the investment returns achievable from willow and miscanthus. This is to be expected given the substantial establishment costs for biomass crop production at the beginning of the projects lifecycle. A 10 year project lifespan fails to generate a positive IRR for willow (-6.59%), however it does so for miscanthus (4.41%). One of the conditions of the national bioenergy scheme is that farmers must produce biomass crops for a minimum of 7 years. If they cease production before that point, they must pay back any grant money received. Under the baseline scenario the payback period for willow is longer than the 16 year project lifespan and is 9 years for miscanthus which suggest that any farmer entering production of these crops at current market prices would need to commit to at least a 10-16 year project as the effect on profitability of the establishment grant being returned would be detrimental to the investment.

5. Conclusion

Given realistic assumptions miscanthus generates a positive rate of return on investment and is a potentially worthwhile investment. However, the risks associated with the extremely long payback periods necessary to recoup investment costs would be a concern to most investors. Especially in the case of willow the negative return on investment means that it is unlikely that most farmers will invest in biomass production while foregoing average returns from a conventional enterprise. These results concur with those of Rosenqvist and Dawson (2005b) who found that the economics of growing willow as an energy crop are marginal and highly dependent on the support for the conventional crops or enterprises they replace and on the maintenance of high yield levels.

Miscanthus consistently outperformed willow in terms of investment performance. Consequently, based on these results miscanthus is most likely to be the biomass crop of choice given its superior yield potential, annual production cycle and cash flow profile. Although willow has a greater maximum production lifespan of 22 years compared with 20 years for miscanthus, the return on investment for willow (3.23%) is still substantially lower than that of miscanthus (11.96%). The cost of removing the crop at the end of the production lifespan is also considerably higher for willow (€562) than miscanthus (€225). However, similar to Styles *et al* (2008), it was found that, after discounting, the cost of crop removal made only a small contribution to overall costs.

However, there are management factors that may make willow a more attractive investment for some farmers. Firstly, willow is in general more tolerant of colder, wetter conditions and poorer quality land, therefore making it more suitable than miscanthus for many Irish farmers. It must be stated that although willow can be grown on poorer land, there is a limit to how 'poor' the land can be as it must allow for sowing and harvesting operations to be carried out from January to April. In this analysis it is assumed that willow and miscanthus are competing for the same land and so face the same opportunity costs. However, the fact that willow tolerates poorer soil conditions suggests that a fairer comparison of the crops might be between willow under a lower and miscanthus under a higher opportunity cost. Further research is required to establish the extent of the underlying trade-offs which are unclear at this point in time.

Given relatively modest rates of return, any value which can be added to biomass crops by giving them a dual function will greatly enhance its economic sustainability. Increasing interest is being given to the concept of disposal of agricultural and municipal wastes on energy crops (Britt *et al.* 2002). Various municipal waste products that are rich in nutrients and/or water such as wastewater and sewage sludge could partly or to a full extent replace the need of conventional fertilisation and enhance growth (Melin *et al.* 2004). This would provide an economic benefit to the producers of energy crops with a reduction in fertiliser costs, a potentially higher yield level and with a gate fee from the waste provider for disposal of the sludge. Research is currently being conducted by the Teagasc Crops Research Centre in to the effects of bioremediation on willow and miscanthus. Upon completion, the data from this research may be incorporated into the DCF model in order to analyze the impact of bioremediation on the economics of biomass crops.

Sensitivity analysis indicates that the establishment grant level, yield level, price level, the length of the production lifespan and land rental values all have an impact on the IRR achievable from willow and miscanthus production. Of course, in all cases the opportunity cost in terms of the revenue foregone from a superseded activity is critically important. It is unlikely for a farmer to find it attractive to grow a biomass crop by reducing a high margin cereal crop such as winter wheat. The investment is most attractive when a store to finished beef enterprise is superseded, with both willow (10.93%) and miscanthus (22.93%) both generating a positive IRR and having a greatly reduced payback period under this scenario. Consequently, in the Irish context, biomass production is likely to be most attractive to lowland beef producers. The returns from biomass crops are above those from beef production under average levels of efficiency but in addition the labour requirements are significantly lower.

Given the high incidence of part time farming especially among beef producers in Ireland, the reduced labour requirement of willow and miscanthus may be a particular attraction in terms of greater compatibility with off-farm work commitments. In other situations the switch to biomass production may free up time to enable a farmer to take up off-farm employment. This potential benefit has not been considered in the calculations within this paper but it could provide a motivation for some farmers to commence biomass production even when the investment returns are below those achievable through a conventional enterprise.

The agronomic and economic characteristics of willow and miscanthus make them risky alternatives compared to many conventional farm enterprises. For example, the lack of information regarding the crops suitability to Irish soil and climate means that yield levels are difficult to predict. The price level is also highly uncertain as the market for biomass crops in Ireland is still in its infancy. Although many energy companies offer guaranteed prices for biomass feedstock, there is still the risk that such companies may go out of business. This would leave the farmers with a perennial crop but no market. Any new purchaser of the feedstock could potentially drive the price down, as farmers have already incurred the substantial establishment costs and the costs of crop removal are high. Moreover, the lengthy production lifespan and extremely long payback periods for investments in biomass crops serves to heighten the level of risk associated with key parameters. Uncertainty about critical variables such as the annual yield level and the price per tonne make it difficult to accurately calculate the returns of such investments.

Accordingly, it can be expected that more risk averse farmers are unlikely to find biomass production an attractive investment prospect during the pioneer stage of the bioenergy market in Ireland. More widespread adoption is only likely when the economic merits of these crops have been proven over an extended period.

About the authors

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Appendix 1: Cash Flow of Willow Enterprise under the Baseline Assumptions

Year	Willow Cash Margin (€)	Superseded Cash Margin (€)	Overall Cash Margin (€)
1	(1644)	236	(1880)
2	309	236	73
3	0	236	(236)
4	324	236	88
5	0	236	(236)
6	810	236	575
7	0	236	(236)
8	810	236	575
9	0	236	(236)
10	810	236	575
11	0	236	(236)
12	810	236	575
13	0	236	(236)
14	810	236	575
15	0	236	(236)
16	248	236	12

Appendix 2: Cash Flow of Miscanthus Enterprise under the Baseline Assumptions

Year	Miscanthus Cash Margin (€)	Superseded Cash Margin (€)	Overall Cash Margin (€)
1	(2363)	236	(2599)
2	535	236	299
3	563	236	327
4	563	236	327
5	563	236	327
6	563	236	327
7	563	236	327
8	563	236	327
9	563	236	327
10	563	236	327
11	563	236	327
12	563	236	327
13	563	236	327
14	563	236	327
15	563	236	327
16	308	236	72

Short abstract (cover)

Using data from Ireland, this paper provides a Discounted Cash Flow (DCF) investment analysis for two of the most common biomass crops, willow and miscanthus. It concludes that due to the level of risk involved in growing biomass, widespread adoption in Ireland is only likely when the economic merits of these crops have been proven over an extended period.