4F – Future Crops for Food, Feed, Fibre & Fuel
FP7-KBBE-2007-1

Cost Analysis & Economic Evaluation of Future Crops in Europe

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EXECUTIVE SUMMARY

The economic analysis in the present project has paid attention to the aspects related to the financial performance of the examined crops. It has examined all parameters directly related to growers' profitability in an attempt to identify crops of possible interest for the profit maximising farmer in many different European countries and different climatic zones.

Costs and revenues of plants are measured against the opportunity cost of land which they occupy. Alternative uses have occurred in several cases, indicating that in several cases, these new crops (or in some cases well known crops from different usage perspective) can indeed be competitive within the established status quo.

However, the overall general conclusion is that non-food (future) European crops have a very promising future, although today, at current food and energy prices and in the absence of any financial support, most of them are not earning the opportunity cost of land. After all this is witnessed both in Europe and in America nowadays, where governments are directly or indirectly subsidising such initiatives in order to secure the continuation of cultivation of such crops for their environmental, economic and strategic advantages.

The oil producing crops (in most cases for food and non-food uses) are involved in tax exemption chains where the benefits are distributed along all the links of such chains. For example, tax exempted biodiesel. The recent experience of reductions of tax privileges in Germany shows how difficult it is for bioenergy chains to survive in Europe without some protection. Today, the pressures from America (Brazil, Argentina) are felt in Europe, where costs are much less flexible.

The situation is pretty much the same with sugar plants in the bioethanol industry. The energy products are also subsidised directly and indirectly both in Europe and in America. Once again, the competition comes from more or less the same countries, where the cost of production of plants such as sugar canes, sweet sorghum, etc. are much lower than in Europe. We have thoroughly tested sweet sorghum in various European regions and it was found that it will probably play a very important role in the bioenergy systems, because of its great adaptability and production stability in a very wide range of soil and climatic conditions.

Fibre crops such as flax and hemp were analysed in order to explore their potential for the future. They both produce various products (besides fibre) and their products are used in tens of different uses in industry. It was found with some exceptions, that, at today's economic conditions, flax is very marginal from an economic point of view, while hemp appears more attractive financially.

Perennial grasses, such as Miscanthus, Switchgrass, Cardoon, Giant Reed and Reed Canary Grass have been analysed for several climatic and political regions in Europe with their energy generation uses as the main product. These crops are either burned for the production of heat and electricity or pelletized for sale in the domestic and industrial sector. It was found that they may be better planted in surplus land, although their financial best was achieved when cultivated on good agricultural lands in spite of their increased land rent. In all cases it was revealed that the increase in productivity due to more fertile soil and increased level of inputs is more than compensated by the sales of higher output.

The exposition below, includes only part of the results of a very large number of cases that have been examined and some indication is given in several cases with regard to sensitivity of some parameters and “what if” alternatives. An unusual large amount of base information is also included in the text and in the Appendices, because it was thought that it might be useful for other researchers. Most graphics and templates have been produced by ABC, the agricultural cost analysis “Activity Based Costing” computer package, which has made all figures compatible and easily comparable.

PART I. DATA and METHODOLOGY

Introduction

The main objective of financial analysis is to identify the cost of production of 4F crops in EU countries. The analysis covers not only conventional crops, but also some promising "future" crops, i.e. crops that have not been sufficiently studied or cultivated in Europe. Most of these crops are cultivated mainly for energy and fibre production and their economic performance is compared with competing conventional plantations in different countries or regions in Europe.

The selected conventional and future crops are subjected to a comparative cost analysis. For the economic appraisal of crops, monitoring of economic parameters, such as commodity prices, interdependency of crops and the new CAP amendments is also included. Economic analysis of new and conventional crops looks into the economic and financial details of production of agricultural products from the point of view of the producer. Computerised analytic methods are used in order to estimate the economic viability and performance of the selected crops.

The economic analysis of crop production requires good knowledge of the cultivation operations, the requirements and productivity of various crops in different climatic conditions, soil types and methods of cultivation. Local labour costs and the degree of mechanisation also play a very important role in overall economics of the plantation under examination, thus making the economic analysis more or less a site specific matter. Therefore, we undertake different studies of specific conditions for different cases or scenarios by taking into account the existing conditions in the region under consideration.

The use of computerised models (*ABC*, the Activity Base Costing constructed for use in this project) for the investigation of economic performance, gives the opportunity to explore and compare a large number of cases and draw useful conclusions. It also allows the maintenance of a common analysis format in all cases under consideration, for uniformity of definition and easy comparison of assumptions and results.

Costing information

The analysis is based on detailed and reliable technical and economic information. The most important data categories for the economic analysis of 4F Crops are the following:

a. *General economic data*: Currency, short/long-term borrowing rates, tax rate, inflation rate, regional unemployment, etc.

b. *Crop details*: Economic life, annual yields in each region and associated inputs needs, rent of different agricultural land types (e.g. irrigated, marginal, agricultural), etc.
c. *Cultivation activities details*: Timing and technical details of crop production, e.g. requirements of machinery, labour, raw materials, etc.
d. *Irrigation needs*: Only for south European regions
e. *Selling prices* of crops' products and relevant subsidies.

Production factors databases

Contain data for agricultural land, machinery, raw materials and labour.

- Crops can grow on different land types and climatic regions. The characteristics of each crop determine the appropriate soil and climatic type for its growth. On the other hand, the same crop may grow under different land and climatic conditions, which differentiate the performance of the crop. For example, a crop on low rent marginal land will need more intensive soil preparation, while its yield may be low. The cost of land (land rent) varies according to land type and the region. Data concerning agricultural land type characteristics and corresponding cost are collected from international and regional statistical databases, regional agronomist and agricultural organisations (agricultural cooperatives, directorates of agriculture, etc.).
- Machinery databases record technical and economic data for mechanical equipment needed for agricultural production. They include purchase cost, economic life, maintenance and insurance cost, fuel type etc. Given the average annual operation, one may estimate the hourly cost of machinery usage. Fuel consumption depends upon the type of operation and the type of land. For example, in "heavy" operations, such as ploughing, a tractor consumes much more fuel than in operations like seeding and spraying. Such data is collected from manufacturers' and statistical databases and from agricultural engineers and other experts.
- For agricultural input products (seeds, rhizomes, fertilizers, pesticides, water, etc.) we need their purchase cost. Data for raw materials are collected from manufacturers and importers as well as from statistics (FAO, Eurostat, etc.) and the Web.
- There is a number of available labour types (skilled, unskilled, operator) in agriculture and their corresponding cost varies not only by type, but also from region to region. Such data is available in international and regional statistical databases and studies.

The cost figures used in the analysis of 4F crops have been drawn from:

- Published cost studies of European crops
- Statistics (FAO, Eurostat, National Statistics Bureaus, etc.)
- The experience on the subject of the project collaborators and existing databases and costing models that have been made available for this work.

Statistics

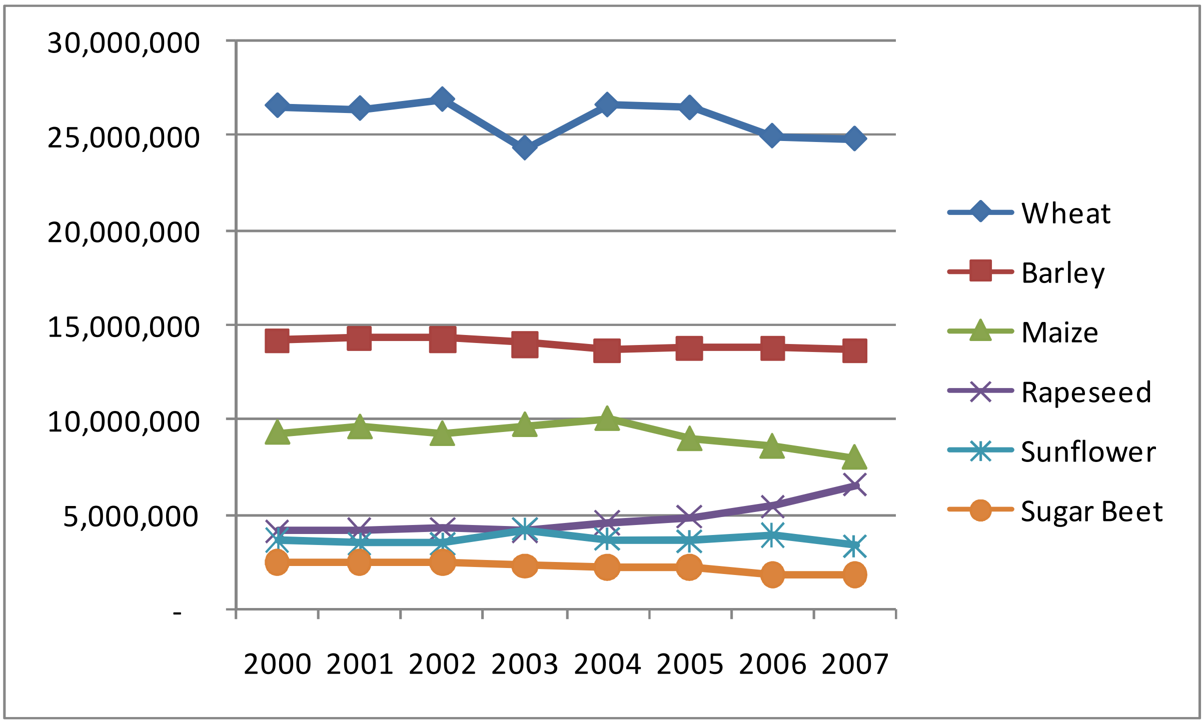
One of the main sources of data for this analysis is available statistical databases. Eurostat, and FAO (Food and Agriculture Organisation) statistical data bases cover a great variety of agricultural data and they are an international source of reasonably reliable and generally accepted figures. The cost data recorded in these databases include:

- Agricultural data, such as land use, crops' cultivated area and production quantities and yield of crops production
- Agricultural product prices in various EU markets
- Land rent by region
- Labour cost in each country
- Agricultural inputs prices

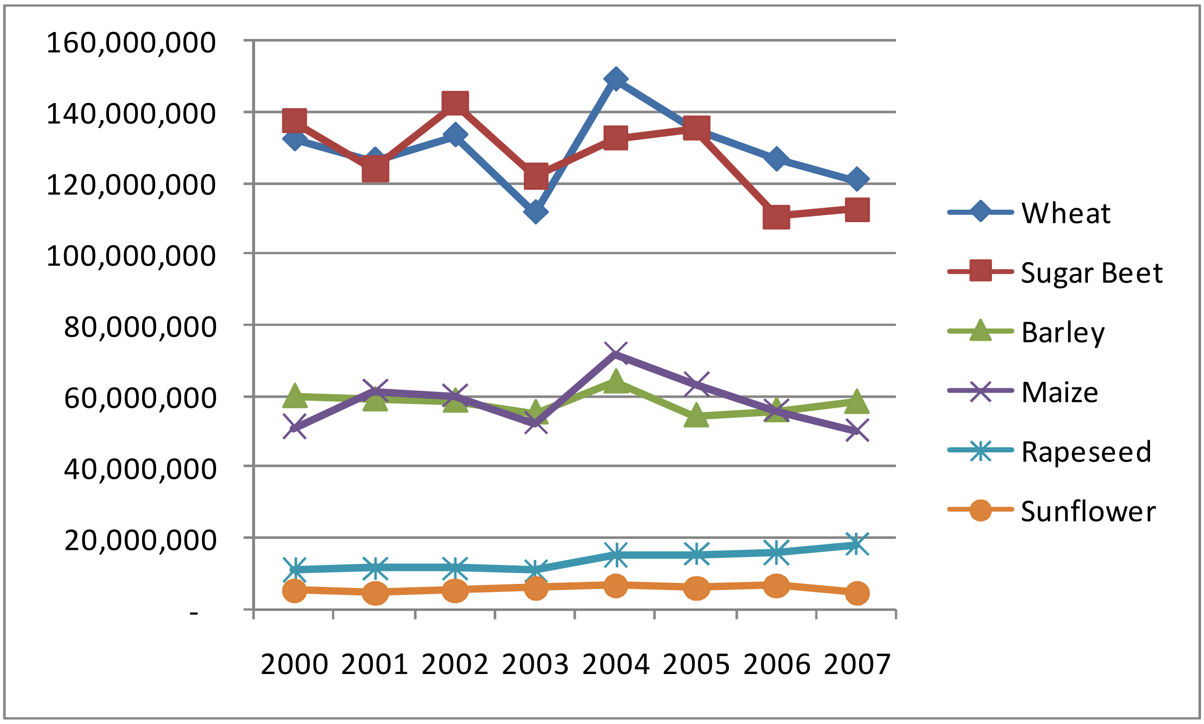
EU 27 Agricultural Land Use – Current Status

This section presents the current status of the EU27 agricultural land use and arable crops production and covers the period from 2000 to 2007. This analysis shows the basic arable crops for EU agriculture and the respective share and importance of these crops in each country's agricultural sector. The selected years cover the whole period of the previous CAP (Common Agricultural Policy), from 2000 to 2006 and the period when the CAP was reformed (2006-2007). Thereby, we may extract useful conclusions for potential changes in arable crops production.

According to FAO 2005 data, total EU 27 agricultural land is about 190 million hectares. Arable land covers 58% of this area, while 21% is covered with temporary crops, 6% with permanent crops and 3% is fallow land (set aside area). Germany, The Netherlands, Poland, Romania, Italy, Spain, Portugal, Greece, France and the UK are the countries with the greatest agricultural land (about 80% of the total agricultural land of the EU).



Harvested Area (ha) of the basic arable crops in EU27 countries, during 2000-2007 *(Source: FAO)*

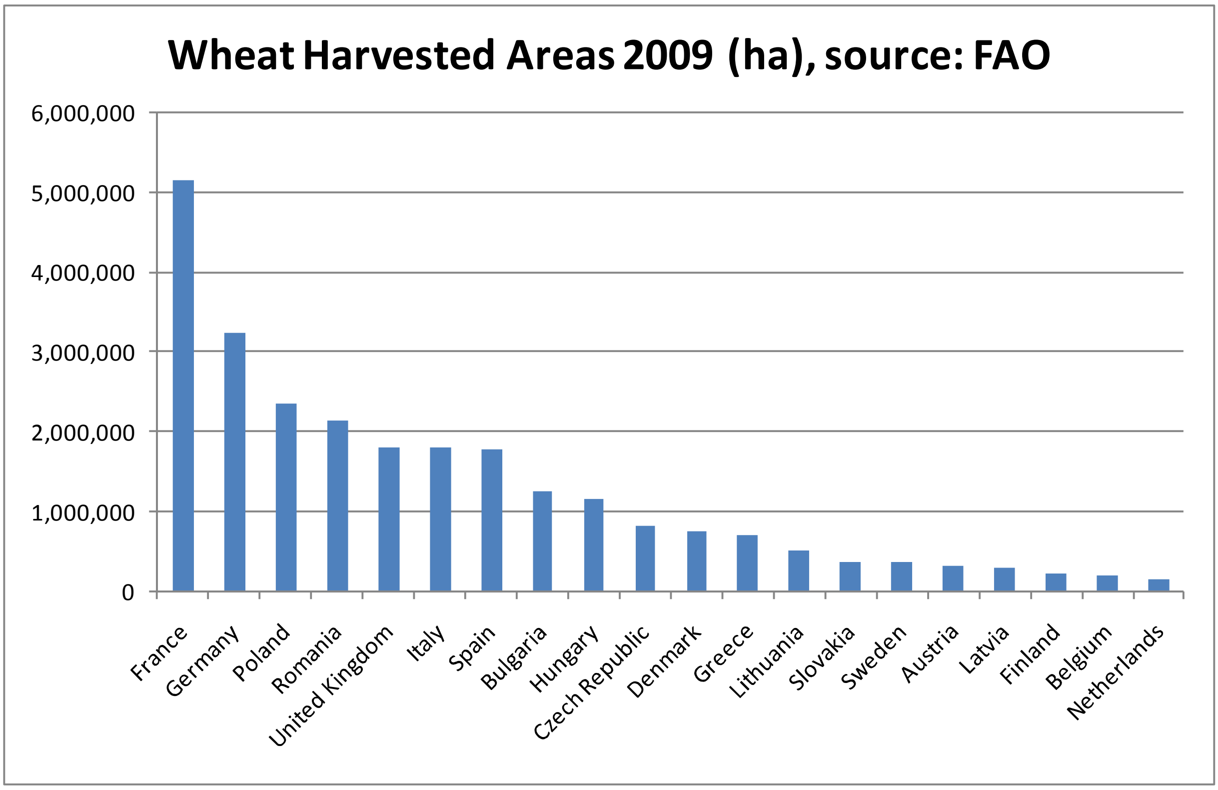


Production Quantities (t) of the basic arable crops in EU27 countries, during 2000-2007 *(Source: FAO)*

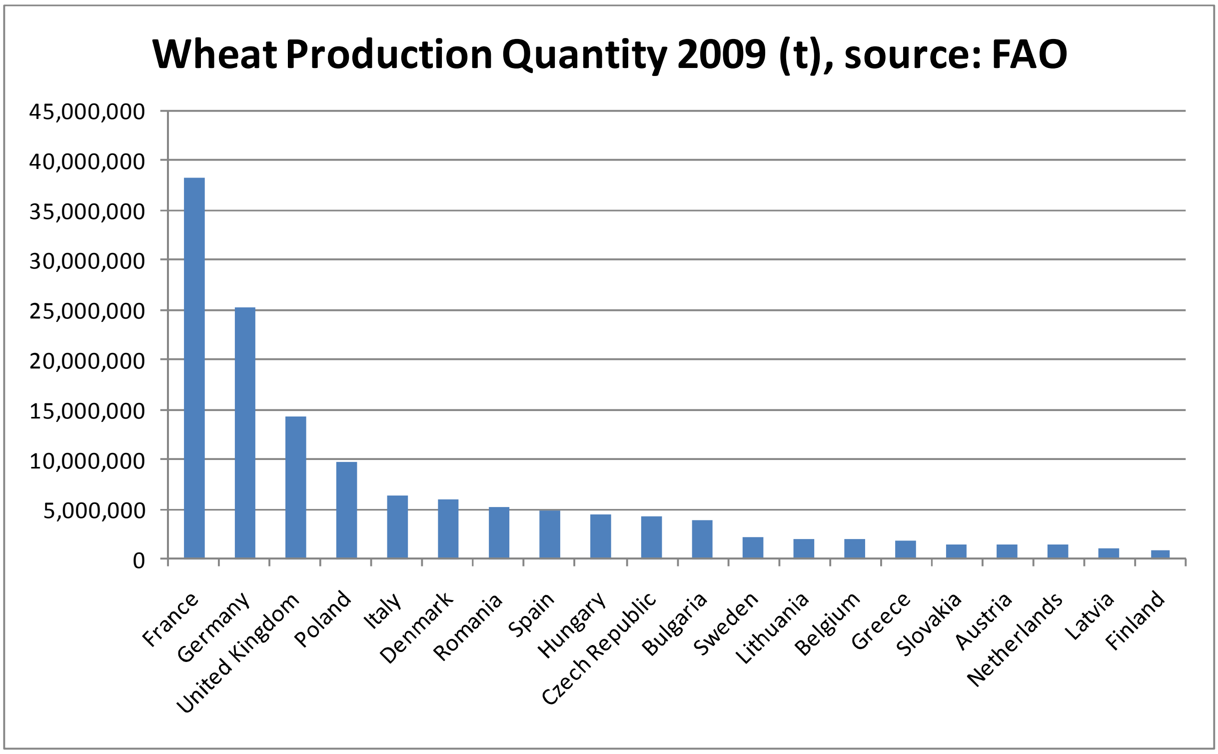
The basic cultivated arable crops of EU 27 are Wheat, Barley, Maize, Rapeseed, Sunflower and Sugar beets. The two line charts show the harvested area and the production quantities of each one of the above crops, as a total for EU 27 countries, during the period 2000-2007. Although Bulgaria and Romania became EU members in 2008, this figure presents data for *all* countries from 2000, for comparability.

Wheat (25 m. ha)

The total EU 27 wheat harvested area in 2007 was about 25 million hectares (13% of EU 27 agricultural land). This area was even larger (about 27 m. ha) during the period 2000-2005, with a small decrease in 2003 (24 m. ha). Nevertheless, the harvested area of wheat in EU 27 is almost steady for the last eight years (see line charts above).

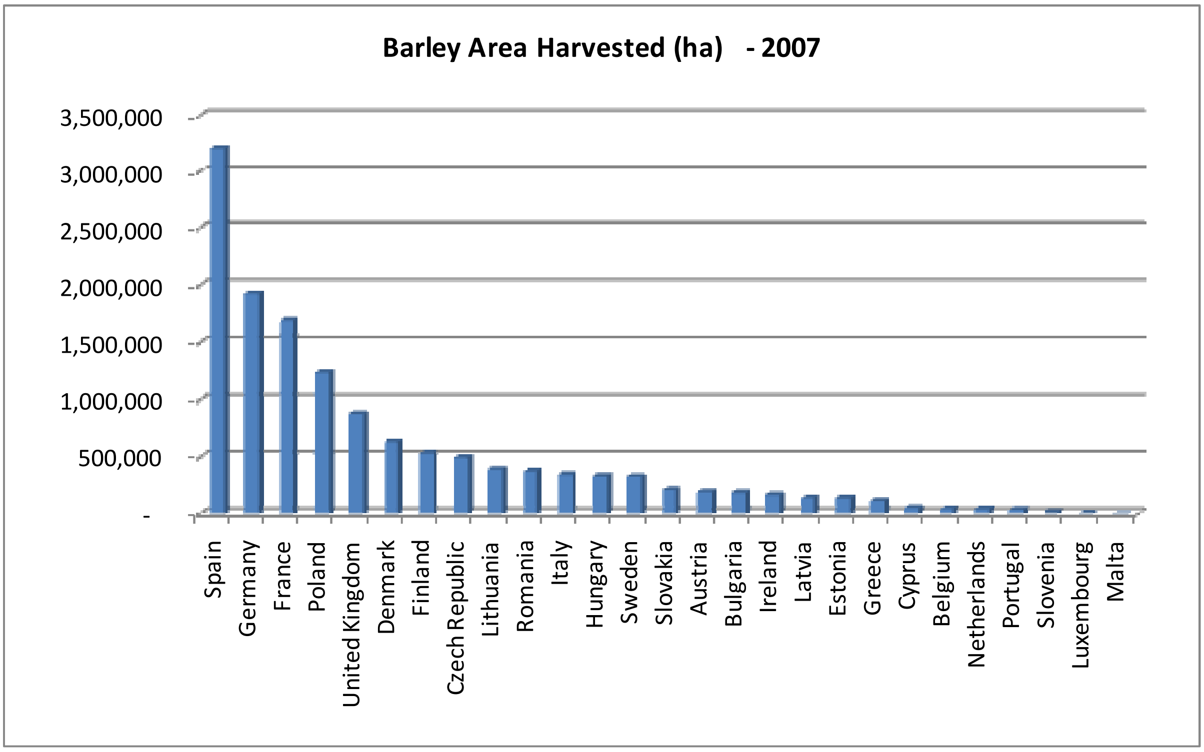


According to FAO 2007 statistical data, the main wheat producer in EU was France, where 5.3 million hectares of wheat were harvested in 2007 and the production of wheat seeds exceeded 33 million tonnes. Germany is the second EU wheat producer (over 21 million tonnes and about 3 million hectares in 2007). UK is third in Europe with about 13 m. tonnes of wheat production and over 2.1 m. ha in 2007.

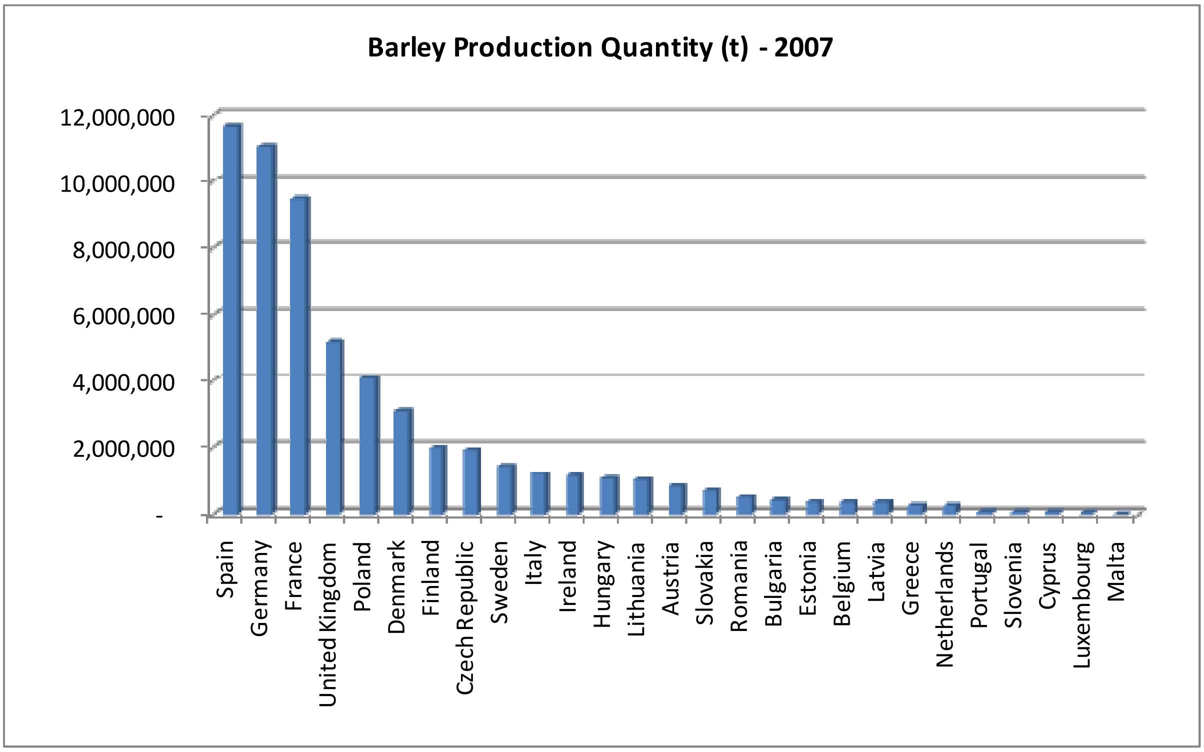


Barley (14 m. ha)

The total barley harvested area for EU 27 countries is has been fairly steady during the 8-year period 2000-2007. This area is about 14 m. This area covers 7% of total EU 27 agricultural area. The main producer of barley in EU is Spain, which in 2007 produced 11.5 million tonnes in 3.2 million hectares (FAO data).

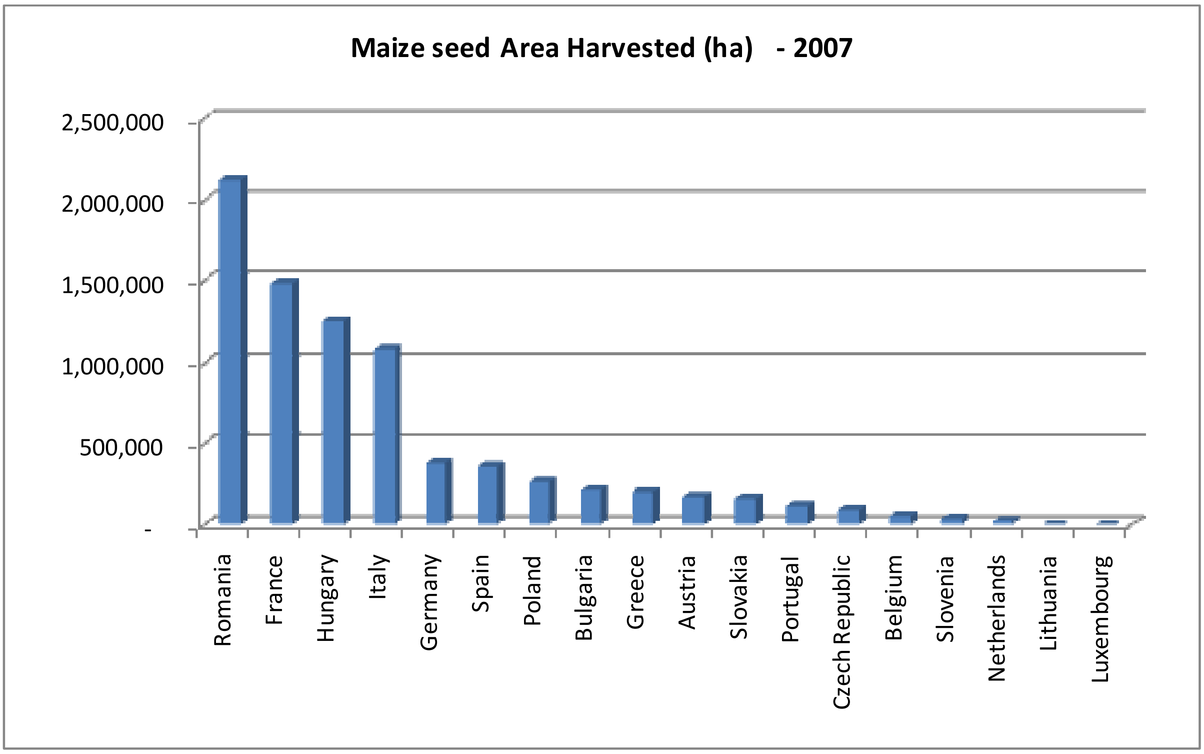


During the same period, Germany and France produced 11 million tonnes (2 million hectares) and 9.5 million tonnes (1.7 million hectares) respectively.

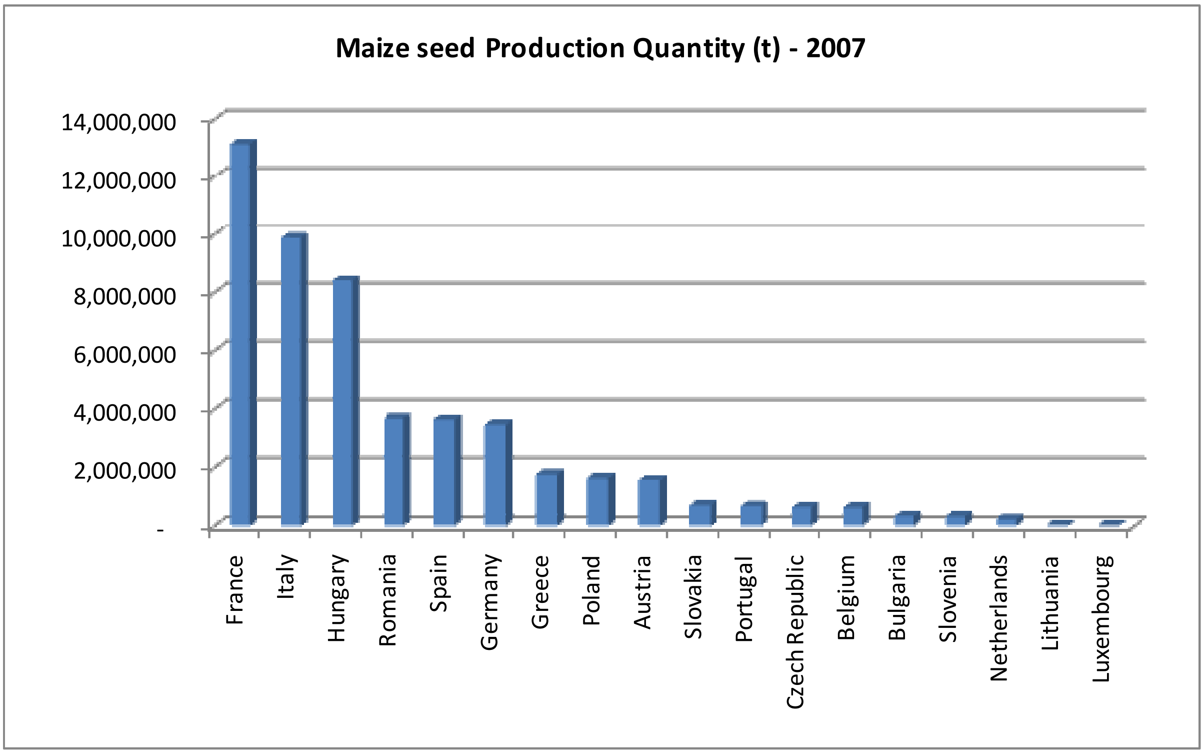


Maize (8 m. ha)

In 2007, maize is the third most important arable crop in EU agriculture. In particular, in this year, 8 million hectares (3% of EU agricultural area) of maize were harvested. Contrary to wheat and barley production, maize is produced only in 18 of 27 EU countries.



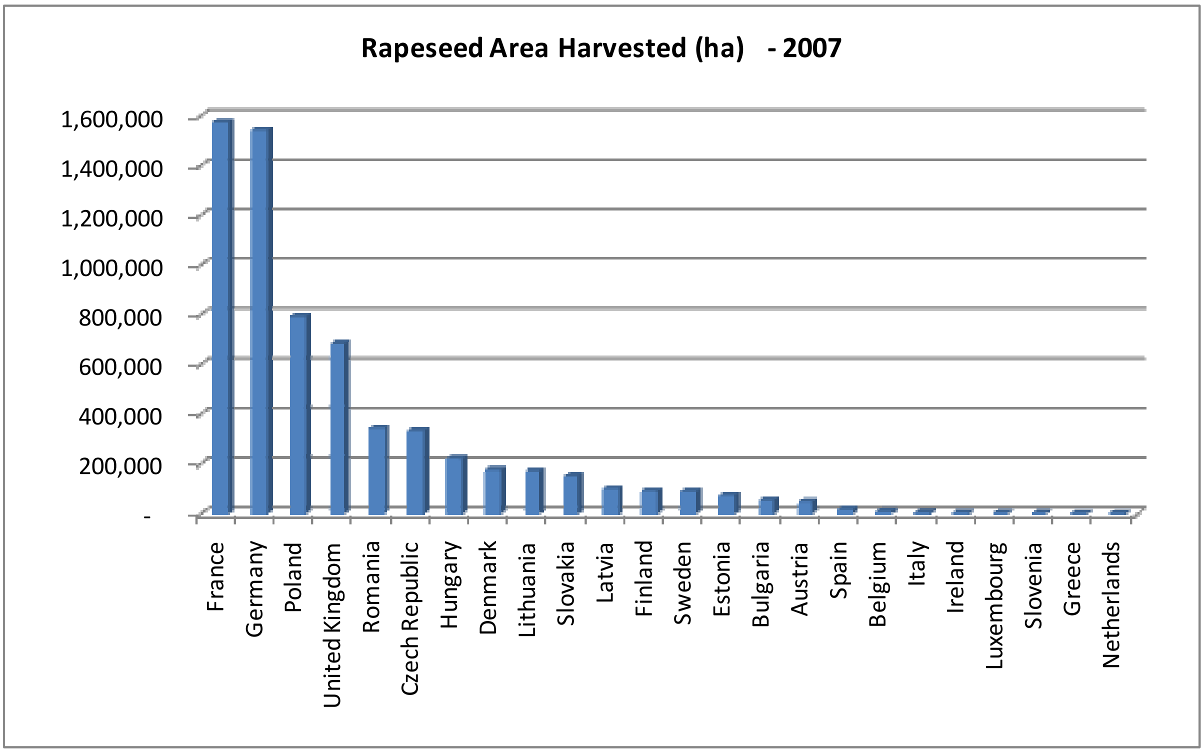
It is important to notice that while EU maize harvested area was slightly increased between 2000 and 2004, from 9.3 million hectares to 10 million hectares, there was a great decrease during the last 3 years. According to FAO data, the total area harvested in 2007, for EU 27 countries, reached 8 million hectares that is 20% decrease compared to 2004 area.



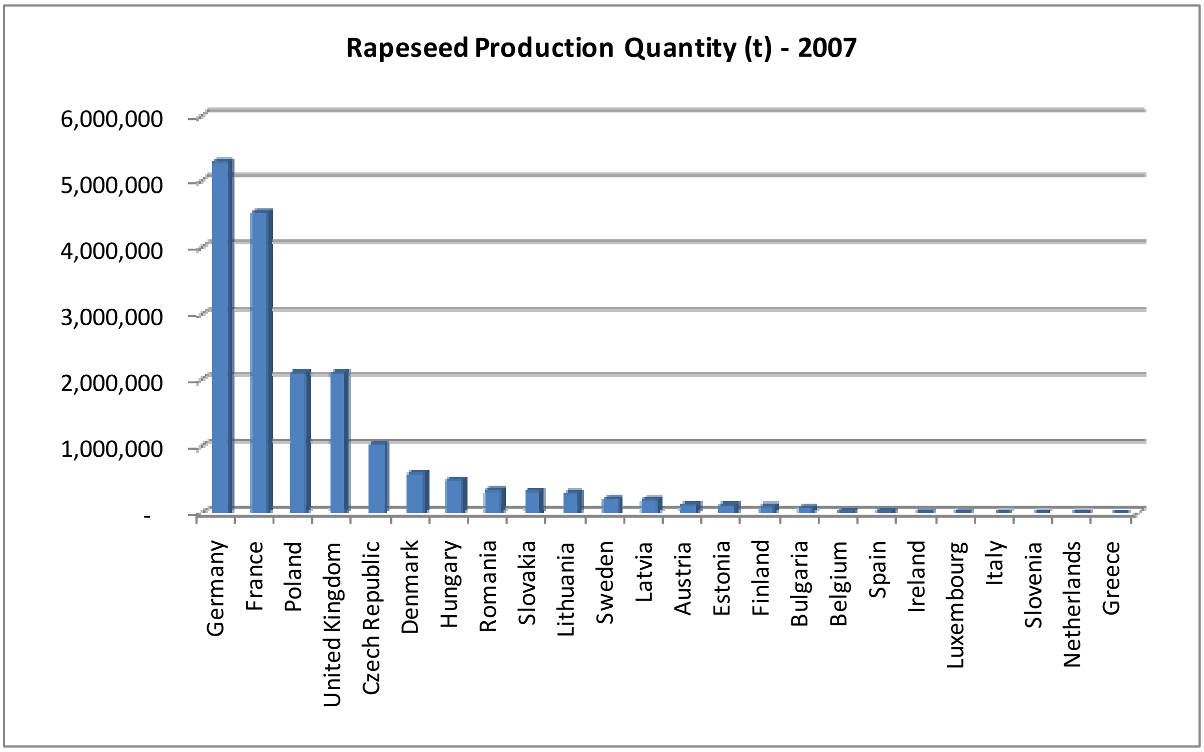
In EU 27, France was the main maize producer for 2007 (13 million tonnes, 1.5 million hectares), followed by Italy and Hungary with production of 10 and 8.5 million hectares.

Rapeseed (6.5 m. ha)

Rapeseed is the fourth most important arable crop in EU agriculture, since, in 2007, it was cultivated



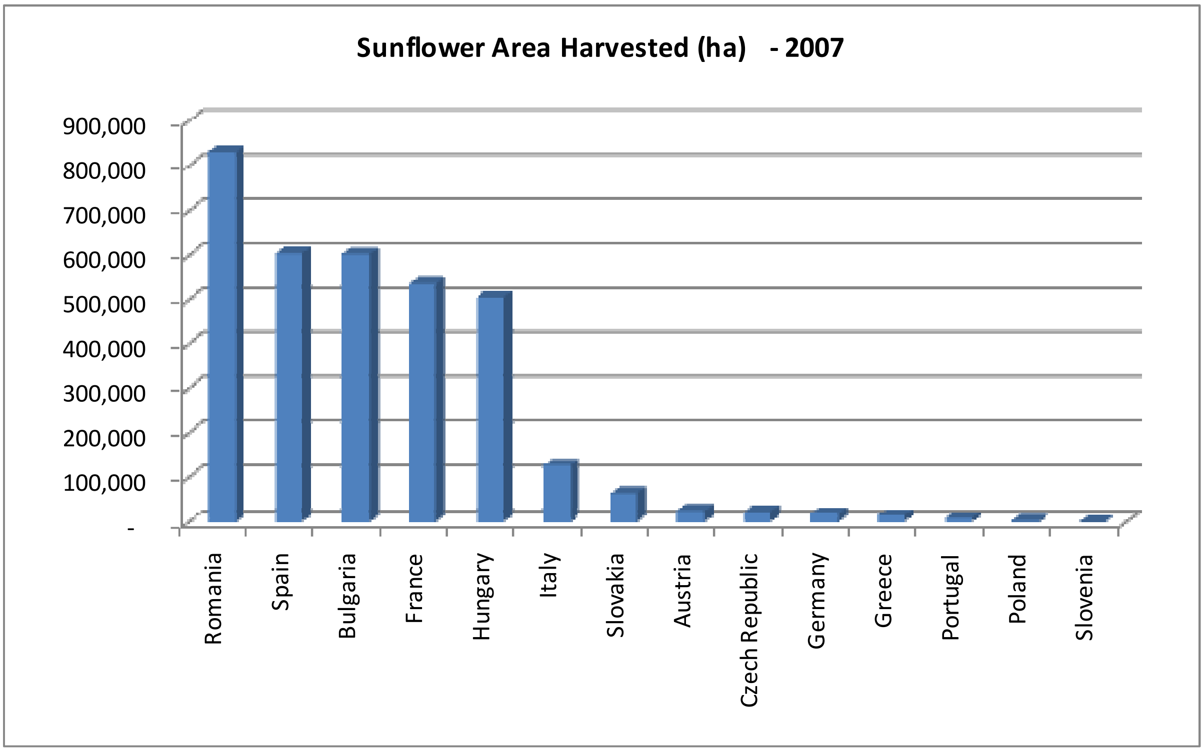
in the 3% of total EU agricultural area (6.5 m. ha). From 2000 to 2008 there was a significant increase of the rapeseed harvested area. This increase was mostly took place during period 2005-2007. In 2000 the total rapeseed area in EU 27 was 4 million hectares, while in 2005 the recorded area reached about 5 million hectares. As mentioned, the greatest increase in rapeseed area, took place the last three years (35% increase between 2005 and 2007). A reason for this was the increase of the use of rapeseed as a raw material for Biodiesel production.



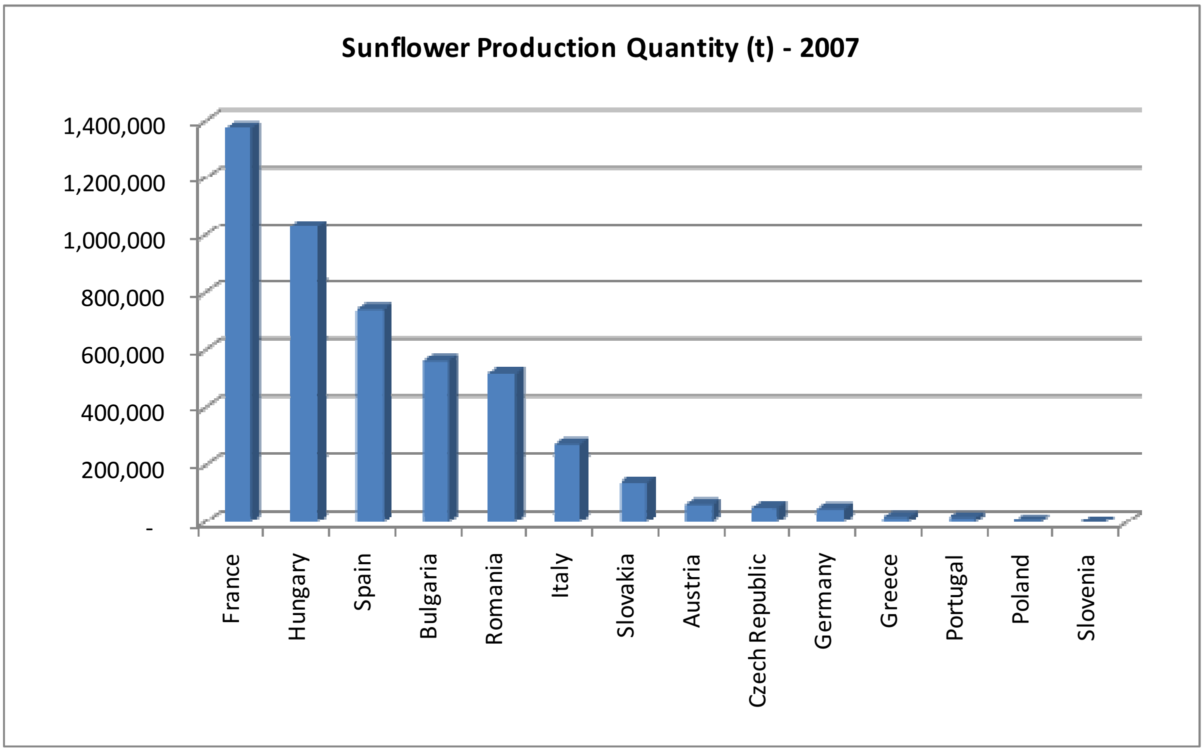
Germany and France are the greatest rapeseed producers in EU 27. Germany's rapeseed production in 2007 reached 5.3 million tonnes from 1.6 million hectares, while France produced 4.5 million tonnes from 1.5 million hectares also. Poland and UK produced also 2 million tonnes rapeseed each, in 2007.

Sunflower (3.5 m. ha)

Sunflower is the fifth most important arable crop in the EU agriculture, based on the harvested area of 2007.In this year, 14 of 27 EU countries produced sunflower. The total harvested area was about 3.5 million hectares (2% of total EU agricultural area), while the EU production reached about 5 million tonnes. The above figures are more or less stable during years 2000 to 2007.

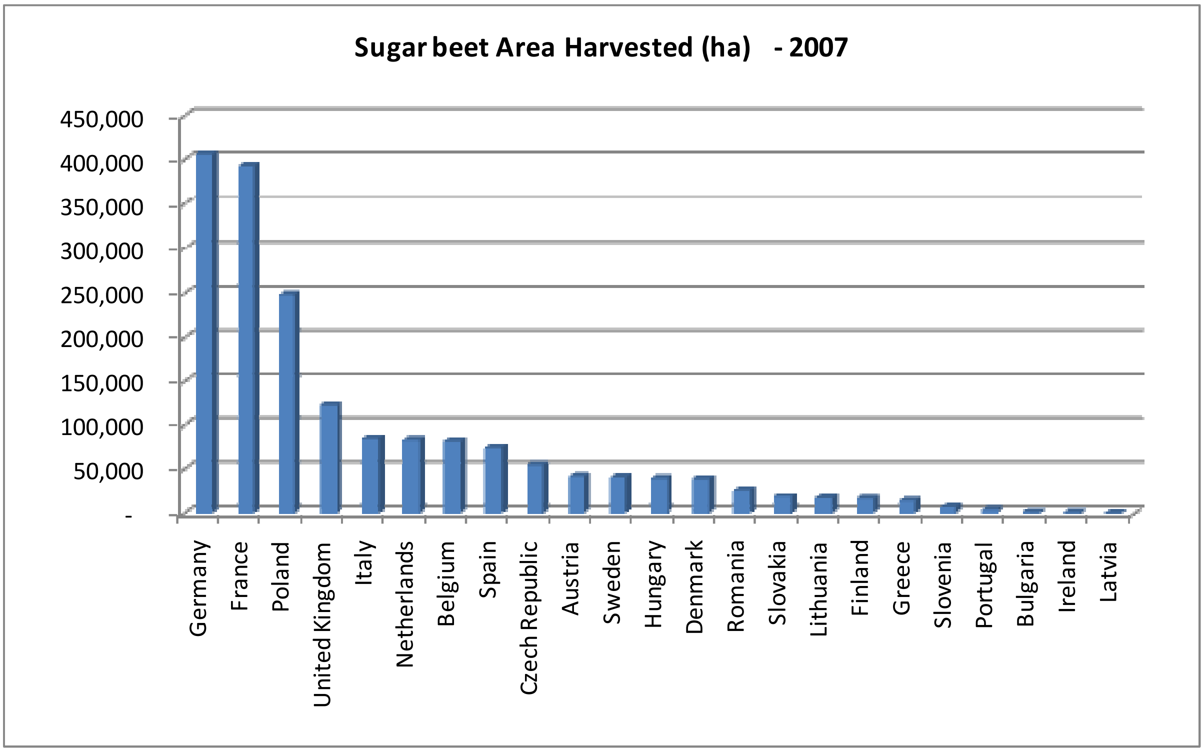


The main sunflower producers in EU are Romania, Spain, Bulgaria, France and Hungary. The harvested area of the above countries reached more than 3 million hectares in 2007, with a respective production of 4.2 million tonnes. This means that these five countries produce about 85% of the total EU sunflower production.

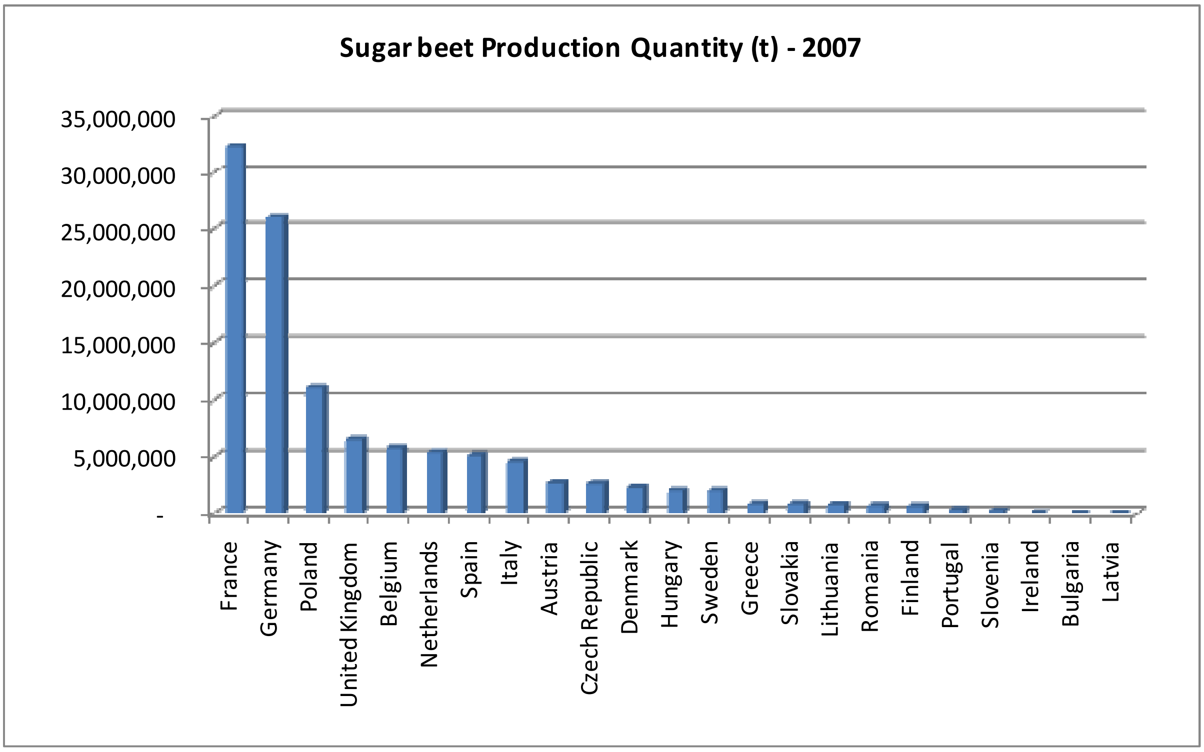


Sugar beet (2 m. ha)

In 2007, sugar beet harvested area reached 1.8 million hectares with a respective production of 113 million tonnes (see Table 2 in Annex I). During the period 2000-2007, the harvested area of sugar beet has been decreasing. The greatest decrease (16%) occurred between 2005 and 2006 production period (see Annex I, Figure 1a). On the other hand, the production quantity has increased in 2004 and 2006, while in 2007 is the lowest of the last 8 years.



Sugar beet is produced in 23 of 27 EU countries. The main producers in EU are France (32 million tonnes of production and about 400 thousand hectares of harvested area in 2007), Germany (26 million tonnes and 400 thousand hectares) and Poland (11 million tonnes of production and 250 thousand hectares). Other important producers are UK, Italy, Netherlands Belgium and Spain (see Annex I, figures 7a and 7b).



Other arable crops

Other important arable crops for EU agriculture are alfalfa and soybean. Alfalfa is mainly produced in Italy, Romania, France, Spain and Hungary. The total EU cultivated area in 2007 reached about 2 million hectares.

Soybean production is much lower. In particular, in 2007 the total harvested area was about 70 thousand hectares and the production reached 135 thousand tonnes. On the other hand, for Italy and Romania, the cultivation of soybean is very important, since the harvested area for each country in 2007 was 130 and 110 thousand hectares respectively.

Conclusions

According to the above analysis, the most important arable crops for EU 27 are wheat, barley, maize, rapeseed and sunflower. Additionally, alfalfa and soybean play an important role in EU agriculture. These crops are the main conventional crops that should be regard as competitors of energy crops for solid and liquid biofuels production. Additionally, set aside area that represents 3% of the total EU agricultural area, should be considered as a potential land for energy crops production. Additionally, among the 27 countries of EU, Germany, The Netherlands, Poland, Romania, Italy, Spain, Portugal, Greece, France and UK are the ones that cover greatest part of the total EU agricultural land.

Crop Yields

Countries with higher productivity, may potentially achieve lower cost of production per tonne of production. This section examines the yields of the main conventional crops that will be analysed. The main source of the data is FAO databases that record average yield per country.

Note that yields for future crops (not regularly cultivated), such as energy and fiber crops, are not available in statistical databases such as FAO and Eurostat, or in the regional statistical services. This is because those crops are not produced commercially at a large scale. For this reason, data for the productivity of new crops is only available from published studies, research projects etc. In some cases, the productivity of conventional crops is an indication of the potential productivity of new crops with similar characteristics. Countries with high yields of conventional crops, due to advantageous soil and climatic conditions, will potentially achieve high yields in "future" crops production.

Tables with detailed yields may be found in the annexes. Based on this, the table below summarises the results from the statistical analysis of the yields.

Average yields in EU 27 (t/ha), year 2007

	Wheat	Barley	Maize	Rapeseed	Sunflower seed	Sugar beet
Average	**4.55**	**3.87**	**6.98**	**2.51**	**1.80**	**52.15**
Min	**1.13**	**1.10**	**1.46**	**1.00**	**0.63**	**12.68**
Max	**8.11**	**7.53**	**10.33**	**3.57**	**2.58**	**82.29**
Standard Deviation	**1.93**	**1.61**	**2.65**	**0.76**	**0.59**	**15.95**

Source: FAO

Yield charts in Annex 8 present the yields of each crop in different countries, ranked by volume. Among EU 27, Ireland, Belgium, UK, Germany, Netherlands, Denmark and France are the countries that present the higher yields in small cereals (wheat and barley) production, while Romania and Cyprus have the lowest. With regard to maize seed production, Belgium and Spain have the highest yields, while Romania and Bulgaria have the lowest.

Rapeseed production has high productivity (higher than 3 t/ha) in Belgium, Netherlands, Germany, Luxemburg Ireland and Denmark. France and Germany have highest yields for sunflower production. For both crops, Romania has the lowest yield among EU countries.

Finally, sugar beets have high productivity in France (about 80 t/ha) and Portugal (about 75 t/ha), while in Bulgaria the productivity is very low (lower than 15 t/ha).

It is important for this project to examine the reasons of this variation of yields. For example, there are countries, like Romania and Bulgaria that record low figures systematically. Additionally, it is very important to determine how this variation of conventional crops yields is reflected on “future” crops production.

Agricultural Product Prices

The prices of agricultural products are necessary in order to estimate agricultural income and profits from crop production and to identify income and expenses of agricultural enterprises or production sectors. In this part, the products form 4F crops may be categorised into two main categories:

a) Products with existing market prices. These products might be conventional products such as wheat and maize seed for food and feed, or new products, for example energy crops with known market prices, such as straw for heating or rapeseed for biodiesel production.

b) Products of future crops with unknown market prices. This category covers the crops that are not produced or traded on a commercial level and for this reason their prices are not quite established in the market. In this case, the price of “future” crops should be imputed from prices of substitutes, by taking into account the specific characteristic of each product.

Annex 9 details the prices of the main arable crops in EU countries for 2006 and 2007. The EU average prices of the main arable crops, for 2006 and 2007, are summarised in the table below.

It is known that there was a great change in agricultural products market prices between 2006 and 2007. Those changes where more obvious in cereals. The following Table shows that cereals prices had a huge increase. In most of the cases, the increase exceeded 50% from 2006 to 2007. The price change was higher for maize and soft wheat. With regard to sunflower, there was also a great increase of 40%, while the rapeseed price increased 21%. Among the main arable crops, the only product with price redaction was sugar beet.

EU 27 average prices (€/t) and % change between 2006 and 2007

	2006	2007	%
Maize	121	197	63%
Soft wheat	113	182	61%
Barley	108	168	56%
Durum wheat	128	200	56%
Rye	105	163	56%
Triticale	100	150	50%
Oats	118	167	42%
Sunflower	257	361	41%
Sorghum	112	157	40%
Soya	198	249	26%
Rape	225	271	21%
Rice	195	235	20%
Sugar beet	34	31	-9%

Source: Eurostat

Cost of Land

Land is an essential factor of agricultural production and in most cases a major cost item. The cost of agricultural products may be significantly increased if planted on high cost land and vice versa. Therefore, land cost must be carefully estimated in all agricultural projects. The cost of land might be considered as one of the major cost factors of agricultural production. In some cases, the cost of land exceeds 30% of the total cost.

The cost of land varies due to a large number of factors, the most important of which are availability, the type of land (fertile, semi-fertile, meadow, mountainous, irrigated or non-irrigated, etc.) and the region or country, where market conditions are determined. If there is a fairly competitive market for land, one may assume that recorded land rent adequately reflects its real or opportunity cost. However, if there is no market, the cost of land is not easily identifiable. In such cases one needs to estimate its opportunity cost as expressed by the net economic profit of current or alternative land use.

The recorded cost of land varies significantly between EU countries. Annex 9 presents land prices and rents of various land types of EU countries, where available. In Netherlands, Denmark and Luxemburg land prices are the highest in Europe, while Malta, Denmark, Greece and The Netherlands have the highest land rent of agricultural land.

Cost of Labour

Labour, especially in small farms, such as the ones in southern EU, is usually provided by the farmer and his family, but it may also be hired, especially during peak labour demand, e.g. at planting or harvesting times. Hired labour in most cases has a market specified rate, which can be used in the analysis. Imputed labour cost should be principally evaluated at market or opportunity cost, i.e. the amount of income forgone for shifting family labour from current activity due to the needs and requirements of the project. When there is no market for a commodity or service, the opportunity cost of the relevant factor of production should be used to estimate the cost of inputs. Opportunity costs should in general reflect market values and vice versa.

The labour cost element in agricultural production depends upon:

a) The ***cultivation characteristics*** of crop production. For example, arable crops demand less human effort than vegetable production. Another example is perennial energy crops, where their production is mostly performed by mechanical means and labour requirements are minimal.
b) The ***type of labour*** needs. The rates of skilled labour, where necessary, are much higher than unskilled labour rates.
c) The ***country*** and the ***region***. In most of the cases, the labour rates differ significantly not only between countries but also between different regions of a country.

Unfortunately, Eurostat databases do not include statistical data about labour rates in agriculture. For this reason, data of regional statistical services are necessary. The relevant tables in Annex 9, based on Eurostat figures, present the general hourly labour cost and the hourly labour cost in the services sector respectively, across EU countries. The countries with the highest labour costs are Luxemburg, Denmark, Sweden, Germany, France and Belgium, while the ones with the lowest are Romania and Bulgaria.

Agricultural Input Prices

This section examines the prices and cost of raw materials and other agricultural inputs, such as energy, fertilizers, pesticides, water etc. Input prices differ between EU countries. Tables 9-14 in Annex III, present the prices of agricultural inputs, as they appear in Eurostat databases. The prices of some of these products have significant differences between countries (see for example electricity, heating gas and diesel oil). Among fertilizers, Sulphate of ammonia, Ammonium nitrate (26% N) and Superphosphate (18% P205) are also priced differently in different countries.

The following table present the average prices of selected basic products used in agricultural production.

Average Prices (EU27) of basic agricultural inputs

		Average Prises 2007	Average Prices 2006	% Change
Electicity	**€/MWh**	317	251	26%
Diesel oil	**€/m3**	485	473	2%
Sulphate of ammonia	**€/ton of nutritive substance**	512	511	0%
Ammonium nitrate (26% N) (in sacks)		660	593	11%
Ammonium nitrate (33% N) (in sacks)		548	465	18%
Urea		564	479	18%
Superphosphate (18% P205)		675	527	28%
Triple Superphosphate (46% P205)	**€/ton merchandise**	520	402	29%
Ternary fertilizers 20 - 10 - 10		323	289	12%
Ternary fertilizers 9 - 9 - 18		253	243	4%
Ternary fertilizers 10 - 20 - 20		275	320	-14%

Source: Eurostat

Selected Regions and Crops

The selection was based on:

1. The proposals of project partners.
2. The relative economic significance of conventional and future crops.
3. Emphasis on the countries involved in this project, i.e.: Germany, The Netherlands, Poland, Romania, Italy, Spain, Portugal and Greece, while France and UK were added because they cover a great part of the total EU agricultural land and activity. In addition, the selected countries also cover a wide range of the selected climatic regions.
4. The suitability of selected crops in the climatic and soil conditions in the selected countries.

The following table shows the basic cultivated arable crops of EU-27 and their contribution in each country's agriculture. These crops are Wheat, Barley, Maize, Rapeseed and Sunflower. Additionally, less widespread crops, such as Soybean, Sugar beet and Alfalfa, are significant for some of the countries.

Table of regions and most popular crops cultivated today

	Soil and Climatic Regions	Agricultural Land	Current Crops	% Agr. Land	4F Crops	
Germany	• Continental • Atlantic Central • Atlantic North	17 million ha **9%** of EU27 Total Agricultural Land	• Wheat • Barley • Rapeseed • Maize • Sugar beet	18% 11% 9% 2% 2%	• Sweet sorghum • Fiber sorghum • Arundo • Switchgrass	• Flax (Linseed) • Willow
Netherlands	• Atlantic Central • Atlantic North	1.9 million ha **1%** of EU27 Total Agricultural Land	• Wheat • Sugar beet • Barley • Maize	7% 4% 2% 1%	• Sweet sorghum • Fiber sorghum • Arundo • Switchgrass	• Flax (Linseed) • Willow
Poland	• Continental	15,9 million ha **8%** of EU27 Total Agricultural Land	• Wheat • Barley • Rapeseed • Maize • Sugar beet	13% 8% 5% 2% 2%	• Sweet sorghum • Fiber sorghum • Arundo • Switchgrass	• Flax (Linseed) • Hemp
Romania	• Continental • Panonian	14,5 million ha **8%** of EU27 Total Agricultural Land	• Maize • Wheat • Sunflower • Barley • Alfalfa • Rapeseed	15% 13% 6% 3% 2% 2%	• Sweet sorghum • Fiber sorghum • Arundo • Switchgrass	• Flax (Linseed) • Hemp
Italy	• Med. North • Med. South	14,7 million ha **8%** of EU27 Total Agricultural Land	• Wheat • Maize • Alfalfa • Barley	14% 7% 5% 2%	• Rapeseed • Sweet sorghum • Arundo • Miscanthus	• Switchgrass • Flax (Linseed) • Poplar
Spain	• Lusitanian • Med. North • Med. South	29 million ha **15%** of EU27 Total Agricultural Land	• Barley • Wheat • Sunflower	11% 6% 2%	• Rapeseed • Cardoon	• Flax (Linseed) • Hemp • Poplar
Portugal	• Lusitanian • Med. North • Med. South	3,7 million ha **2%** of EU27 Total Agricultural Land	• Maize • Wheat • Barley	3% 2% 1%	• Sunflower • Rapeseed • Sweet sorghum	• Cardoon • Poplar
Greece	• Med. North • Med. South	8,4 million ha **4%** of EU27 Total Agricultural Land	• Wheat • Barley • Maize	8% 1% 2%	• Sunflower • Rapeseed • Sweet sorghum • Arundo	• Cardoon • Miscanthus • Switchgrass • Poplar
France	• Atlantic Central • Lusitanian • Med. North • Med. South	29,6 million ha **15%** of EU27 Total Agricultural Land	• Wheat • Barley • Maize • Rapeseed • Sunflower	18% 6% 5% 5% 2%	• Sweet sorghum • Miscanthus • Switchgrass	• Flax (Linseed) • Hemp • Poplar
UK	• Atlantic Central • Atlantic North	16,6 million ha **9%** of EU27 Total Agricultural Land	• Wheat • Barley • Rapeseed	11% 5% 4%	• Sweet sorghum • Fiber sorghum • Arundo • Switchgrass	• Flax (Linseed) • Willow

PART II. CROPS ECONOMIC EVALUATION METHODOLOGY

The economic analysis of crops is tracing all costs incurred in the production and harvesting of the plants. Soil preparation, seeding or planting, fertilisation or harvesting and other operations are broken down into single activities, each with specific needs, duration and cost. After crop establishment there are one or more periods (normally years) of the plant's life, during which a number of cultivation *operations* are required for growing and maintaining the plant in good condition. The harvesting operation takes place in the first or subsequent years of the plant's life. Sometimes harvesting may occur a few years after the installation of the plantation (especially in the case of trees), or even year after year, etc. Yields consequently vary due to the reasons just described. They may also differ from year to year due to maturity and other plant characteristics. Yield variation due to weather conditions is not easily predicted, therefore in most cases, meaningful averages are widely used.

Cost breakdown is useful not only because it measures and reveals major or important cost elements, but because it indicates possible improvement or cost saving opportunities. For managerial analysis, the definition of cost is broader than the cost reported for tax purposes. In accounting, the concept of actual historical cost is central, but it ignores several important components of economic costs. These items are costs associated with the use of financial capital (including equity), long-lived factors such as equipment and buildings owned and used by the business, paid labour and the contribution of unpaid time and effort provided by the farm operator and family members. Estimates of such implicit costs are obtained using the economic concept of "opportunity costs". (AEEA, 2000).

The Methodology is general enough to evaluate conventional plants or plantations as well as future crops with sufficient description. This allows the analyst to evaluate conventional crops which compete directly with the future crops for the same land, and draw useful conclusions. The analysis consists of all the steps necessary for decision making and capital budgeting, i.e. cost analysis, and investment appraisal. For this purpose it estimates and analyses the full cost of crop production and calculates the most important financial indices, consistent with current financial standards.

Cost Analysis of Agricultural Projects

Agricultural production differs from industrial activity mainly because of the significance of land as a production factor and the fact that a number of production inputs, such as labour and land, are not "paid and bought", but usually belong to the typical producer, the farmer. Furthermore, *farm* and *family income* or *return to own land* is usually reported in agricultural accounts which indicate the significance of the farmer family and land in the production process. Here, we attempt a more business- like approach and a compromise between agricultural accounts and usual financial reporting in order to be consistent with financial accounting common practice.

Cost analysis is required for the correct valuation of production processes of agricultural products. It is traditionally exercised for the identification of cost of goods sold and inventory valuation. However, the prime target of cost analysis here will be the estimation of costs for decision making and price setting. For this reason costs of production are examined along the lines of two major costing bases: (a) Cost by activity or operation (*Activity Based Costing*, ABC[1]) and (b) cost by input or factor of production. The first identifies production as a total of the necessary activities for the completion of the task and values each one of them. The second accumulates the cost of all factors or inputs required for the production.

Activity Based Costing, identifies all major production and non-production activities of the economic unit, traces their costs and assigns them to the product or products that use the resources of the consuming activities. *Activity Based Costing* helps to assign to final products a larger amount of total costs, because it identifies and classifies a large part of agricultural production overheads into production related activities. ABC is equally useful in the case of multi product farming using varying significant amounts of different production activities because it results in more accurate estimation of product costs.

Direct and Indirect Costs

Direct costs are costs that may easily be traced to a product, such as for example raw materials or man-hours consumed for its production. However, some costs are not so easily traced to the product(s). These are called *indirect costs* and are allocated with difficulty to the products produced. Indirect costs include cost of utilities, depreciation, taxes, etc. All costs, if possible, should be allocated, even at the expense of some minor allocation errors. When this is very difficult, it makes sense not to allocate some indirect costs, especially when their magnitude is small, in order to preserve credibility to the outcome of the analysis. The rules of allocation should always be objectively based on available non-negotiable data regarding the nature of the cost item and its utilisation in the production process.

[1] See for example Meigs R.F., Meigs W.B., 2002.

Paid Expenses and Imputed Costs

It is customary to record *Paid Expenses* separately, (a) because it is easier to identify them, especially in agriculture, where the economic units are usually small and their accounting records are not ideal, (b) because they affect directly the unit's cash flow and (c) because there is no much doubt about their value, unlike *Imputed Costs,* which should usually be estimated in the light of their *opportunity cost*.

Paid expenses are in general real amounts spent for the purchase of raw materials, maintenance of capital investments or the payment for the use of resources required for agricultural production, e.g. rented land, hired labour, etc.

Imputed costs include the cost of deterioration (or *depreciation*) of the productive capacity of factors such as own machinery and buildings, the opportunity cost of own labour, land as well as the imputed interest on all invested capital.

Fixed and Variable Costs

The distinction between fixed and variable costs is important for decision making, because it signifies how volume and price changes affect profits. A product may be worth producing if its selling price covers at least its variable cost and generates some, even smaller than profit making, contribution towards the recovery of fixed costs. *Fixed costs* are costs not changing, at least in the short run, within a range of production activity. *Variable costs* are proportional to volume of output. It is understood that all costs are variable in the long run. Examples of fixed costs are land rent, the remuneration of permanent personnel, interest, insurance, depreciation of fixed assets, property taxes, etc. *Variable costs* include seasonal labour, raw materials used, irrigation water, hired machinery and equipment, etc. The distinction between fixed and variable costs is also used for the estimation of production break-even points.

Product Costs and Period Costs

Product costs are costs assigned directly to the product. They include direct labour, machinery & equipment, materials and production overheads and are the constituents of *Cost of Goods Produced*. All other costs are regarded as operational expenses consumed over each accounting period and are not assigned directly to the products.

Full Product Cost

The *Full Product Cost* includes not only the costs of direct labour and materials, but also the cost of all production and other activities required for the product, as well as the interest for the capital required. For example, the cost of agricultural production includes not only the cost of direct labour, fuel, seeds, water, other production materials, etc, but also the cost of land, depreciation, insurance, interest on own and borrowed capital, cost of marketing and administration, etc.

Cost analysis estimates the full product cost and reports it in two main formats (a) by operation or activity and (b) by input factor or factor of production. Energy is reported separately because of its importance in environmental analysis.

Project Economic Evaluation Methodology

The purpose of the proposed methodology is to encourage agricultural economists to adopt some aspects of financial and economic analysis as customarily used in industry and commerce. This will not only improve its effectiveness, but will also facilitate investment decisions, usually based on well established investment appraisal methodologies.

The most important objective of financial analysis is to *assess the financial impact* of projects on the farmers and enterprises involved, as well as any others who may be affected by the project. This is achieved by analysing all costs and benefits due to the project and by projecting them into the foreseeable future, in order to anticipate the net financial effect on all actors involved. In most cases financial analyses are based on some form of computerised mathematical model for profit and cost calculations and investment appraisal (*Gittinger* 2000).

A second equally important objective of financial analysis is the preparation of *financial plans* or *scenarios*. These financial or business plans are somehow indirectly obtained while in the process of assessing the impact of the project or, to put it another way, they are the means through which project financial assessment is usually made.

Financial analysis is also concerned with the measurement of performance against set targets on every aspect of the project. It identifies the *efficiency of use of resources* and provides the tools of improving overall performance. It also measures the effectiveness of management in mobilising the factors of production for the achievement of financial goals and supports the search for improved approaches.

Financial analysis requires three easily identifiable steps. The first is *Farm Income Analysis*, based on Income and Expense as well as property data. This is based on Farm Budgets projecting income and expenses for the following years. The second step consists of gross estimates of future Balance Sheet items based on Farm Income forecasts and on assumptions regarding the timing of receipts and payments. This step approximates project related future *Cash Flows.* The third step is *Farm Investment Analysis.* It utilises Cash Flows to estimate the attractiveness of the project, by comparing future net inflows against initial investment requirements.

In practice, most Farm Accounts do not identify the full cost of agricultural production, probably due to lack of consensus and data on imputed costs, such as family labour, own land, etc. For financial analysis, these items should be estimated at their opportunity cost and be included in cost analysis, in order to identify net income attributed to the project.

The proposed methodology demands the decomposition of the project into a number of *operations* (or *activities*), which sufficiently describe all required jobs for plant establishment, cultivation and harvesting activities. Each *operation* is characterised by its duration and frequency. It is also associated with its requirements for *labour, equipment, materials* and *capital*. Fuel consumption depends upon the operation and machinery used and can easily be estimated.

Mechanical equipment may be hired if own machinery is insufficient or non existent. When hired, its cost is equal to the rent paid (provided that there is a reasonably large rental market to justify a competitive market rent; otherwise its cost is the sum of economic depreciation, maintenance, insurance, labour and fuel.

Land is an essential factor of agricultural production and in most cases a major cost item. The cost of agricultural products may be significantly increased if planted on high cost land and vice versa. Therefore, land cost must be carefully estimated in all agricultural projects. If there is a fairly competitive market for land, one may assume that its rent adequately reflects its real cost. However, if there is no market, the cost of land is not easily identifiable. In such cases one needs to estimate its opportunity cost as expressed by the net economic output of current land use. For project evaluation purposes involving alternative use of the same land, the cost of land can be excluded, since it is a common cost item in both the “with” and “without” the project situations.

Labour in small farms is usually provided by the farmer and his family, but it may also be hired, especially during periods of peak labour demand, e.g. planting or harvesting times. Hired labour, in most cases, has a market specified rate, which can be used in the analysis. Imputed labour cost should be principally evaluated at its opportunity cost, i.e. the amount of income forgone for shifting family labour from current activity due to the needs and requirements of the project. However, own labour imputed cost is in most cases set equal to the market rate, since this adequately reflects the opportunity cost of labour if the market is sufficiently competitive.

Subsidies are sometimes granted in order to support current agricultural policies. These are temporary cash injections, influencing production decisions, but external to the financial mechanism and the identity of production. It is important to isolate the effect of subsidies by entering these amounts at the bottom of Profit & Loss accounts, although common practice requires subsidies to be added to income from sales in order to calculate “total income”. However, this is scrutinising the real economic characteristics of production and impairs many important financial indices. It may be argued though, that subsidisation is a decisive factor in agricultural decision making (this is after all the purpose of subsidising activities that wouldn’t otherwise be undertaken) and that this financial support is part of the projects’ financing. Nevertheless, we still believe that the existence of temporal subsidies should not hide the market or true value of the project, which is revealed if one considers the subsidies at the end.

Project evaluation or *Investment Appraisal* is based on project related Cash Flows. By applying Discounted Cash Flow (DCF) methods, it compares the present value of the net benefit from future inflows and outflows against the cost of the initial investment required. There is a large number of investment criteria and huge amount of bibliography on the subject. For practical reasons at least three indices must be estimated, namely, Net Present Value, Internal Rate of Return and Payback Period. The choice of appropriate discount rate is a complex task, but very important for the appraisal. Good financial accounting textbooks explain the job in detail (e.g. Dickerson et al). *Systematic Risk* is usually handled by some kind of agricultural insurance, but it is more difficult to defend against *Unsystematic Risk*, especially in the agricultural production sector, which is in general less informed than Industry and Commerce. Discount rates may be increased appropriately in order to express anticipated risk levels.

Cost Analysis

The methodology can equally handle conventional and future crops with individual characteristics. Each crop is cultivated on identified own or hired land and has its individual *operations* or *activities* as described in the crop’s associated data. It may also use resources common to other crops in the same farm, such as buildings & constructions, utilities, administration, etc., the cost of which is allocated according to user selected rules.

Labour and Machinery & Equipment are used according to the operations’ requirements.

Operations & Overheads

Agricultural production for each crop is decomposed into a number of necessary *operations* or activities. Each operation needs all or some of factors such as labour, raw materials, water, machinery & equipment, etc.

Operation requirements are satisfied by farm labour and equipment and by purchased raw materials. If labour or equipment is not available or uneconomic to be offered by the farm, they may be hired or rented.

Administration overheads (Management), Buildings, Utilities and *Other Costs* are identified as general expenses (overheads) required for agricultural production. The allocation of overheads to the various crops is a difficult task, equivalent to allocating overheads to company divisions and/or products. However, in agricultural projects, overheads are in most cases rather insignificant, and a less precise or no allocation may be more satisfactory than having to go through complex allocation rules for each crop and each overhead category.

Useful Economic Life

The Useful *Economic Life* of various assets such as Machinery & Equipment, Buildings, Crops, etc, is the number of years before they should be substituted, in order to maintain economic efficiency.

For example, a tractor with a useful economic life of 15 years should be replaced 15 years after purchase, although it may still be physically functioning. The replacement makes economic sense when the old asset is too expensive to maintain and service or its efficiency has dropped significantly or the new machine is much more efficient or technologically advanced and therefore the expected benefits of the replacement outrange the expense of extra investment in the new asset.

Interest & Discount Rates

Interest rates measure the cost of capital (or the cost of funds). In the absence of risk and inflation, the time value of money is expressed by r, which is termed *real interest rate.* This rate is alternatively called the *time value of money* and shows the opportunity, or best alternative use of the monetary capital. For example, the real interest rate of investing an amount for the purchase of a productive machine is the amount foregone by not using this amount in its best alternative opportunity.

If *f* is the inflation rate, then the interest rate which incorporates inflation is termed *nominal interest rate*[2] *(i)*, and is calculated by means of the *Fisher* equation:

$$(1+i) = (1+r) \times (1+f)$$

The real rate of interest is used when comparing real magnitudes, while nominal interest rates are used when using current values, i.e. values including inflation.

Discount rate (*d*), is the interest rate used to discount and compound magnitudes that appear in different months or years. The choice of the appropriate discount rate depends on the nature of the cash flows being considered (i.e. if the amounts are real, then one should use real discount rates and vice versa). If values are real, i.e. deflated, then *r* can be used as the discount rate, since it correctly represents the cost of money in the absence or *risk*.

When evaluating agricultural projects, the choice of interest and discount rate is equivalent to the rigorousness with which we evaluate investment proposals. If the interest rate is high, a project has to be very profitable to be positively evaluated. This feature is used in order to introduce the existing or anticipated *risk* or future uncertainty of the outcomes of various agricultural projects. Risk is introduced by means of increasing the *risk-free* interest rate by a *risk premium*. There are many methods for measuring the risk and approximating a proper risk premium in the literature, (see for example Bierman and Smidt, 1993).

Land

Land is essential for agricultural projects. It is distinguished into various *land types*, e.g. irrigated, non-irrigated, marginal, etc. This is important because different types of land have different rent or opportunity cost and relative operations may also differ.

All projects involve some use of land. Even when land has no financial cost, (i.e. when no rent is being paid), its economic value should be estimated and included in the calculation of economic viability. The demanded price for land does not always give an accurate reflection of the economic value of land because supply cannot be expanded and land can be held for speculative, as well as productive, purposes or to meet immediate needs. The value of land is best determined through its *opportunity cost*, what it would have been used to produce without the project. In a relatively competitive land rental market, land rent is generally a good estimate of the opportunity cost.

[2] Nominal interest rates should not be confused with J_m which is the nominal interest rate of frequency *m*, i.e. the 1/*m* of the year interest rate multiplied by *m*.

Cash costs are incurred when factors of production are purchased or rented. Non-cash costs are incurred when factors are owned. For example, a farmer who fully owns the land used to produce a commodity (e.g. wheat) has no cost for land rental or loans to pay for purchasing land. Yet, an economic cost arises. By owning the land and using it to grow plants, the farmer forgoes income from other uses of his land, such as e.g. renting it to another producer.

Labour

There are two categories of labour: (a) *Direct labour* for the operations of agricultural production and (b) *Administrative labour* or overhead labour. In agricultural production the second category is less significant. In the case of coordinating a large number of producing farms, some supervisory and coordinating staff should be necessary.

Direct labour can be distinguished into several usual *labour types* with different cost. These types may include: Farmer, spouse, other unpaid, hired farm labour, contract labour, mechanic, bookkeeper, machine operator, field worker, etc.

The most important distinction is between paid and non-paid labour. *Paid labour* (hired) has a cost equal to its market rate. The opportunity cost of *non-paid labour* (non-hired) may also be set equal to the market rate for equal labour skills. In a stricter implementation of the opportunity cost issue, it should be set equal to the best alternative opportunity the farmer or his spouse, etc. would have. However this more difficult to estimate.

In effect, labour, hired or own, is evaluated at its going market rate, (assuming that such a labour market exists in the area under examination). The distinction between own and hired labour is useful for the estimation of overall human labour needs in different periods and the consequent identification of possible labour peaks.

Machinery & Equipment

The total cost related to machinery & equipment is the sum of (a) Economic Depreciation, (b) Opportunity Cost of holding the asset (i.e. interest), (c) Maintenance cost, (d) Insurance, (e) Fuel and (f) Operator(s) cost. The last two can be reported separately.

Economic Depreciation (*D*), is the loss of value during the period (year) due to breakage, wear and tear, technological devaluation, etc. In general, it is the difference between the value of the asset at the beginning and at the end of the period. Economic depreciation reflects (a) service reduction capacity, (b) change in the price of the capital asset, etc. The most widely used method of depreciation is *linear depreciation*, which is defined as

$$D = \frac{V_0 - \frac{V_n}{(1+d)^n}}{n}$$

Where V_o is the initial value of the asset at the beginning of the evaluation period and V_n is its value at the end of the last period of its *useful* *economic life* (n). The above formula suggests that V_n (*Salvage value*) is subtracted from V_o after being discounted to the beginning of the first period and therefore the nominator of the fraction is equivalent to net purchase price.

Capital Service Cost (CSC) is the annual equivalent of the annuitised stream of the amount:

$$V_0 - \frac{V_n}{(1+d)^n}$$

plus annual Machinery and Equipment Maintenance (*M*) *plus* annual Machinery and Equipment Insurance (*Ins*)

This is equal to

$$CSC = \frac{V_0 - \frac{V_n}{(1+d)^n}}{a(n,d)} + M + Ins$$

where $a(n,i)$ is the unitary annuity present value[3]. The capital service cost consists of *Depreciation*, the *Opportunity Cost of holding the asset* (i.e. the *interest* or *cost of capital* captured in the asset during its useful economic life), annual *Maintenance* and *Insurance* cost. One way of splitting CSC into its components, which maintains the uniformity of all annuity payments as well as of the familiar depreciation amount, is to subtract *D, M* and *Ins* from *CSC* and define the difference

Opportunity Cost of Holding the asset = Interest = CSC – (*D + M + Ins*)

Holding cost is the uniform *interest* part of the Capital Service Cost, which is not charged, as usual, on the remaining (not yet depreciated) value of the asset, but it is the annual equivalent of this holding cost.

The information supplied with regard to *machinery & equipment* includes data that fully describe each item such as machinery purchase cost, average annual operating hours, useful economic life, salvage value, maintenance cost, fuel type , etc. This makes possible the calculation of its annual and hourly *depreciation & maintenance* and *interest charge*. Fuel consumption of machinery & equipment

[3] $a(n,r) = \frac{1-(1+d)^{-n}}{d}$ see for example Cissell and Cissell, or any other book on financial discounting.

depends upon the operation being performed; for example, a tractor is consuming more fuel when ploughing and less when spraying. Fuel consumed for moving the machine to and from the operation location is introduced by means of an *additional fuel consumption coefficient*. This coefficient usually ranges from 5% to 10%. (AAEA, 2000).

One or more of the requirements of each operation may be rented or hired. It is for example not unusual in certain periods to hire extra labourers, e.g. for hand-collection of the product, or to hire the service of expensive machinery used for very short period in the year. When a machine is hired, the rent paid by the farmer covers machine depreciation, interest, maintenance, insurance, fuel, operator(s), and a *rental premium*, which is the profit of the third party offering the required service.

Plantation Establishment and Useful Life

There are two types of plantation / crop: (a) *annual* and (b) *multiannual* or *perennial*. For the *annual crops*, it is assumed that the life cycle of the plant is one year, during which it is established, grown and harvested. This cycle is uniformly repeated year after year.

For *multiannual crops*, it is assumed that establishment takes place in *year zero* (a period of one or more years) and that annual treatment and harvesting is taking place until the end of the plant's useful life, when the plantation should be re-established to repeat the same life cycle. The expense of establishing the plantation is depreciated over the useful economic life of the crop (in similar manner as with machinery & equipment depreciation as described above). By assuming zero salvage plantation value, economic depreciation (*D*) is equal to

$$D = \frac{V_0}{n}$$

where V_0 is the establishment cost and *n* is the plantation's useful economic life. The establishment cost of the plantation is the sum total of all operations of year zero plus the corresponding cost of land and overheads.

Economic depreciation reflects the reduction of the value of the plantation as it reaches the end of its useful economic value.

Due to different useful lives of perennial plants, only one life cycle of each plant needs to be explicitly studied. This is sufficient because each full life cycle includes all the variety of operations required for economic analysis.

Investment appraisal is based on annual equivalent flows. If a given time horizon needs to be appraised, such as for example a time period equal to the useful life of a product treatment plant, crop life cycles are repeated as many times as necessary to fill this time period.

Buildings & Constructions

Buildings & Constructions include all necessary fixed structures such as dedicated office buildings, farm roads and paths, irrigation channels, water reservoirs, product storage facilities, etc. For agricultural applications, Buildings & Constructions are usually of less importance than Machinery & Equipment and in many cases their cost is disregarded. However, in some situations they may be of great significance, e.g. when storage at certain temperature is required or accommodation of large number of workers must be provided.

The economic manipulation of Buildings & Constructions is very much the same as Machinery & Equipment. Their cost is the sum of (a) Economic Depreciation, (b) Opportunity Cost of holding the asset (i.e. interest), (c) Maintenance cost and (d) Insurance cost. The description of the economic calculations is the same as in the case of Machinery & Equipment.

The Buildings & Constructions cost of agricultural production is usually relatively small, therefore this cost item is treated as a “total”, irrespective of the number of different buildings and constructions that might exist.

Overheads

Overheads is a cost item that includes all costs incurred due to the need of supervisory management, and other costs that cannot be easily allocated to the production units and which may be as simple as a caretaker, telephone bills, travel, etc., or as complex as an administration system including sales, accounting and marketing departments, etc.

The administration overheads of agricultural production are usually relatively small, therefore the Agri-Cost model records this cost item as a total, irrespective of the number of crops which are simultaneously cultivated.

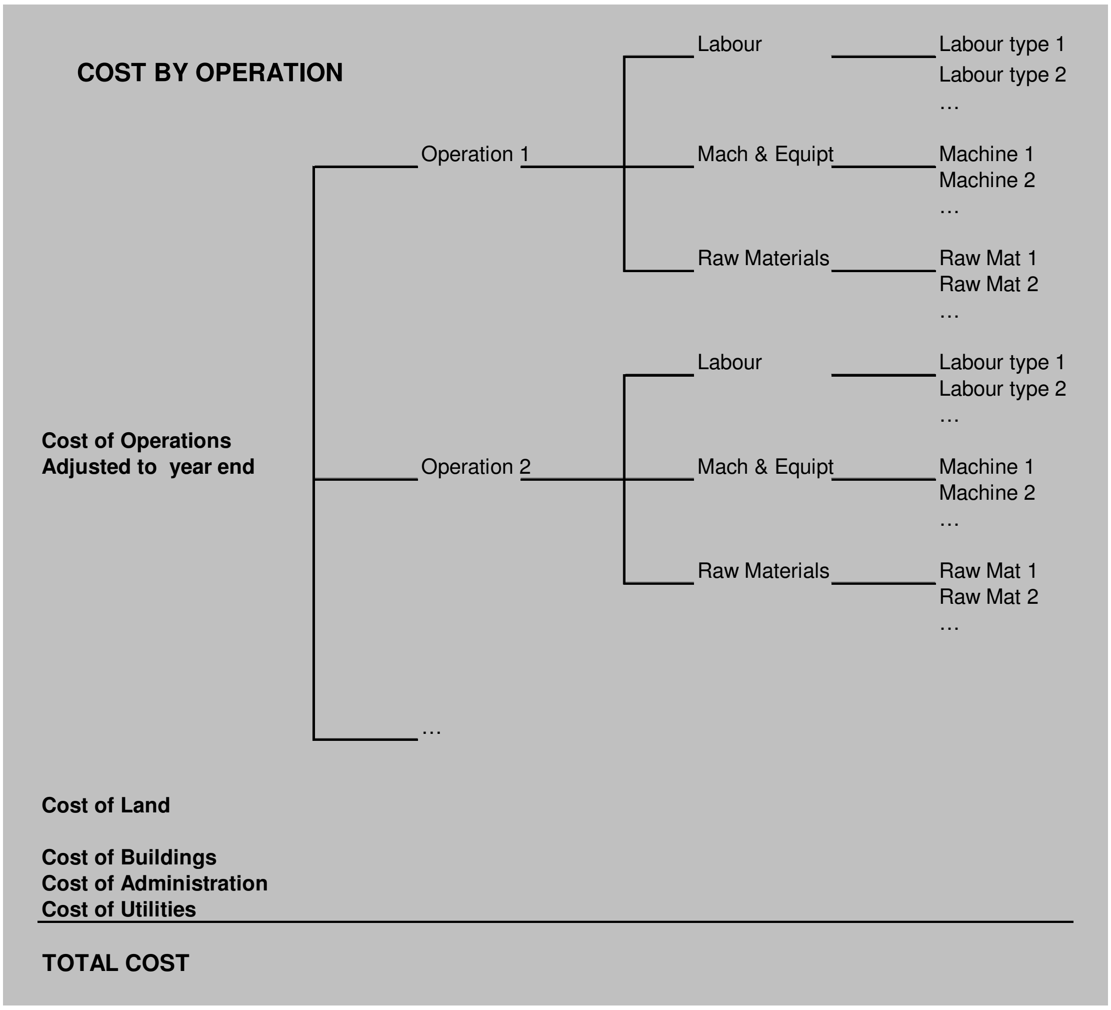
Cost Analysis Layout

Two main forms of cost analysis are used, in order cover the majority of the needs of the analyst.

- *Cost breakdown by operation or activity*

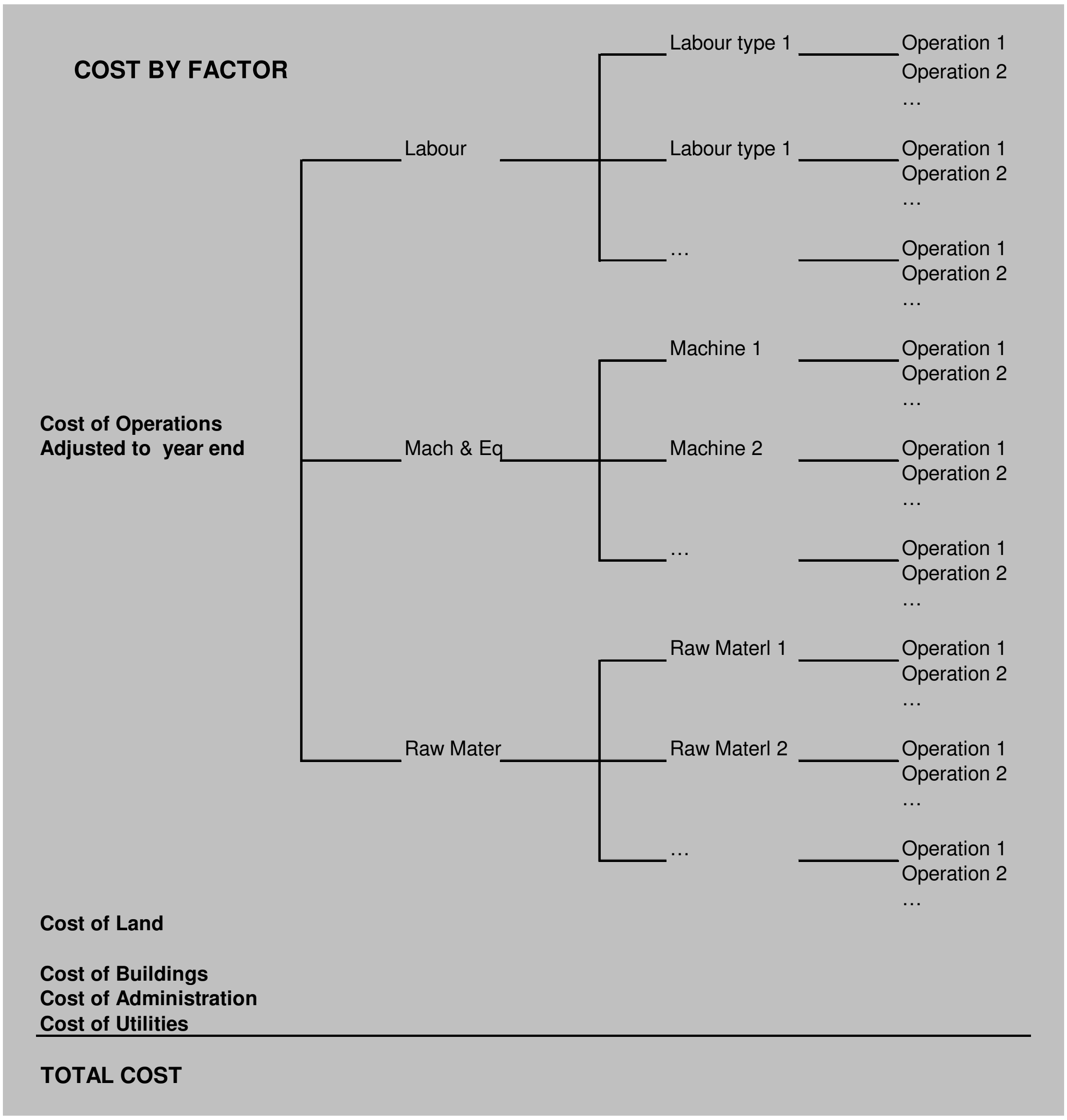
- *Cost breakdown by input factor*

The structure of the first is:



This form can be detected at any depth of detail and describes the importance of the various operations required for crop production.

The second structure (by Factor) is somewhat similar, but it emphasises on the use of resources such as labour, machinery and raw materials. The layout can be inspected below:



Each of the cost analysis forms and formats may be inspected in a large number of monitoring (pivot) tables which are calculated on the fly for

- Each crop
- Each land type
- Each year

in any combination. This is very useful mainly for auditing purposes, since every detail is being available.

However, if overall cost estimation is required, inspecting the individual cost in such analysis is of no use because some operations are not performed regularly and uniformly year after year and therefore, annual cost may differ among the years of the plantation life.

The overall cost estimates are calculated as *annual equivalent costs,* i.e. costs that express lifetime averages incorporating the time value of money. To calculate the annual equivalent cost, the present value of all costs over the useful life of the plantation is transformed into an equivalent annuity with an annual uniform payment which is the annual equivalent cost.

As an example, assume the following annual costs of a project:

Discount Rate= 10%					*thousnand eur*
year:	*0*	*1*	*2*	*3*	*4*
Operating costs	30	20	15	15	20
Land	10	10	10	10	10
Overheads	5	7	8	8	8
TOTAL COST	45	37	33	33	38
PV of Cost	156.66				
Annual Equivalent Cost		49.42	49.42	49.42	49.42

The present value of all costs, including the base year (year zero) investment cost, is equal to 156.66 thousand euros, which is then distributed by means of an annuity to 49.42 thousand euros per typical year.

The present value of total cost (*PV*) is calculated by means of the *Present Value* formula:

$$PV = \sum_{t=0}^{n} TC_t \times (1+d)^{-t}$$

where *d* is the discount rate, and TC_t is the Total Cost in year *t*, and *n* is the number of years of useful economic life.

The Annual Equivalent Cost is then calculated from the annuity formula:

$$Annual\ Equivalent\ Cost = \frac{PV \times d}{1-(1+d)^{-n}}$$

The format of a standard Annual Equivalent Cost table is as in the following example:

ANNUAL COST ANALYSIS BY OPERATION

Crop: **xxx** — Occupied Land Area (ha)= **120**

Land type: **Irrigated** — Cultivated Land Area (ha)= **100**

Yield (t/cul.ha)= **20** — Hired land %= **50%**

DIRECT COST

OPERATION	FACTOR	Units	Cost/unit	Volume/cul.ha	Cost/cul.ha	Cost/ton	Total Cost	%on Tot
Fertilisation	Labour	hrs	10	20	200	10	1000	17%
	Fertiliser	kg	24	10	240	12	1200	21%
….								
Cost of Operations					440	22	2200	38%
	Land*				600	30	3000	52%
Total Direct Cost					1040	52	5200	90%
INDIRECT COST								
	Overheads				120	6	600	10%
Total Indirect Cost					120	6	600	10%
TOTAL COST					1160	58	5800	100%

*Land rent is 500 eur/ha. However since cultivated land is only 5/6 of occupied land, effective rent is 500 x 6/5 = 600 eur/cul.ha

Agricultural Projects Evaluation

Investment Appraisal differs from cost analysis because it is not concerned with profits (sales minus costs), but concentrates on cash inflows & outflows and measures Net Present Values, i.e. compares the Present Value of Net Benefits (net inflows) caused by the project versus Initial Investment. The attractiveness of the Project is then measured by the difference of those two magnitudes.

There are two methods for the identification of cash flows, (White et al., 2003).

The *direct cash determination method*, utilises data regarding the terms of receipts & payments, inventory & receivables policies and other cash-flow related information, and then calculates flows based on the timing of production and sales.

The second *indirect cash determination method,* estimates regular (monthly) *Balance Sheets* based on the same information and then calculates what is sometimes called the *Sources and Uses of Funds Statement*.

The resulting cash levels are the same irrespective of the method of calculation.

The justification of using cash-flows rather than profitability measures in investment appraisal lies on the fact that profitability does not by itself secure cash availability and company viability, because the timing of receipts and payments is overlooked. Also, satisfactory cash flows guarantee in the long run satisfactory profits (Lumby & Jones 2002).

The model is reading the opening Balance Sheet from user data and calculates consequent Balance Sheets with the *indirect cash determination method*, i.e. it calculates Balance Sheets for every period.

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PART III – COST ANALYSIS OF CONVENTIONAL CROPS

We have outlined the current situation and trends in EU agriculture with focus on the most popular crop cultivations in each country. We have also surveyed the yields and selling prices of about ten crops in ten EU regions, which cover over 90% of the arable land of the European countries. It was found that land and labour costs as well as irrigation patterns may differ significantly between European regions giving rise to substantial variability in the cost of agricultural production. Energy and chemicals costs may also differ from region to region with a less significant effect on total production cost.

The selection of countries is based on the work of other work packages of this project with a view to include regions from all geo-climatic parts of Europe. After selecting all crops covering anything over 1% of the total arable land in each selected country, we ended up with the table of regions and crops for economic analysis shown below (see above, Part I).

In this part of the report is a collection of cost breakdown for selected crops based on the same assumptions and following the same methodology. The format is the same in all cases, since all cases have been analysed with the same software, the ABC[4] package, developed by the Agricultural University of Athens.

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[4] Activity Based Costing www.abc.aua.gr . The package is splitting each case in any number of activities or operations and each operation has “needs”, e.g. labour, machinery, raw materials, etc. Costs in volumes as well as prices are supplied by the researcher or extracted from extensive information bases maintained by the Agricultural University of Athens, or from more popular databases such as FAO and Eurostat, easily accessible on the internet.

Cost Analysis of conventional crops

For the analysis of costs of the selected conventional (current) crops, all activities and operations required for agricultural production have been examined and evaluated. For any given plant, these operations are not necessarily the same in all countries (for example irrigation may be required only in southern regions), but there are many common activities. Available technical information regarding the crops combined with current prices of factors of production has formed the basis of cost valuation.

Labour costs are also different in the EU countries; therefore a database of labour costs has been constructed with data from Eurostat and FAO. It has though been assumed that labour productivity is similar in all regions examined, when the level of mechanisation is the same.

The cost of land differs from country to country very significantly. In effect, it can even be very different from site to site in the same country or region. This causes some problems when using country averages that may be well out of scope. To give an example, in Greece, land in the North Eastern region of Thrace is much less expensive although it is very fertile and precipitation levels are much higher in the area. The cost of land is more related to social, transport network and geographical reasons than the fertility of land. In the cost analysis tables that follow, all costs other than land rent are firstly identified and added up to calculate the *production cost*. Then the cost of land is added to estimate *total production cost*.

Total production cost is further compared to the selling price per tonne of product to give an estimate of the profit that has been or is expected to be achieved.

It is of interest to note that in most cases, the net profit (before any subsidy, direct or indirect) is negative, which practically means that the European farmer is in many cases working in order to receive a small reward for his (and possibly his family) labour and land.

Synopsis of Results – Conventional Crops

In view of the revenue received by farmers at current selling prices, the cost of production of crops is too high for the achievement of profit in most of the crops that have been examined. The need for rotation of several crops is only making things worse. However, there are a good number of cases of profitable crop farming in several countries. Among the most profitable examples are the cultivation of wheat in high yield countries, France, Germany, Sweden and the UK, the cultivation of sugar beets in Germany, Poland, Sweden and the Netherlands and the cultivation of Alfalfa in Italy and Romania.

European subsidisation of the farmers is compensating for their losses in all other cases and preventing them from abandoning their land. It has however been observed that in many cases, the farmers' income opportunity is very low and so is the use of their land and equipment, and therefore their decision to continue cultivating "the usual" seems optimal under the circumstances.

Many of the conventional food and feed crops examined are also today being used for energy or other non-use purposes, e.g. for the production of biofuels (wheat, corn, sunflower, sugar beets, etc.). Nevertheless here they are analysed with their conventional use in mind. For example, their selling price is the price of the products in markets for food purposes.

All costs are in the form of *annual equivalent costs*, which is important in the cases of multiannual crops. This insures that, for example, initial investment costs are reflected in the cost per tonne or per ha.

The cost of land is on the one hand its opportunity cost, which in turn depends upon its fertility or productivity with regard to possible plantations. In the case of Europe, since we assume that there is sufficiently large market for land, we have adopted the land rent as it is recorded in European and international statistics (Eurostat and FAO). Although the figures found in these databases may not be the best estimates of land rent, as well as other costs, they provide a common and consistent data reference, accessible to all and official. With regard to the cost of land, we have found that there are great differences among the European countries, which are partly explained by equally big land fertility / productivity differences. In other words, it seems that land is rewarded in proportion to the income it may offer to the farmer. In southern countries, where irrigation is required, there are also great differences in land rent between irrigated and non irrigated land, although in general, irrigation is profitable in spite of the extra cost of land. In the tables that follow costs are first aggregated without the cost of land, which is in all cases one of the most important cost items, and the land rent is added afterwards. Moreover, all costs have been expressed in a "per tonne" of output form in order to facilitate comparisons among countries. However, in Annex 4, we have also added the corresponding tables with the cost analysis "per hectare".

Conventional Crops – Summary Tables

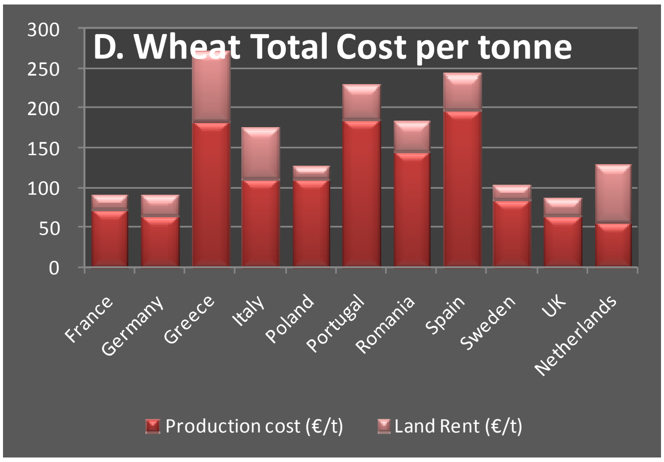
Wheat

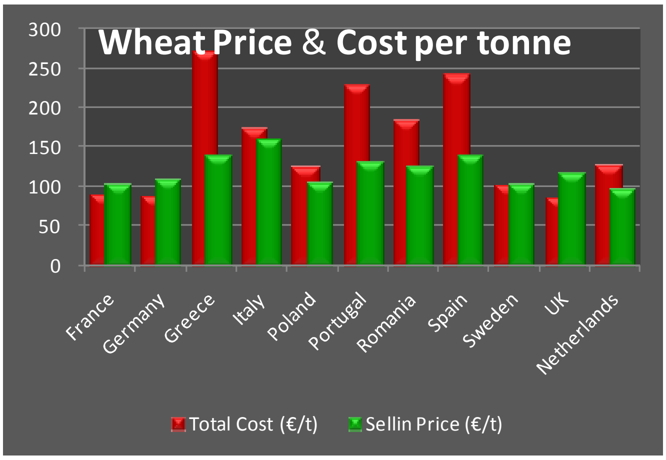
D. Wheat EUR/tonne

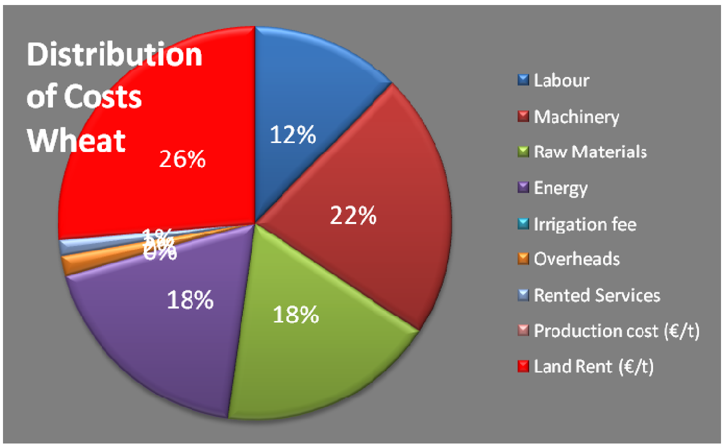
	France	Germany	Greece	Italy	Poland	Portugal	Romania	Spain	Sweden	UK	Netherlands	EU %
Labour	18	13	27	28	10	18	10	45	19	14	12	12%
Machinery	20	19	59	29	25	61	52	58	23	17	16	22%
Raw Materials	16	15	47	23	28	49	41	46	18	14	12	18%
Energy	16	15	47	29	21	54	39	45	22	18	14	18%
Irrigation fee												0%
Overheads	1	1	4	2	3	5	4	4	2	1	1	2%
Rented Services	0	0	0	0	23	0	0	0	0	0	0	1%
Production cost (€/t)	71	63	184	111	110	187	146	198	84	64	55	
Land Rent (€/t)	19	27	87	***64***	16	43	38	45	19	22	***73***	26%
Total Cost (€/t)	90	90	271	175	126	230	184	243	102	86	128	100%
Yield (t/ha)	6.8	7.3	***2.3***	4.7	3.8	***2.2***	***2.6***	***2.4***	5.9	7.8	8.7	
Total Cost (€/ha)	612	656	622	822	480	505	479	570	604	671	1,116	
Sellin Price (€/t)	103	109	140	160	106	132	126	140	104	117	97	
Profit (€/t)	13	19	-131	-15	-20	-98	-58	-103	2	31	-31	

Notes

D. Wheat production in Greece, Portugal Romania and Spain is at reasonable cost levels. Nevertheless, the low average yield is the main reason for negative profits.
For Italy and the Netherlands, the main cost item is the high land rent which increases the final cost of production.







Barley

Barley EUR/tonne

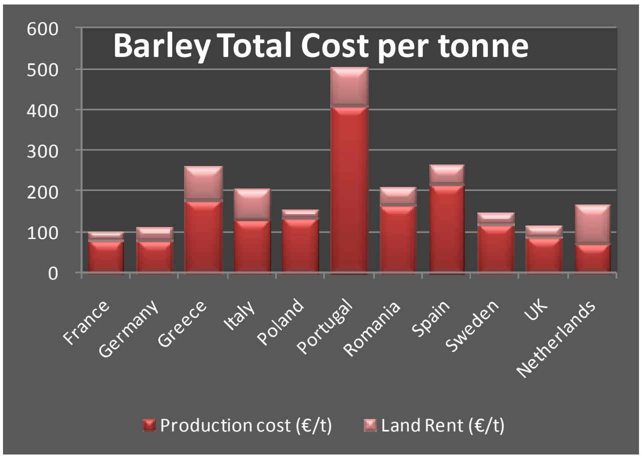
	France	Germany	Greece	Italy	Poland	Portugal	Romania	Spain	Sweden	UK	Netherlands	***EU %***
Labour	20	16	26	33	12	39	11	49	27	18	16	12%
Machinery	22	23	57	34	31	135	59	63	33	23	20	22%
Raw Materials	17	18	44	26	34	106	46	49	25	18	16	18%
Energy	18	19	45	34	26	118	44	50	31	23	18	19%
Irrigation fee												0%
Overheads	2	2	4	3	3	10	4	5	2	2	1	2%
Rented Services	0	0	0	0	28	0	0	0	0	0	0	1%
Production cost (€/t)	79	79	176	130	134	408	164	215	119	84	71	
Land Rent (€/t)	21	34	84	***75***	20	95	43	49	27	30	***95***	26%
Total Cost (€/t)	100	112	259	205	154	503	208	264	145	114	166	100%
Yield (t/ha)	6.1	5.8	***2.4***	4.0	3.1	***1.0***	***2.3***	***2.2***	4.2	5.9	6.7	
Total Cost (€/ha)	610	654	620	820	478	503	477	568	602	669	1,114	
Sellin Price (€/t)	99	97	145	130	106	135	130	125	93	101	90	
Profit (€/t)	-1	-15	-114	-75	-48	-368	-78	-139	-52	-13	-76	

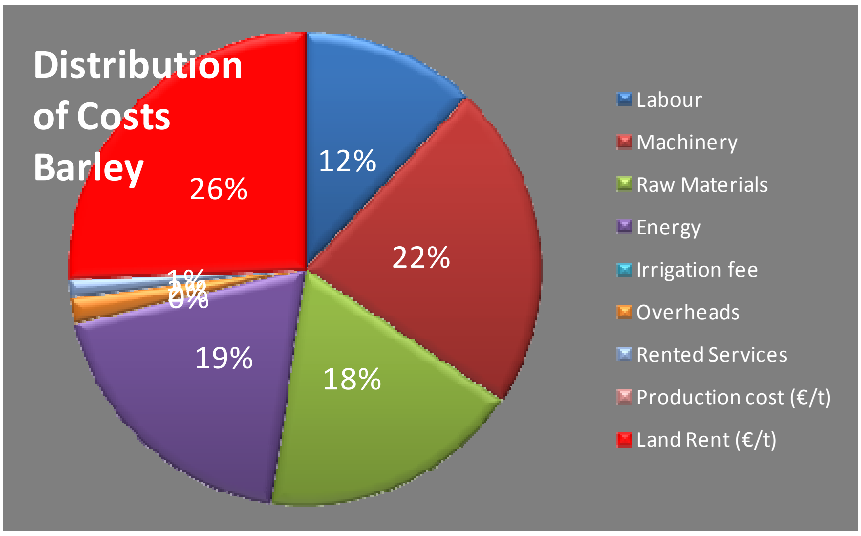
Notes

Barley production in Greece, Portugal Romania and Spain is at reasonable cost levels per ha. Nevertheless, low yields are the cause negative profits.

For Italy and Netherlands, the main problem is the high cost for land the increases the final cost of production.

Sweden has negative profits because many of the cost parameters are in higher levels compared to the other countries.





Maize

Maize EUR/tonne

	France	Germany	Greece	Italy	Poland	Portugal	Romania	Netherlands	*EU %*
Labour	21	12	12	29	8	17	8	14	7%
Machinery	25	18	26	29	21	45	43	19	14%
Raw Materials	**91**	64	54	**121**	95	**134**	155	67	47%
Energy	15	13	13	22	15	21	30	15	9%
Irrigation Fee	0	0	**10**	0	0	**10**	0	0	1%
Overheads	2	2	2	3	4	3	6	2	1%
Rented Services	0	0	0	0	16	0	0	0	1%
Production cost (€/t)	155	109	117	204	158	231	242	118	
Land Rent (€/t)	16	23	**50**	**64**	11	43	29	**79**	19%
Total Cost (€/t)	170	132	167	268	169	274	271	197	100%
Yield (t/ha)	8.4	8.6	10.0	7.0	**5.7**	7.0	**3.5**	8.1	
Total Cost (€/ha)	1,421	1,131	1,677	1,876	965	1,916	947	1,592	
Sellin Price (€/t)	112	118	144	135	100	145	135	86	
Profit (€/t)	-58	-14	-23	-133	-69	-129	-136	-111	

Notes

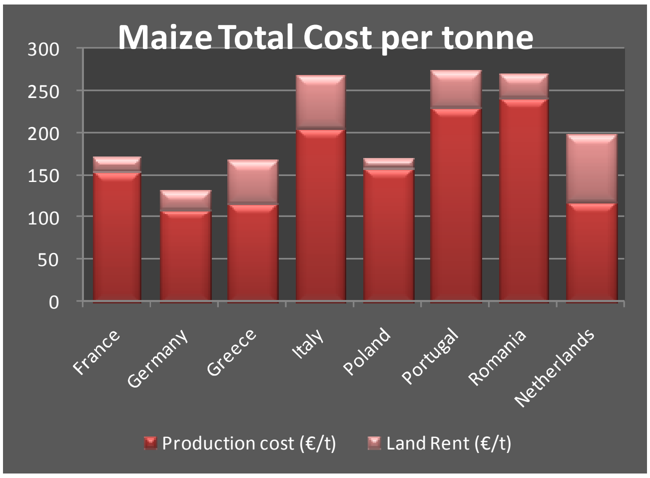
France, Italy and Portugal have increased cost of raw materials because water cost is included.

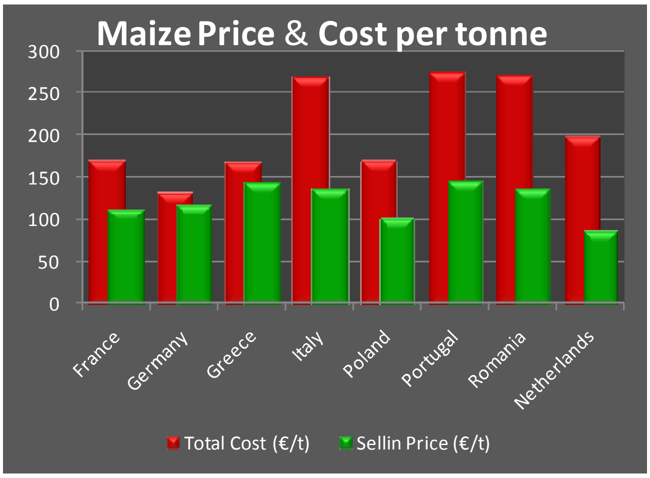
For Italy increased irrigated land rent is also considered.

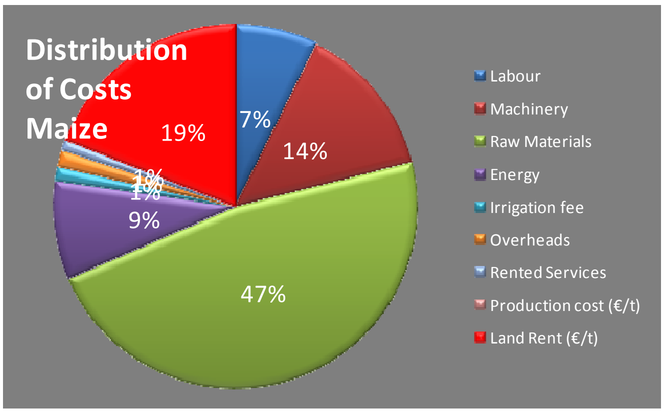
In Greece and Portugal there is an additional irrigation fee per hectare.

For Poland and Romania the low yields are the main reason for economic losses

Land rent in the Netherlands is very high.







Rape seed

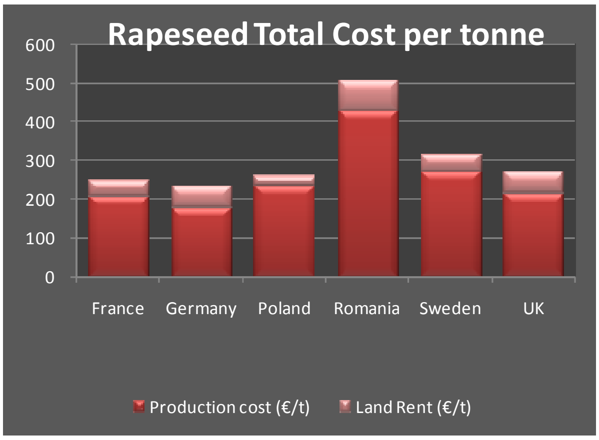
Rapeseed EUR/tonne

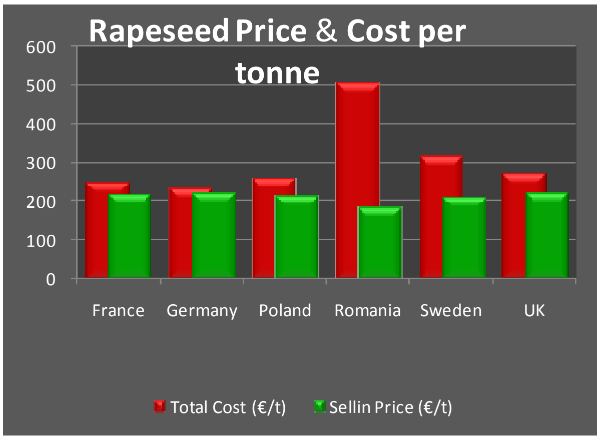
	France	Germany	Poland	Romania	Sweden	UK	EU %
Labour	40	28	**16**	**21**	**48**	35	10%
Machinery	45	40	39	110	57	45	18%
Raw Materials	87	77	107	213	111	88	37%
Energy	35	32	32	79	52	45	15%
Irrigation fee	0	0	0	0	0	0	0%
Overheads	3	3	4	8	4	3	1%
Rented Services	0	0	40	0	0	0	2%
Production cost (€/t)	209	180	237	431	272	216	
Land Rent (€/t)	41	55	24	77	44	56	16%
Total Cost (€/t)	250	235	261	508	316	272	100%
Yield (t/ha)	3.2	3.6	2.6	1.3	2.5	3.2	
Total Cost (€/ha)	799	841	678	660	791	857	
Sellin Price (€/t)	218	224	215	185	211	224	
Profit (€/t)	-32	-11	-46	-323	-105	-48	

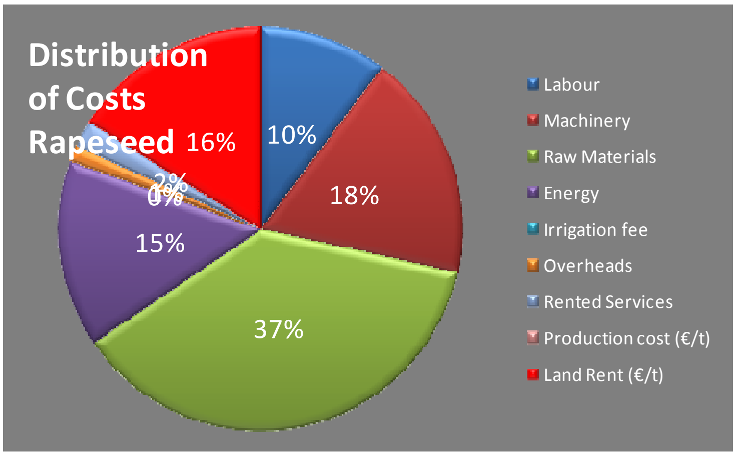
Notes

Rapeseed production in Poland and Romania is at reasonable cost levels. Nevertheless, the low average yield is the main cause of negative profits, (see eg. Romania).

For Sweden also the main problem is the low yield.







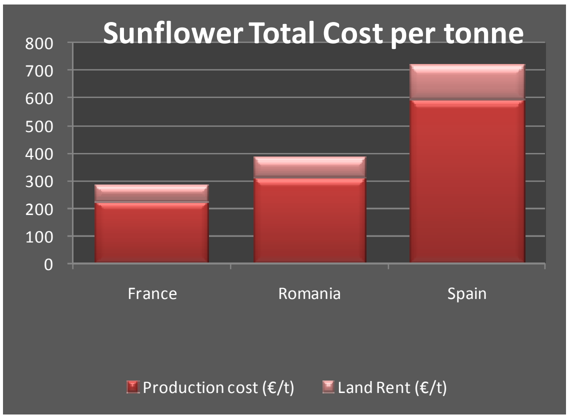
Sunflower

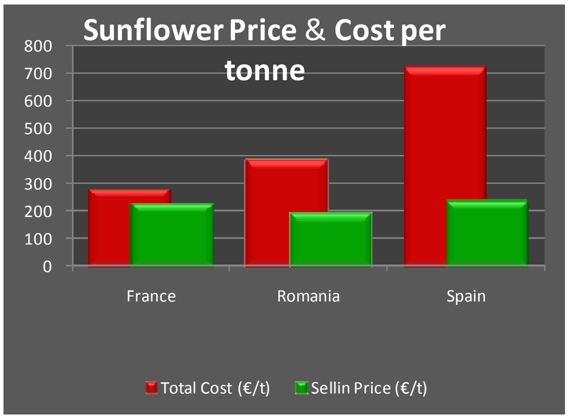
Sunflower		EUR/tonne		
	France	Romania	Spain	***EU %***
Labour	52	19	124	14%
Machinery	59	100	159	23%
Raw Materials	66	112	177	25%
Energy	47	73	124	18%
Irrigation fee	0	0	0	0%
Overheads	4	7	12	2%
Rented Services	0	0	0	0%
Production cost (€/t)	228	312	596	
Land Rent (€/t)	57	74	125	18%
Total Cost (€/t)	285	386	721	100%
Yield (t/ha)	2.3	**1.35**	**0.9**	
Total Cost (€/ha)	655	522	613	
Sellin Price (€/t)	226	195	235	
Profit (€/t)	-59	-191	-486	

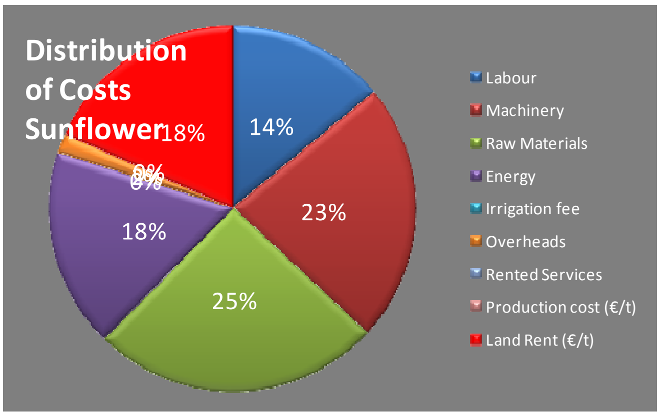
Notes

All countries have reasonable cost levels.

In Romania and Spain the yield is very low.







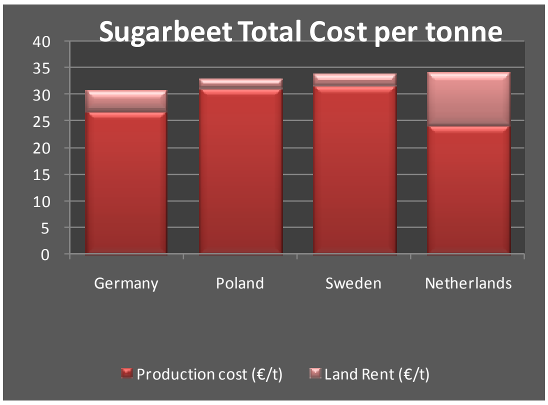
Sugar beet

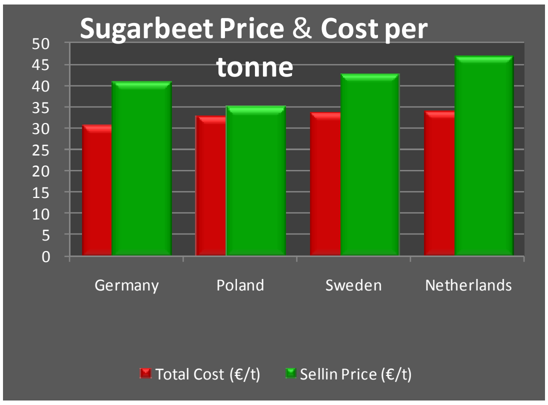
Sugar beet EUR/tonne

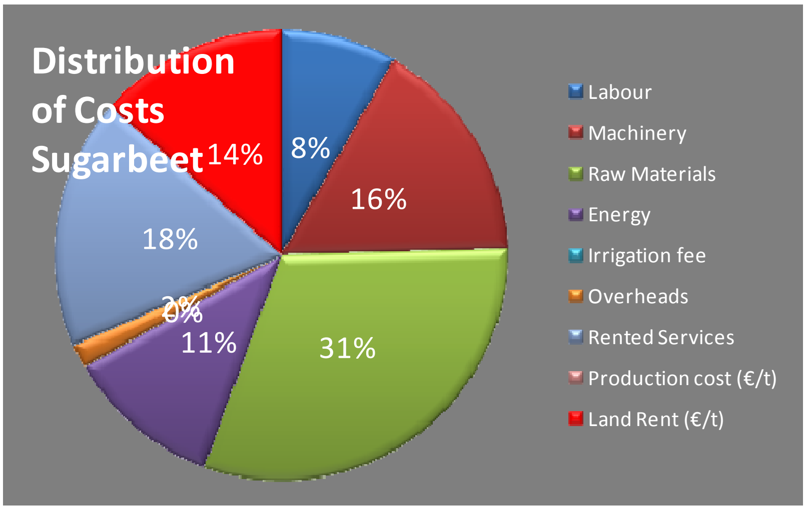
	Germany	Poland	Sweden	Netherlands	EU %
Labour	2	2	4	3	8%
Machinery	5	6	6	4	16%
Raw Materials	10	12	11	8	31%
Energy	4	4	4	3	11%
Irrigation fee	0	0	0	0	0%
Overheads	1	1	1	0	2%
Rented Services	6	7	6	5	18%
Production cost (€/t)	27	31	32	24	
Land Rent (€/t)	4	2	2	10	14%
Total Cost (€/t)	31	33	34	34	100%
Yield (t/ha)	51.5	44.1	48.9	63.8	
Total Cost (€/ha)	1,581	1,456	1,656	2,186	
Sellin Price (€/t)	41	35	43	47	
Profit (€/t)	10	2	9	13	

Notes

For all countries the high yield and selling price are the cause of positive profits.







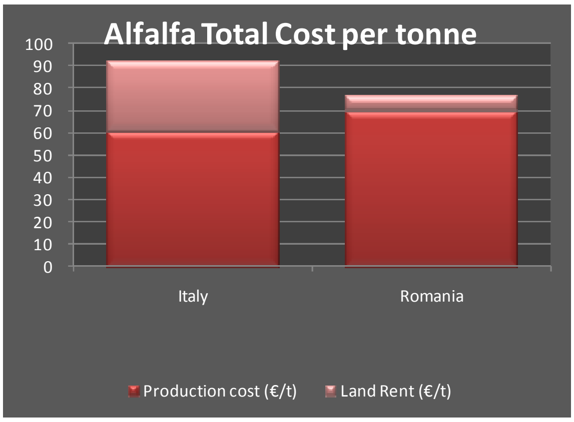
Alfalfa

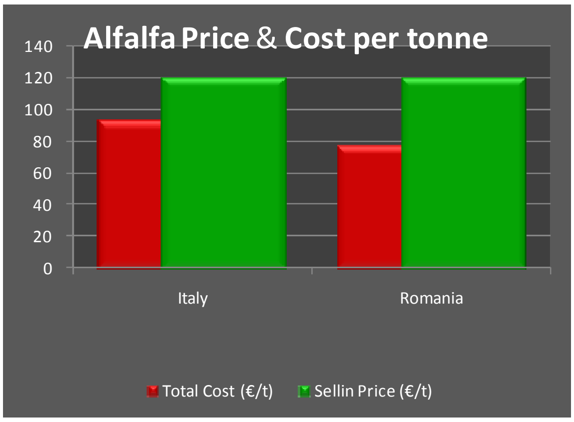
Alfalfa	EUR/tonne		
	Italy	Romania	***EU %***
Labour	13	7	12%
Machinery	14	17	18%
Raw Materials	25	40	38%
Energy	7	5	7%
Irrigation fee	0	0	0%
Overheads	1	1	2%
Rented Services	0	0	0%
Production cost (€/t)	60	70	
Land Rent (€/t)	32	7	23%
Total Cost (€/t)	93	77	100%
Yield (t/ha)	14.0	14.0	
Total Cost (€/ha)	1,295	1,078	
Sellin Price (€/t)	120	120	
Profit (€/t)	27	43	

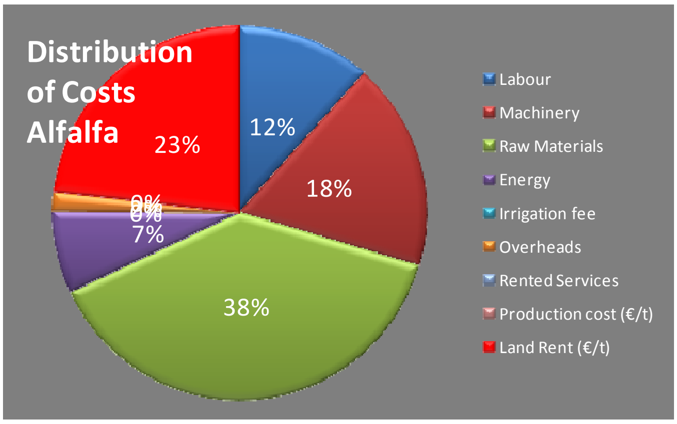
Notes

Alfalfa has an average life of 3 years with low inputs for the 2nd and 3rd year. This decreases its annual equivalent cost.

Both the yield and the price are high enough to cover the cost.







PART IV - ECONOMIC VIABILITY OF BIOFUEL CROPS

Nowadays, the cultivation of energy crops is, in most cases, directly or indirectly subsidised at EU and global levels. However, their financial viability, i.e. sustainable profitability in the absence of subsidies, is not too remote any more given the increasing cost of fossil fuels, pressing environmental concerns and the rapid technological progress in the renewable energies field.

This paper presents a number of case studies examining the viability of the most promising oil and sugar crops for the production of first generation biofuels. The presented outputs of this work indicate that today, the viability of energy crops, such as rapeseed (*Brassica napus*), *Brassica carinata*, sunflower and sweet sorghum, under favourable conditions can be attained. Detailed cost analysis of these crops in various European regions leads to the estimation of profitability and illustrates their financial profile. Comparative analyses are made with the most widespread conventional food crops such as wheat and maize.

The results of the study have shown that first generation oil producing crops in Europe are worth cultivating under current support regimes and under favourable market conditions. In view of the prevailing instability in crops' prices, the farmer has to make decisions on a rather short term basis. Sweet sorghum in southern Europe appears to be a very promising proposition for the production of bioethanol, as it appears much more efficient than cereals and sugar beets, which are used today in the bioethanol industry.

Introduction

The cultivation and exploitation of non-food energy crops is still at the early stages of their development. Production costs are dropping quickly as the technology is rapidly progressing along a steep learning curve, while on the other hand, fossil fuels are losing ground on the basis of their relative scarcity, uncertainty of supply and hostility to the environment. However the cost of producing biofuels (in solid or liquid form) is still high enough in comparison with the cost of competing fossil fuels and therefore their market penetration is generally based on direct or indirect subsidisation due to their challenged environmental benefits. The economic viability of energy crops depends very much upon technological efficiency *along the interfaces of the bioenergy chains*, and policy makers are observing closely technical progress in this industry, in order to form meaningful strategies for sufficient energy supplies, with minimum damage to the environment, at least cost.

In general terms a crop is considered viable if it generates sufficient return on investment for the farmer and, at the same time, business stability at low risk.

The latest EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources sets the following targets for the year 2020 [1]:

Reducing greenhouse gas (GHG) emissions by at least 20% from 1990 levels;

Improving energy efficiency by 20%;

Raising the share of renewable energy to 20%;

Increasing the level of biofuels in transport fuel to 10%.

In this context, bioenergy will have to play an important role in order to meet the above targets, while farmers' willingness to cultivate energy plants will depend upon the financial prospects of these crops.

Biofuels are generally not directly competitive with fossil fuels at current prices. In order to increase their market share, they are financially supported (a) by means of subsidisation of agricultural raw materials through the Common Agricultural Policy (CAP), (b) by targeted tax reliefs and (c) by law enforced introduction of a minimum percentage of biofuels in transport fuel, where the increased cost of biofuels blends is effectively transferred to the final consumer. [2] Direct subsidisation of energy crops cultivation was established for the first time by the EU Regulation 1782/2003 (CAP) with a modest support of 45 €/ha. In parallel, CAP-2003 has decoupled subsidies from the production of conventional crops, thus eliminating the advantage of some conventional crops and paving the way for wider introduction of energy crops. [3-5]

In Europe today, the most common first generation biofuel chains are (a) the production of *biodiesel* from sunflower or rapeseeds, (b) the production of *bio-ethanol* from corn, cereals, sugar beets. Both are today fully commercialised (in most cases with private investment plants), operating under a partially protected regime and managing to achieve sufficient return on their invested capital.

Further to this, European support for the new biofuel technologies is not only encouraging higher capital investment and mobilising private interest towards the achievement of various environmental goals, but is also promoting efficiency improvement and technological breakthrough with consequent economic benefits.[6] More specifically:

Biodiesel today is most often used in 5%-20% blends (B5, B20) with fossil diesel, or even in pure B100 form.[7] The main process for biodiesel production is based on trans-etherification of vegetable oils, through the addition of methanol (or other alcohols) and a catalyst. The main feedstock is oil from sunflower, rapeseed, soy and palm trees.

Bioethanol is mostly used in low 5%-10% blends with petrol (E5, E10) but also as high as 85% blend (E85) in flex-fuel vehicles.[7] The main feedstock for bioethanol production is starchy raw materials, such as wheat and corn, and sugar from such as sugar beets, sugar cane and sweet sorghum. Bioethanol production from sugar and starch comprises of two major process steps (i) the production of sugar and (ii) the fermentation of sugar into ethanol. Production of sugar from sugar crops (e.g. sugar beet, sugar cane or sweet sorghum) involves crushing, and extraction of the sugar. Production of sugar from starch crops (e.g. wheat) involves milling of the grains to obtain the starchy material, dilution and heating to dissolve the starch and conversion of the starch to sugars by hydrolysis.[8]

Bioenergy crops are in general less demanding cultivations that may be grown on various types of land and under various input regimes.

The goal of this work is to explore the effect of land type/quality and cultivation practices (e.g. with or without irrigation, etc.) on the agronomic and financial behaviour of the under study energy crops in different European climatic zones,[9] assuming that the physical performance of each crop is the same within each climatic zone, while the financial parameters, such as prices, wages and other costs, may differ from country to country.

Within this work the production of rapeseed (*Brassica napus* L.) is analysed in Germany and France, in two major climatic zones, Atlantic Central (ATC) and Continental (CON) and its profitability to the farmer is measured in comparison to crops competing for the same land (e.g. wheat and maize). In south Europe, the cases of *Brassica carinata*, sunflower and sweet sorghum are examined in Italy and Greece, in the Mediterranean North (MDN) and South (MDS) climatic zones in comparison to wheat and maize.

The work is part of the research carried out in the context of the EU supported project *4F Crops: Future Crops for Food, Feed, Fibre and Fuel*, www.4fcrops.eu [10]

Methodology of Economic Appraisal

In the free market, viability of a crop is achieved when farmers are willing to undertake its production. This happens when they earn a satisfactory return on their invested capital and there are prospects of maintenance of a strong position at least in the near future, or even longer in the case of perennial crops. Based on this line of thinking, this paper is examining the financial position of the farmer with regard to the allocation of his land among the various cultivation options which are available. As a result, the cost analysis of the cultivation of energy crops is compared to the analysis of competing conventional crops in order to provide realistic estimations for the available options to the farmers.

Other considerations, such as the need for new investment and familiarisation with new crops are not too significant for the crops under study, while the risk of change is not much higher than the risk of selling price fluctuation of wheat and corn. Economic viability is preferably examined in the context of a complete bioenergy chain (from farm to final use). However, here the focus is on the viability of the agricultural production of energy crops, by measuring farmer profitability, which may also depend upon existing or estimated subsidy regime.

All economic analyses of the selected bioenergy crops have been conducted with the help of ABC, the Activity Based Costing packaged software that has been developed by the Agricultural University of Athens. [11] ABC can analyse both annual and perennial crops in great detail and facilitates appraisal and direct comparisons among crops. All analyses are prepared with exactly the same methodology, the Discounted Cash Flow approach, which bridges the gap between conventional agricultural accounting and investment appraisal. In each case agricultural production is broken down into a number of individual agronomic operations which are necessary for growing the crop. Each operation requires “variable inputs” such as labour-hours, machine-hours, fertilizers, etc. It also needs land, which is incorporated in cost analysis as “land rent”. Overheads and subsidies may be added at crop level to complete the cost list which adds up to the total cost of crop production.

The focus is on the analysis of costs of production vis-à-vis revenues from the sale of the crop. Subsidies or taxes that might exist along the product development chain from the farm to its final product market outlet are taken into account since they greatly affect financial viability. [12]

The cost of Land and Labour

Energy crops may grow on different types of *land* and the analysis of costs and returns is required in order to identify the most economic choice, since yields are higher on more fertile land, which however is more costly. Two different types of land have been considered in the case studies: *agricultural land*, where food and non-food crops are competing and *marginal land*, i.e. land of lower quality, which is usually not cultivated, but where it may be possible to grow the less demanding energy crops.

The most appropriate value of the land on which energy crops are grown is its *opportunity cost*, [13] which depends upon the long term profit from its current or most rewarding alternative use. For the present case studies, since there are sufficiently large land rental markets in the selected areas, the current land rent was regarded as the most appropriate measure. [14]

The cost of paid labour is fairly straight forward, since it is not difficult to find useful averages of labour remuneration in many regions in Europe. Unpaid *labour* is ideally valued at its opportunity (imputed) cost. For example the work of the owner farmer or his (unpaid) family is valued at income forgone due to their engagement in the production of energy crops. However, here the imputed cost of all labour engaged in crop production is regarded as equal to the country average wage in the agricultural sector.

Cost of Fixed Assets

The cost of equipment and buildings that may be used for the cultivation of energy crops can be distinguished in two parts: (a) the cost of the fixed asset itself and (b) the recurring cost of its maintenance and operation, such as fuel lubricants, repairs, etc. All capital expenses are transformed into annual equivalent values at an appropriate interest rate. This value is equivalent to depreciation plus interest on capital employed. This capital service annual equivalent cost is allocated to activities or operations according to the use of the fixed asset. [15] Annual recurring costs of the equipment (maintenance, fuel, etc.) are later added, in order to add up to a meaningful total annual equivalent cost.

Therefore, at first, given the asset's purchase cost (*C*), its economic life (*n*) and an appropriate discount rate (*i*), an annual equivalent cost (*P*) is calculated.

$P= C \times a(n,i)^{-1}$

where *a(n,i)* is the annuity present value factor[5]

P may also be thought as the amortisation instalment (principal plus interest) of a loan with amount equal to the fixed asset's purchase cost, and duration equal to the economic life of the fixed asset. If there is salvage value of the item, allowance must be made for this amount.

Because of this second interpretation, *P* is also called Capital Service Cost (*CSC*). The calculation of total annual cost of the fixed asset (Total Annual Cost) requires the addition of maintenance and operation variable cost (M&O) to CSC. Labour costs, such as wages and salaries of operators are classified under "labour costs" and similarly, fuel that might be consumed during the operation of the fixed asset is classified as "energy cost".

Materials and energy

Raw materials such as seeds, fertilizers, pesticides, etc. are usually expenses paid by the farmer in the local market. Therefore these cost items enter the calculations at average market prices for the specific market. Energy in the form of fuel, electricity, etc. is mainly used by the necessary equipment for the production of the crop and depends on the type and capacity of required machinery, the type of the task (heavy duty or light operation) and the number of hours of operation.

Case studies

A selected number of case studies have been undertaken for the identification of the most important cost items in the production of energy crops and the examination of performance improvement conditions. The case studies look into the financial position of selected crops in various European Regions and estimate costs under different cultivation regimes. The selected energy crops belong to two different families, contributing to the production of two different biofuels. *Brassica napus* L. var. *oleifera* D.C. (Rapeseed), *Brassica carinata* (Ethiopian Mustard) and Sunflower for the production of biodiesel and Sweet Sorghum, a sugar plant for the production of bioethanol. *Rapeseed* is representing a success story of the past in Germany (until recently world leader of biodiesel

[5] $a(n,i) = (1-(1+i)^{-n})/i$, as can be found in almost any financial or accounting book, e.g. (Garrison and Noreen, 2003).

production from rapeseed) and in France where it also gives similar yields. Brassica Carinata belongs to the same family of brassicae with Rapeseed, but it is most adapted to Southern climates. Sunflower is also a Southern crop cultivated in the Mediterranean countries for its seeds and for the extracted sunflower oil, which is more recently used for the production of biodiesel. The case of *Sorghum bicolor* (L) Moench (sweet sorghum) is somewhat different, since there is less experience from its commercial exploitation as an energy crop and consequent difficulty in the approximation of possible selling prices. However, it appears today as one of the most promising future crops for the production of ethanol, because it gives high fuel per hectare ratio (about 8,000 l/ha), it grows in a very wide range of climates, it is resistant to long periods of drought, and it gives high yields of biomass for ethanol production. Wheat and Corn are the most widespread crops in Europe, well known for very long. Their use as energy crops for the production of ethanol has increased the demand for land and has driven selling prices up. At the same time questions have been raised regarding the competition between their use for food or fuel.

The economic parameters of energy crops production, such as labour rates, land rent, raw materials and other inputs prices, etc., are mostly related to the geo-political regions, while, technical/agronomic parameters, such as cultivation activities, irrigation needs and productivity of crops, depend upon the specific environmental characteristics of each climatic zone. The proposed methodology places the selected energy crops into a matrix of regions according to their geo-political *and* climatic zone classification. [8, 16] In this matrix, the most important characteristics and parameters for each region that affect crops production are defined and used by the cost model[6]. Eventually, the economic evaluation of energy crops is based on both financial and technical parameters, in order to identify the most important key cost factors for each category. The following table summarises the cases analysed in this paper.

[6] The cost analysis of all case studies has been worked out using *ABC*, the Activity Based Costing software developed by the Agricultural University of Athens (ABC, 2010).

List of case studies

	Crop	Climatic Zone	Country	Land	Input
1	Brassica Napus	ATC	Germany	Marginal Agricultural Agricultural	Low Low High
2	Brassica Napus	ATC	France	Marginal Agricultural Agricultural	Low Low High
3	Brassica Napus	CON	Germany	Marginal Agricultural Agricultural	Low Low High
4	Brassica Napus	CON	France	Marginal Agricultural Agricultural	Low Low High
5	Brassica Carinata	MDS	Italy	Marginal Agricultural Agricultural	Low Low High
6	Sunflower	MDN	Italy	Marginal Agricultural Agricultural	Low Low High
7	Sunflower	MDN	Greece	Marginal Agricultural Agricultural	Low Low High
8	Sweet Sorghum	MDN	Italy	Marginal Agricultural Agricultural	Low Low High
9	Sweet Sorghum*	MDN	Greece	Agricultural Agricultural	Low High
10	Sweet Sorghum*	MDS	Greece	Agricultural Agricultural	Low High
11	Wheat	ATC	Germany	Marginal Agricultural Agricultural	Low Low High
12	Wheat	ATC	France	Marginal Agricultural Agricultural	Low Low High
13	Wheat	CON	Germany	Marginal Agricultural Agricultural	Low Low High
14	Wheat	CON	France	Marginal Agricultural Agricultural	Low Low High
15	Wheat	MDN	Italy	Marginal Agricultural Agricultural	Low Low High
16	Wheat	MDN	Greece	Marginal Agricultural Agricultural	Low Low High
17	Wheat	MDS	Italy	Marginal Agricultural Agricultural	Low Low High
18	Wheat	MDS	Greece	Marginal Agricultural Agricultural	Low Low High
19	Maize	CON	Germany	Marginal Agricultural Agricultural	Low Low High
20	Maize	CON	France	Marginal Agricultural Agricultural	Low Low High
21	Maize	MDN	Italy	Marginal Agricultural Agricultural	Low Low High
22	Maize*	MDN	Greece	Agricultural Agricultural	Low High
23	Maize*	MDS	Greece	Agricultural Agricultural	Low High

ATC: Atlantic Central, CON: Continental, MDN: Mediterranean North, MDS: Mediterranean South
** Irrigated*

The data sources are statistics from FAO and Eurostat, related articles and other publications, related research programmes, etc. Specific references are given in various parts of this paper. In general though, the basic parameters of the cultivation details have been drawn from the *4F Crops* project agronomic database developed by the University of Catania, [17] the Bioenergy chains project [18] and from the database of the Agricultural University of Athens. Selling prices come mainly from the FAOSTAT [19] producer price statistics as averages for the period 2004-2008. Land rent from European publications, de Wit et al., [20] and from EU. [21] Machinery and Equipment data have been collected from the Agricultural University Database and other European suppliers of agricultural machinery and equipment. The costs of fertilizers and other raw materials are based on the Agricultural University Database, Eurostat online database and published data e.g. from Nix [22] and de Wit et al. [20] Fuel prices were derived from the EC Market observatory [23].

The case studies represent the production and other agronomic characteristics of the climatic zone which each case study represents, but the financial data, costs and prices (land rent, labour cost, etc.) depend upon the country of the case study. Other financial data is less site specific and more global/ European prices have been used (e.g. machinery cost).

Rapeseed (Brassica Napus) cultivation in Germany and France

Rapeseed, presently cultivated in many European countries [24] is suitable for many climatic zones, mainly in central and northern Europe. In southern Europe yields are less satisfactory. It is an annual crop which is sown in spring (northern areas) or winter (southern areas). Seed yield ranges from 1.2 to 4.8 t ha^{-1} with the highest yield in the Atlantic Central and Continental climatic zones and in the West, in the Lusitanian and Atlantic North. [1, 10, 25]

Rapeseed has been traditionally cultivated in Germany for the manufacture of oil, mainly non-edible, but also for the production of various edible oils as well as for animal feed, in the form of rapeseed cake from the crushing of rapeseed grain. Since the beginning of this century, its cultivation has acquired increasing importance in Germany and in the whole of Europe due to the high demand for biodiesel. In effect Germany, until 2009, was the world leader in biodiesel production with annual volume of 2.4 million tonnes [26] and installed biodiesel production capacity of almost five million tonnes per year. In 2010, world biodiesel production is expected to jump to almost 18 million tonnes, from less than 15 in 2009. For 2010, Germany will be placed in the third position of world biodiesel producers, after the US and Argentina. This is due to the fact that the government has decided to gradually eliminate the subsidies of biodiesel by withdrawing its tax exemption, which will make it much less competitive and push the German biodiesel industry from a very strong position to a financially unstable situation.

The demand for biodiesel in the EU27 depends mainly upon the level of the biofuel quotas (quantities guaranteed for tax exemption, usually expressed as percentages of diesel consumption) in each member country. For the year 2010, France has the highest figure, 7%, followed by Germany with 6.25% and Spain and Poland with quotas over 5.50%. However, "not all countries have sanction mechanisms applicable when quotas are not met". [26]

The competitiveness of rapeseed production in the course of crop rotation, in which rapeseed competes mainly with grain and particularly winter wheat, *depends naturally on the prices at which producers can sell***.** In contrast to cereals, rapeseed cannot be cultivated every year on the same land, as it is not tolerant to itself. The cultivation interval is 3 – 4 years, so a maximum rotated cultivation area ratio of 20 – 25 % is appropriate for agricultural reasons. There are several rotation schemes for the introduction of rapeseed depending upon the relevant climatic zone. According to the University of Catania Database, [17] rotations of Rapeseed/Flax/Sunflower, Rapeseed/Pea/Sunflower, Rapeseed/Pea/Cereal, Rapeseed/Cereal/Flax/Red clover are some of the possible combinations in Germany. It is clear that the farmer will be willing to cultivate rapeseed only if he may profit more than by cultivating e.g. wheat or corn, which are competing for the same land.

According to the Food and Agriculture Organisation (FAO 2010), the yield of rapeseed in Germany and France ranges roughly between 3 and 4.8 tonnes/ha (seeds). For our analysis we assumed a range of yields from as low as 1.2 to 4.8 tonnes/ha because we are also evaluating cultivation in non agricultural (marginal) land. With regard to the producer's selling price of rapeseed (at farm gate), also according to FAO, the average price in 2007 was 287 €/tonne. Today, the rapeseed producer price in Germany and France is around 270 €/tonne (free at warehouse)[7].

Due to the fact that *the rapeseed harvest per hectare averages about half the volume of grain, rapeseed selling price must correspondingly be at least twice as high to allow rapeseed to compete with wheat or winter barley***.** This indicates that the increase in the cultivated area is mainly demand driven at the moment. As an immediate result of the current high demand for rapeseed to supply the expanding biodiesel industry in Germany, the competitiveness of rapeseed versus other crops and thereby the incentive to further increase the rapeseed area has risen. The cultivated area increased to almost 950,000 ha in 2009, which is about half the area of all non food crop plantations in the country and covers 8% of total arable land. [27]

[7] Source: personal communication Ronny Winkelmann, Agency for Renewable Resources (FNR)

Rapeseed productivity ranges from 1.2 t/ha to 4.8 t/ha depending upon the type of land and the amount of inputs used for the cultivation. Fertilizers and land are the most costly items in the cost analysis tables, accounting for more than 50% of total cost. It is interesting that crops planted in high quality land, using high inputs are more profitable. Crops planted on marginal, low yield land are clearly uneconomic. The substantial instability of selling prices and of the cost of fertilizers has turned what was thought as a first class investment into a very risky venture. In Germany for example, the gradual removal of biodiesel tax exemption has brought several biodiesel plants near bankruptcy. [28]

For the economic viability of rapeseed though, one has to compare returns with the competing food crops that may be grown on the same land. No farmer would cultivate rapeseed in a one hectare wheat field, unless he would profit more from the change in the use of his land. Therefore in the cost analysis table, there is an extra column indicating the corresponding cost of wheat production and an immediate comparison of profitability of the two alternatives. The producer price of wheat fluctuates sharply according to supply/demand conditions and the same can be true for rapeseeds. In Figure 1 we have plotted “equi-cost” combinations along the red line each point of which represents a combination of rapeseed and wheat selling prices at which the profit per hectare is exactly the same for the farmer. Therefore each price combination corresponding to a point above the line (i.e. relatively expensive rapeseed) will result in substitution of rapeseed for wheat, while for each combination under the line, the farmer will choose to cultivate wheat[8].

The long term future of biodiesel in Germany and France may be somewhat uncertain. As from 2011, biofuels in Germany will have to achieve a minimum 35% reduction of greenhouse gasses, which is met by rapeseed methyl ester (RME). However, from 2017 it is expected that the EU will demand a 50% greenhouse gasses reduction efficiency a figure that rapeseed biodiesel does not reach and therefore it will probably be disqualified as a biodiesel feedstock. [26]

The cost analysis of Rapeseed (Brassica Napus) has been estimated for Germany and France in the Atlantic Central and Continental climatic zones. The basic results can be summarised in the Table.

[8] Wheat growers may also sell the straw to earn an extra income, which here is not considered in the calculations.

COST ALLOCATION by OPERATION	Brassica Napus ATLANTIC CENTRAL climatic zone Germany Marginal Low input	Agricult Low Input	Agricult High Input	France Marginal Low input	Agricult Low Input	Agricult High Input	CONTINENTAL climatic zone Germany Marginal Low input	Agricult Low Input	Agricult High Input	France Marginal Low input	Agricult Low Input	Agricult High Input	Overal %
Yield	1.8 t/ha	3.2 t/ha	4.8 t/ha	1.8 t/ha	3.2 t/ha	4.8 t/ha	1.2 t/ha	2.7 t/ha	4.4 t/ha	1.2 t/ha	2.7 t/ha	4.4 t/ha	
Selling price/tonne	270 €	270 €	270 €	263 €	263 €	263 €	270 €	270 €	270 €	263 €	263 €	263 €	
(Land Rent)	24%	37%	29%	18%	29%	22%	24%	37%	29%	18%	29%	22%	**26%**
Fertilization	21%	20%	27%	25%	25%	34%	21%	20%	27%	25%	25%	34%	**25%**
Harvesting	16%	12%	11%	16%	12%	11%	16%	12%	11%	16%	12%	11%	13%
Sowing	14%	12%	10%	15%	14%	11%	14%	12%	10%	15%	14%	11%	12%
Spraying	5%	3%	4%	5%	4%	4%	4%	3%	3%	4%	3%	4%	4%
Tillage	21%	16%	19%	21%	17%	19%	21%	16%	19%	21%	17%	19%	19%
PROFIT (eur/ha)	- 63.94	329.24	**624.20**	- 12.67	383.44	**663.34**	- 224.68	195.51	**518.67**	- 169.22	253.24	**560.70**	
PROFIT (eur/t)	- 35.52	102.89	**130.04**	- 7.04	119.83	**138.20**	- 187.23	72.41	**117.88**	- 141.02	93.79	**127.43**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Brassica Napus			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
ATLANTIC CENTRAL	**Germany**	**Marginal Low input**	1.8	270 €	66.08	42.38	72.78	46	0	78.28	0	305.52	549.936
		Agricult Low Input	3.2	270 €	26.9	16.78	61.56	17.83	0	44.03	0	167.11	534.752
		Agricult High Input	4.8	270 €	23.83	14.43	41.04	14.87	0	45.79	0	139.96	671.808
	France	**Marginal Low input**	1.8	263 €	62.32	28.56	48.33	46	0	84.83	0	270.04	486.072
		Agricult Low Input	3.2	263 €	25.38	11.3	40.94	17.83	0	47.72	0	143.17	458.144
		Agricult High Input	4.8	263 €	22.48	9.72	27.29	14.87	0	50.44	0	124.8	599.04
CONTINENTAL	**Germany**	**Marginal Low input**	1.2	270 €	99.12	63.58	109.17	69	0	116.38	0	457.23	548.676
		Agricult Low Input	2.7	270 €	31.89	19.89	72.96	21.13	0	51.72	0	197.59	533.493
		Agricult High Input	4.4	270 €	26	15.74	44.77	16.23	0	49.39	0	152.12	669.328
	France	**Marginal Low input**	1.2	263 €	93.48	42.83	72.5	69	0	126.21	0	404.02	484.824
		Agricult Low Input	2.7	263 €	30.07	13.4	48.52	21.13	0	56.09	0	169.21	456.867
		Agricult High Input	4.4	263 €	24.52	10.6	29.77	16.23	0	54.45	0	135.57	596.508
		Overall %			20%	11%	**25%**	14%	0%	**30%**	0%		

Yields in France and Germany do not differ significantly between the two climatic zones which are being examined. The average yield is between 3 and 4 tonnes of seeds per year. The cost of production and rapeseed profitability have been estimated for each country, in two different types of land and under three cultivation regimes: Marginal land – Low input, Agricultural land – Low input and Agricultural land – High input. The cost of land and fertilizers are in all cases the dominant cost elements (even in the case of Marginal land with Low inputs). Due to the mechanisation of production, the cost of energy (mainly diesel) is the third important single cost item. These three account for about 3/4 of total cost.

By assuming selling prices at the level of recent average figures (around 265 €/tonne) [19] the expected profitability is ranging between 350 and 650 €/ha for the Atlantic Central climatic zone, but is much lower (200-550 €/ha) for the Continental zone (Table 2). Most striking is the fact that when cultivated in marginal land with low level of inputs, rapeseed becomes uneconomic in both countries, because the loss of yield is more significant than the savings in land rent and inputs. The economic profile of rapeseed compares rather favourably with wheat and corn cultivation in the same areas for at least some of the cases (Tables 8-11). However, without state intervention (tax exemptions or environmental taxes) producer prices will have to fall drastically. On the other hand, the prices of wheat and corn fluctuate significantly from year to year (the price of corn in 2008 exceeded 200 €/t and this year the price of wheat will probably approach the 200 €/t level).

Brassica Carinata L. (Ethiopian Mustard) in South Italy

Brassica Carinata L. (Ethiopian Mustard) is a variation of the Brassica family, performing well in warmer climates, where *Brassica Napus* L. is not giving satisfactory yields. [29] It has been traditionally cultivated in Africa and has been well adapted in southern European climates, such as the South of Italy, where it grows with lower input and satisfactory oil output. The seeds of *Brassica Carinata* L. are very much the same with the seeds of rapeseed, they are undergoing the same industrial process and apparently, their selling price cannot be very different from the price of rapeseed.

Table 3 shows the results of financial analysis of *Brassica Carinata* L., in very much the same manner as the table of rapeseed above. The cost of production per hectare is a little higher compared to rapeseed in Germany and France. The main reason for this is the higher land rent for Italy. Additionally, the yields of Ethiopian mustard are lower and this is the main reason for lower profitability of the crop. It is shown that *Brassica Carinata* L., is hardly profitable and if so, the profit is expected to be minimal. If one takes into account the substantial risk that energy crop producers are facing, one concludes that investment in *Brassica Carinata* L., is not an attractive proposition.

COST ALLOCATION by OPERATION	Brassica Carinata MEDITERRANEAN SOUTH climatic zone **Italy** Marginal Low input	Agricult Low Input	Agricult High Input	**Overal %**
Yield	0.8 t/ha	1.9 t/ha	3 t/ha	
Selling price/tonne	240 €	240 €	240 €	
(Land Rent)	27%	41%	34%	**34%**
Fertilization	20%	18%	26%	**21%**
Harvesting	16%	11%	11%	13%
Sowing	13%	11%	9%	11%
Spraying	3%	2%	2%	3%
Tillage	20%	16%	18%	18%
PROFIT (eur/ha)	- 375.68	- 107.56	**29.61**	
PROFIT (eur/t)	- 469.60	- 56.61	**9.87**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Brassica Carinata			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
MEDITERRANEAN SOUTH (	**Italy**	**Marginal Low input**	0.8	240 €	147.46	97.08	193.75	103.5	0	167.81	0	709.6	567.68
		Agricult Low Input	1.9	240 €	44.95	28.76	122.11	30.13	0	70.66	0	296.61	563.559
		Agricult High Input	3	240 €	37.82	23.49	77.33	23.8	0	67.7	0	230.13	690.39
		Overall %			19%	12%	**32%**	13%	0%	**25%**	0%		

Sunflower in Northern Italy and Greece

Sunflower has been cultivated in Central America and South Europe for very long for its seeds and later for the oil subtracted from its seeds. Recently, sunflower oil has been used as the raw material for the production of biodiesel and this has boosted demand and interest on its cultivation. Today, the prices of sunflower seeds have increased substantially due to increased demand for the production of biodiesel. Table 4 shows recent price levels in Europe.

Sunflower seeds Price in €/t

	2004	***2005***	***2006***	***2007***	***2008***
France	213.0	216.0	225.6	432.7	317.4
Germany	215.3	193.5	190.2	207.1	277.8
Greece	207.2	190.8	162.0	250.0	376.0
Italy	218.0	202.5	195.2	219.8	-

Source: FAO

The case studies illustrated in table 5 assume rather moderate producer prices [19] and average yields from the University of Catania database. [17] It is shown, as in many crop cultivation choices today, that emerging prices (supply and demand conditions) are the most decisive factor for the economic performance of sunflower and the consequent choice of the farmer.

Table 5 summarises the results of economic analysis of non-irrigated sunflower in Italy and Greece.

Sunflower

COST ALLOCATION by OPERATION — MEDITERRANEAN NORTH climatic zone

	Italy Marginal Low input	Italy Agricult Low Input	Italy Agricult High Input	Greece Marginal Low input	Greece Agricult Low Input	Greece Agricult High Input	Overal %
Yield	2.2 t/ha	3 t/ha	3.5 t/ha	2.2 t/ha	3 t/ha	3.5 t/ha	
Selling price/tonne	209 €	209 €	209 €	237 €	237 €	237 €	
(Land Rent)	26%	39%	30%	41%	55%	46%	**39%**
Fertilization	24%	22%	30%	18%	16%	23%	**22%**
Harvesting	15%	10%	10%	12%	8%	8%	10%
Sowing	13%	12%	11%	12%	10%	10%	11%
Spraying	4%	3%	3%	3%	2%	2%	3%
Tillage	19%	15%	16%	15%	10%	12%	14%
PROFIT (eur/ha)	- 146.74	24.78	- **31.32**	- 130.86	2.25	- **17.92**	
PROFIT (eur/t)	- 66.70	8.26	- **8.95**	- 59.48	0.75	- **5.12**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Sunflower			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
MEDITERRANEAN NORTH (	**Italy**	**Marginal Low input**	2.2	209 €	53.62	35.3	70.45	37.64	0	78.68	0	275.7	606.54
		Agricult Low Input	3	209 €	28.47	18.22	77.33	19.02	0	57.7	0	200.74	602.22
		Agricult High Input	3.5	209 €	31.58	19.72	66.29	20.1	0	80.26	0	217.95	762.825
	Greece	**Marginal Low input**	2.2	237 €	54.94	11.31	120.91	37.64	0	71.68	0	296.48	652.256
		Agricult Low Input	3	237 €	29.16	5.84	129.67	19.02	0	52.57	0	236.25	708.75
		Agricult High Input	3.5	237 €	32.35	6.32	111.14	20.1	0	72.2	0	242.12	847.42
		Overall %			16%	7%	**39%**	10%	0%	**28%**	0%		

In Greece, lately, sunflower production levels had dropped significantly because of much cheaper supplies from Bulgaria, Turkey, and other producing countries. However, current legislation determines that only sunflower that has been cultivated in Greece qualifies for subsidised biodiesel production, and these seeds are indeed purchased at much higher price, than sunflower seeds sold for food or edible oil. For as long as the refineries continue to buy sunflower oil at between 300 and 400 €/t, the Greek farmer will be willing to cultivate sunflower.

Sweet Sorghum cultivation in Italy and Greece

Among annual biomass sugar crops European research is primarily focused on *Sorghum bicolor* (L) Moench (Sweet Sorghum), which can supply sugar and cellulose for first and second generation bioethanol respectively. This warm season crop is characterised by a high yield potential and a great resistance to long drought periods. In the Mediterranean environment, its productivity ranges between 11 to 30 t/ha of dry matter or 50 to 100 t/ha fresh, according to nitrogen fertilisation and soil water content with almost 70% of water content at harvest. [30] The advantages of cultivating sweet sorghum for energy purposes mainly derive from the easy introduction of the crop into current cropping systems by applying ordinary crop management and utilising the existing farm machinery.

Sweet Sorghum has been extensively tested in the last 10-20 years in Europe and elsewhere with great success. [31] France, Spain, Greece and Italy are among the most tested areas. Today, it is regarded as one of the most promising energy crops in both first and second generation options.

Sweet Sorghum is suitable for energy production for several important reasons. It has a very positive energy output balance of 800%, it grows with very little input under very wide climate ranges and gives between eight to ten thousand litres of ethanol per hectare per year. Besides the sugar which is converted to bioethanol, sweet sorghum also offers its seeds for food, while the *bagasse* which remains after extraction of the syrup, is fed to the animals, or may be used for lignocellulosic production of ethanol. Although it is suitable for warm climates, sweet sorghum can be cultivated in all Mediterranean regions and even in central Europe.

The specific Mediterranean North (MDN) climatic zone was selected, in order to reduce the irrigation needs of the crop and to achieve higher yields. The case studies (Tables 6 and 7) assume no irrigation in Northern Italy. However, in Greece it has been proved by testing that irrigation of sweet sorghum is necessary. In spite of the additional irrigation cost, which appears in the form of more expensive (irrigated) land and higher irrigation energy cost, the increased yields more than compensate for the extra cost. The main assumption of the analysis is that the produced fresh stems of sweet sorghum will be used for bioethanol production.

Sweet Sorghum

COST ALLOCATION by OPERATION

MEDITERRANEAN NORTH climatic zone

	Italy			
	Marginal Low input	Agricult Low Input	Agricult High Input	Overal %
Yield	51 t/ha	83 t/ha	100 t/ha	
Selling price/tonne	20 €	20 €	20 €	
(Land Rent)	25%	37%	27%	**30%**
Fertilization	20%	18%	19%	**19%**
Harvesting	19%	13%	12%	15%
Sowing	21%	19%	13%	17%
Spraying	15%	14%	19%	16%
Tillage	0%	0%	10%	3%
PROFIT (eur/ha)	398.88	1,031.25	**1,135.43**	
PROFIT (eur/t)	7.82	**12.42**	11.35	

COST ALLOCATION by INPUT FACTOR (eur/t)

Sweet Sorghum		Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
MEDITERRANEAN NORTH cl **Italy**	**Marginal Low input**	51	20 €	1.33	1.07	3.04	1.53	0	5.21	0	12.18	621.18
	Agricult Low Input	83	20 €	0.54	0.43	2.8	0.62	0	3.2	0	7.58	629.14
	Agricult High Input	100	20 €	1.04	0.66	2.32	0.77	0	3.86	0	8.65	865
	Overall %			10%	8%	**29%**	10%	0%	**43%**	0%		

Sweet Sorghum

COST ALLOCATION by OPERATION

	MEDITERRANEAN NORTH		MEDITERRANEAN SOUTH		
	Greece		Greece		
	Agricult Low Input	Agricult High Input	Agricult Low Input	Agricult High Input	Overal %
Yield	70 t/ha	100 t/ha	63 t/ha	90 t/ha	
Selling price/tonne	20 €	20 €	20 €	20 €	
(Land Rent)	39%	27%	39%	28%	**33%**
Fertilization	7%	8%	6%	6%	7%
Harvesting	5%	5%	5%	5%	5%
Irrigation	34%	42%	34%	42%	**38%**
Sowing	9%	6%	9%	6%	7%
Spraying	6%	9%	7%	9%	8%
Tillage	0%	4%	0%	4%	2%
PROFIT (eur/ha)	97.99 €	**150.00 €**	-22.05 €	**-23.40 €**	
PROFIT (eur/t)	1 €	**2 €**	- 0.35	**- 0.26**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Sweet Sorghum			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
MEDITERRANEAN NORTH	**Greece**	**Agricult Low Input**	70	20 €	3.01	0.43	7.17	2.93	0	5.06	0	18.6	1302
		Agricult High Input	100	20 €	4.36	0.58	5.02	3.85	0	4.69	0	18.5	1850
MEDITERRANEAN SOUTH	**Greece**	**Agricult Low Input**	63	20 €	3.35	0.48	7.97	3.25	0	5.31	0	20.35	1282.05
		Agricult High Input	90	20 €	4.85	0.65	5.58	4.28	0	4.91	0	20.26	1823.4
		Overall %			**20%**	3%	**33%**	18%	0%	**26%**	0%		

Today, there is no commercial use for sweet sorghum in Greece and for this reason there is no market price for the harvested material. For comparison, we report that the selling price of sugar beets in Greece for 2007 was 31.90 €/tonne. [19] In view of the fact that 12 tonnes of sugar beets or sweet sorghum give 1 tonne of bioethanol, the estimated price of sweet sorghum (20 €/tonne) seems to be rather low.

The total cost of production of sweet sorghum under the current conditions in Greece is about 20 €/tonne of fresh matter @ 70% moisture content. This is around the estimated (break even) selling price of the product. The main item in production cost is the need for irrigation under Greek climatic conditions. The sorghum field must be in an irrigated area, where the market cost of land is around 500 €/ha, (instead of 200-250 €/ha for non-irrigated land), The expected annual irrigation fee is around 100 €/ha (not included in land rent), plus irrigation machinery and labour cost and energy, adding up to a total irrigation cost between 400 and 800 €/ha, i.e. over 30% of total sweet sorghum production cost. At the price of 20 €/tonne, wheat and maize are tough competitors.

In Italy, the production cost of sweet sorghum is much lower, and in spite of somewhat lower yields, economic results are much better. Sweet sorghum selling at 20 €/tonne or higher is indeed a good business opportunity for the farmer.

Conclusions

After the 1973 and 1980 oil crises, renewable energy sources appeared for the first time as a viable option, in the light of scenarios of shooting oil prices in combination with quickly diminishing oil and gas reserves. Today, although it is still understood that fossil fuels will possibly be the dominant energy source for many years ahead, pressing environmental and strategic problems have pushed governments to move fast towards renewable, sustainable solutions to the energy problem. The path of economic viability of the examined energy crops is following a very steep learning curve and today there are plenty of commercial applications enjoying satisfactory financial returns, with or without state financial support. The future seems to be in favour of the wider introduction of energy crops as oil prices are expected to continue increasing dragging the prices of all other fossil fuels up and leaving more room for renewable energies. Second generation biofuels are expected to give them an extra advantage over the competition for agricultural land.

In this study, we examined the financial profile of a number of energy crops, i.e. food or non-food crops that are used for the production of biofuels. We have established that under the current protective legislation, energy crops provide good business opportunities for farmers in comparison with alternative land use, such as the cultivation of wheat or maize. The risk of reduced state support is though fairly high and this is why governments are obliged to plan ahead in order to offer investors a more secure business environment. On the other hand, food crops prices are also fluctuating and adding to the uncertainty of the farmer, who is losing money in order to secure a price for his next harvest. The cases examined in this study are minimum risk crops since they are all annual and the required investment in machinery and cultivation methods is minimal.

Brassicae seem to make good businesses sense today, since there are a large number of biodiesel plants in Europe and the farmer can sell his products usually under contract. The profit has been satisfactory even when compared with cereals or maize as alternatives (see cost analysis of wheat and maize in appendix). There are two big risks: (a) gradual withdrawal of supportive legislation and (b) commercial introduction of new technologies which make current industrial units obsolete (e.g. second generation plants).

Sunflower, also cultivated for the production of biodiesel, can be profitable. However, competition from outside the EU is tough, while the *Brassica* species *(B. napus* and *B. carinata*) appear to be more profitable in central and north Europe. Under certain circumstances (the case of Greece) sunflower can be an attractive option in the short term.

Sweet sorghum is not yet sufficiently commercialised and therefore the cost of its production gives an indication only with regard to its potential economic performance. The multiplicity of its applications, the low input requirements and the exceptionally high yields are stimulating interest and research on this crop. The need for irrigation in climates such as the Greek, increase costs by as much as 50%, but even so, it is worth cultivating as long as its selling price is over 20 €/tonne, which compares favourably with the price that sugar beets are selling today (over 30 €/tonne).

Wheat

COST ALLOCATION by OPERATION

	ATLANTIC CENTRAL climatic zone						CONTINENTAL climatic zone						
	Germany			**France**			**Germany**			**France**			
	Marginal Low input	Agricult Low Input	Agricult High Input	Marginal Low input	Agricult Low Input	Agricult High Input	Marginal Low input	Agricult Low Input	Agricult High Input	Marginal Low input	Agricult Low Input	Agricult High Input	**Overal %**
Yield	4.7 t/ha	6.4 t/ha	7.5 t/ha	4.7 t/ha	6.4 t/ha	7.5 t/ha	2.1 t/ha	3 t/ha	6 t/ha	2.1 t/ha	3 t/ha	6 t/ha	
Selling price/tonne	137 €	137 €	137 €	133 €	133 €	133 €	137 €	137 €	137 €	133 €	133 €	133 €	
(Land Rent)	29%	45%	33%	22%	36%	25%	29%	45%	33%	22%	36%	25%	**31%**
Fertilization	20%	18%	25%	23%	22%	30%	20%	18%	25%	23%	22%	30%	**23%**
Harvesting	19%	14%	12%	20%	15%	13%	19%	14%	12%	20%	15%	13%	16%
Sowing	28%	20%	14%	31%	23%	15%	28%	20%	14%	31%	23%	15%	**22%**
Spraying	4%	3%	2%	4%	3%	2%	4%	3%	2%	4%	3%	2%	3%
Tillage	0%	0%	14%	0%	0%	15%	0%	0%	14%	0%	0%	15%	5%
PROFIT (eur/ha)	184.80	432.75	**418.80**	226.27	484.33	**472.93**	- 170.35	- 31.65	**213.90**	- 120.08	31.50	**273.19**	
PROFIT (eur/t)	39.32	67.62	**55.84**	48.14	75.68	**63.06**	- 81.12	- 10.55	**35.65**	- 57.18	10.50	**45.53**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Wheat			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
ATLANTIC CENTRAL	**Germany**	**Marginal Low input**	4.7	137 €	12.14	10.22	27.87	13.44	0	33.61	0	97.28	457.216
		Agricult Low Input	6.4	137 €	6.15	5.08	30.78	6.66	0	20.31	0	68.98	441.472
		Agricult High Input	7.5	137 €	12.45	7.91	26.27	8.55	0	25.59	0	80.76	605.7
	France	**Marginal Low input**	4.7	133 €	11.45	6.89	18.51	13.44	0	34.78	0	85.06	399.782
		Agricult Low Input	6.4	133 €	5.8	3.42	20.47	6.66	0	21.17	0	57.52	368.128
		Agricult High Input	7.5	133 €	11.74	5.33	17.47	8.55	0	27.05	0	70.14	526.05
CONTINENTAL clim	**Germany**	**Marginal Low input**	2.1	137 €	27.18	22.87	62.38	30.07	0	75.22	0	217.72	457.212
		Agricult Low Input	3	137 €	13.12	10.83	65.67	14.21	0	43.32	0	147.15	441.45
		Agricult High Input	6	137 €	15.56	9.89	32.83	10.68	0	31.98	0	100.95	605.7
	France	**Marginal Low input**	2.1	133 €	25.63	15.41	41.43	30.07	0	77.84	0	190.38	399.798
		Agricult Low Input	3	133 €	12.37	7.3	43.67	14.21	0	45.15	0	122.7	368.1
		Agricult High Input	6	133 €	14.68	6.66	21.83	10.68	0	33.82	0	87.67	526.02
		Overall %			13%	8%	**31%**	13%	0%	**35%**	0%		

Wheat

COST ALLOCATIOI by OPERATION

	MEDITERRANEAN NORTH climatic zone						MEDITERRANEAN SOUTH climatic zone						
	Italy			**Greece**			**Italy**			**Greece**			
	Marginal Low input	Agricult Low Input	Agricult High Input	Marginal Low input	Agricult Low Input	Agricult High Input	Marginal Low input	Agricult Low Input	Agricult High Input	Marginal Low input	Agricult Low Input	Agricult High Input	**Overal %**
Yield	2 t/ha	4.1 t/ha	6.8 t/ha	1.5 t/ha	3.5 t/ha	4.5 t/ha	1.5 t/ha	2.4 t/ha	3.5 t/ha	1.5 t/ha	3 t/ha	4 t/ha	
Selling price/tonne	173 €	173 €	173 €	178 €	178 €	178 €	173 €	173 €	173 €	178 €	178 €	178 €	
(Land Rent)	32%	48%	36%	48%	64%	51%	32%	48%	36%	48%	64%	51%	**46%**
Fertilization	20%	18%	24%	14%	12%	18%	20%	18%	24%	14%	12%	18%	**18%**
Harvesting	18%	13%	12%	14%	9%	9%	18%	13%	12%	14%	9%	9%	12%
Sowing	26%	18%	13%	22%	14%	11%	26%	18%	13%	22%	14%	11%	17%
Spraying	4%	3%	2%	3%	2%	1%	4%	3%	2%	3%	2%	1%	2%
Tillage	0%	0%	13%	0%	0%	10%	0%	0%	13%	0%	0%	10%	4%
PROFIT (eur/ha)	- 141.32	225.82	**522.76**	- 292.27	11.90	**44.69**	- 227.57	- 67.42	**- 46.44**	- 292.27	- 76.98	**- 44.24**	
PROFIT (eur/t)	- 70.66	55.08	**76.88**	- 194.85	3.40	**9.93**	- 151.71	- 28.09	**- 13.27**	- 194.85	- 25.66	**- 11.06**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Wheat			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
MEDITERRANEAN N	**Italy**	**Marginal Low input**	2	173 €	28.31	24.45	77.5	31.58	0	81.33	0	243.16	486.32
		Agricult Low Input	4.1	173 €	9.52	8.07	56.59	10.4	0	32.84	0	117.42	481.422
		Agricult High Input	6.8	173 €	13.62	8.88	34.12	9.43	0	29.57	0	95.62	650.216
	Greece	**Marginal Low input**	1.5	178 €	38.66	10.45	177.33	42.1	0	104.11	0	372.65	558.975
		Agricult Low Input	3.5	178 €	11.43	3.03	111.14	12.18	0	36.62	0	174.4	610.4
		Agricult High Input	4.5	178 €	21.08	4.3	86.44	14.24	0	41.8	0	167.87	755.415
MEDITERRANEAN S	**Italy**	**Marginal Low input**	1.5	173 €	37.74	32.6	103.33	42.1	0	108.44	0	324.21	486.315
		Agricult Low Input	2.4	173 €	16.27	13.78	96.67	17.77	0	56.11	0	200.59	481.416
		Agricult High Input	3.5	173 €	26.45	17.26	66.29	18.31	0	57.46	0	185.77	650.195
	Greece	**Marginal Low input**	1.5	178 €	38.66	10.45	177.33	42.1	0	104.11	0	372.65	558.975
		Agricult Low Input	3	178 €	13.33	3.53	129.67	14.21	0	42.72	0	203.46	610.38
		Agricult High Input	4	178 €	23.71	4.84	97.25	16.03	0	47.03	0	188.86	755.44
		Overall %			11%	5%	**46%**	10%	0%	**28%**	0%		

Maize

COST ALLOCATION by OPERATION

COST ALLOCATION by OPERATION	CONTINENTAL climatic zone – Germany – Marginal Low input	Germany – Agricult Low Input	Germany – Agricult High Input	France – Marginal Low input	France – Agricult Low Input	France – Agricult High Input	MEDITERRANEAN NORTH – Italy – Marginal Low input	Italy – Agricult Low Input	Italy – Agricult High Input	Overal %
Yield	4.5 t/ha	7.4 t/ha	9.8 t/ha	4.3 t/ha	7.1 t/ha	9.7 t/ha	4.3 t/ha	7.1 t/ha	9.7 t/ha	
Selling price/tonne	137 €	137 €	137 €	127 €	127 €	127 €	151 €	151 €	151 €	
(Land Rent)	17%	27%	21%	12%	20%	15%	19%	30%	23%	**21%**
Fertilization	16%	15%	22%	18%	18%	26%	17%	16%	23%	**19%**
Harvesting	15%	10%	11%	15%	10%	11%	14%	10%	10%	12%
Sowing	29%	28%	22%	31%	31%	24%	27%	26%	21%	**27%**
Spraying	8%	8%	11%	9%	9%	12%	8%	7%	11%	9%
Tillage	15%	12%	13%	15%	12%	12%	14%	11%	12%	13%
PROFIT (eur/ha)	- 145.94	280.02	**411.81**	- 149.99	245.81	**374.43**	- 148.65	292.58	**476.55**	
PROFIT (eur/t)	- 32.43	37.84	**42.02**	- 34.88	34.62	**38.60**	- 34.57	41.21	**49.13**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Maize			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
CONTINENTAL climatic	**Germany**	**Marginal Low input**	4.5	137 €	28.95	18.21	29.11	20.61	0	72.56	0	169.43	762.435
		Agricult Low Input	7.4	137 €	12.4	7.64	26.62	8.38	0	44.12	0	99.16	733.784
		Agricult High Input	9.8	137 €	12.52	7.5	20.1	8.12	0	46.73	0	94.98	930.804
	France	**Marginal Low input**	4.3	127 €	28.57	12.84	20.23	21.57	0	78.67	0	161.88	696.084
		Agricult Low Input	7.1	127 €	12.19	5.36	18.45	8.74	0	47.65	0	92.38	655.898
		Agricult High Input	9.7	127 €	11.94	5.1	13.51	8.21	0	49.65	0	88.4	857.48
MEDITERRANEAN NORT	**Italy**	**Marginal Low input**	4.3	151 €	30.04	19.4	36.05	21.57	0	78.77	0	185.82	799.026
		Agricult Low Input	7.1	151 €	12.82	8.1	32.68	8.74	0	47.7	0	110.04	781.284
		Agricult High Input	9.7	151 €	12.55	7.71	23.92	8.21	0	49.73	0	102.12	990.564
		Overall %			15%	8%	**20%**	10%	0%	**47%**	0%		

Maize

COST ALLOCATION by OPERATION

COST ALLOCATION by OPERATION	MEDITERRANEAN NORTH – Greece – Agricult Low Input	Greece – Agricult High Input	MEDITERRANEAN SOUTH – Greece – Agricult Low Input	Greece – Agricult High Input	Overal %
Yield	8 t/ha	12 t/ha	7 t/ha	10 t/ha	
Selling price/tonne	173 €	173 €	173 €	173 €	
(Land Rent)	35%	26%	35%	24%	**30%**
Fertilization	7%	10%	7%	9%	8%
Harvesting	5%	4%	5%	4%	4%
Irrigation	30%	40%	30%	44%	**36%**
Sowing	14%	10%	14%	10%	12%
Spraying	4%	5%	4%	5%	4%
Tillage	5%	5%	5%	5%	5%
PROFIT (eur/ha)	-49.44 €	**123.60 €**	-222.81 €	**-394.61 €**	
PROFIT (eur/t)	-6 €	**10 €**	- 31.83	- **39.46**	

COST ALLOCATION by INPUT FACTOR (eur/t)

Maize			Yield	Selling Price	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	TOTAL Cost eur/t	TOTAL Cost eur/ha
MEDITERRANEAN NORTH	**Greece**	**Agricult Low Input**	8	173 €	32.28	4.61	62.75	26.98	0	52.96	0	179.58	1436.64
		Agricult High Input	12	173 €	37.89	5.07	41.83	32.26	0	46.03	0	163.1	1957.2
MEDITERRANEAN SOUTH	**Greece**	**Agricult Low Input**	7	173 €	36.89	5.27	71.71	30.83	0	60.53	0	205.23	1436.61
		Agricult High Input	10	173 €	54.02	7.01	50.2	46.39	0	55.24	0	212.86	2128.6
		Overall %			**21%**	3%	**30%**	18%	0%	**28%**	0%		

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PART V - ECONOMIC VIABILITY OF PERENNIAL GRASSES[9]

In the following we examine the cost analysis and profitability of five most promising perennial grasses, namely miscanthus, switchgrass, giant reed *(arundo donax*), cardoon (*cynara cardunculus*) and reed canary grass in six different European countries (Netherlands, UK, Spain, Portugal, Romania, Sweden) and six climatic zones (Atlantic North, Atlantic Central, Nemoral, Mediterranean North and South, Continental).

The cost analysis that follows does not include the cost of transporting the products to the market (i.e. it is the cost at *farm gate,* including however the cost of chipping or baling and drying on the farm). The selling price is in most cases imputed because there are no established markets in the regions that we have examined. In most cases the prices used are figures that have been quoted or reported in recent transactions, but in any case, they do not represent long term prices. Furthermore, farmers cannot cultivate these plants unless they have secured the sale of the product, which assumes some transformation plant nearby, which consumes or transforms the biomass. Consideration is therefore paid to changes in selling prices.

The cost analyses are very detailed and they are presented in tables breaking the cost down by operation and by production input factor. All figures are annual equivalent costs (annuitised costs) per hectare. Cost per tonne of production is easily found by dividing all costs by the average annual yield. The cost of initial investment (sometimes called establishment cost) has been annuitised at a discount rate of 5% (including an element of risk) and is included in the figures, which therefore represent the annualised total cost of production.

Each table is accompanied by comments which discuss each case's individual peculiarities. All cases have been tested for (a) Agricultural Land with High Inputs (signified by AH), (b) Agricultural Land with Low Inputs (AL) and (c) Marginal Land[10] with Low Inputs (ML). In most cases it was found that marginal land crops are less profitable in spite of the lower cost of cultivation and lower land rent, because the loss in yield was disproportionally high. For economy of space, below we present only the graphics of AL results, which seems most appropriate in most cases, but the associated comments

[9] All graphics and tables in this Part and in the next have been prepared by ABC, www.abc.aua.gr

[10] The exact nature and cost of "Marginal Land" is rather difficult to define. Here we have assumed that Marginal Land is not Agricultural, not cultivated with food crops, sometimes it is called "surplus land" within the project, a definition which leaves room for e.g set aside agricultural land as well. Data for the land cost of different land types, etc. can be found in De Wit M, and A Faaij, 2010 .

in each case discuss alternate land types, different prices, etc. when necessary. At the end of this Part there is a table, the Table of Profits, summarising the effects of different land types and level of inputs on the cost of production and profitability of all grasses. Other considerations, e.g. food sufficiency, environment, etc., may support the use of marginal land, which seems to be the worst case in all our experiments.

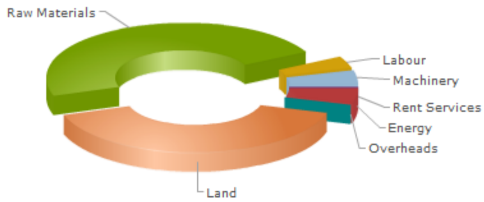
MISCANTHUS

MISCANTHUS in Netherlands in Atlantic Central zone planted in Agricultural Land with Low Level of Inputs.

Miscanthus Netherlands ATC AL (20 yrs)

Country/Region: Netherlands
Annual yield: 24.3 ton
Economic life: 20 yr
Selling Price: 50 €/ton

Sales: 1215.00 €/ha
Cost: **1137.73** €/ha
Profit: 77.27 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			457.04					*457.04*
Fertilization	0.49	1.34		1.02		4.12		*6.97*
Fertilization	0	0		0		0		*0.00*
Harvesting	42.82	30.34		37.5				*110.66*
Sowing	3.19	4.9		7.65		528.57		*544.31*
Spraying	0.25	0.67		0.49		6.34		*7.75*
Tillage	5.37	3.56		1.98				*10.91*
TOTAL (€/ha)	52.12	40.81	457.04	48.64		539.03		*1137.64*

The cultivation of Miscanthus in the Netherlands can only be considered in Atlantic Central Regions (i.e. the Southern Part of Holland) because expected yields are much higher, in the range of 20 – 30 tonnes per hectare. Even under best conditions (AH), the economic performance of the crop is marginal mainly because of the high land cost of the country. In effect, as may be seen in the Table of Profits, the profitability of the crop on agricultural land is minimal (less than 5 euros per tonne) and in view of the great uncertainty about selling prices, it doesn't make economic sense.

Miscanthus might also be planted on marginal land, however with poorer financial results, because the slim benefit of 30 euros reduction in the cost of each hectare of land is not sufficient to make up the loss in yield (25%) and the increased cost of harvesting on marginal land. High input cultivation on agricultural land (AH) results in slightly higher profitability because the extra income from the increased yield (3 extra tonnes per ha) is higher than the extra cost of required inputs (110 EUR/ha).

The cost of Miscanthus in Holland is dominated by two single items: the establishment cost and the cost of land, both accounting for about 90% of the total in almost equal terms. Although the cost of initial investment (establishment) has been annuitized, it still remains the outstanding cost element in the cost analysis table above. (The establishment cost of Miscanthus, including rhizomes and all other materials and work, exceeds five thousand euros per hectare).

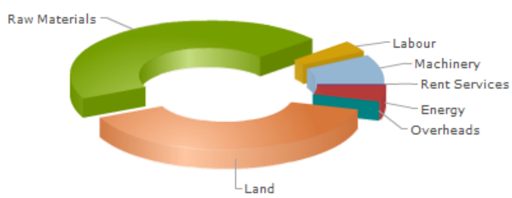
On pure financial ground, the conclusion is that at a selling price of 50 euros per hectare, miscanthus is not yet ready to compete as an alternative candidate crop in Holland. Small possible profits of a few euros per ha are not sufficient payment for the risk of a new investment, even in the existence of a long term contract.

MISCANTHUS in Netherlands in Atlantic North zone planted in Agricultural Land with Low Level of Inputs.

Miscanthus Netherlands ATN AL (20 yrs)

Country/Region: Netherlands
Annual yield: 12.5 ton
Economic life: 20 yr
Selling Price: 50 €/ton

Sales: 625.00 €/ha
Cost: **1183.25** €/ha
Profit: -558.25 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			457.04					*457.04*
Fertilization	0.49	1.34		1.02		4.12		*6.97*
Fertilization	0	0		0		0		*0.00*
Harvesting	42.82	30.34		83.04				*156.20*
Sowing	3.2	4.9		7.65		528.57		*544.32*
Spraying	0.25	0.67		0.49		6.34		*7.75*
Tillage	5.37	3.56		1.98				*10.91*
TOTAL (€/ha)	52.13	40.81	457.04	94.18		539.03		*1183.19*

The significantly lower productivity of Miscanthus in the Atlantic North climatic region in combination with the high cost of land in Holland is responsible for negative financial results in all cases examined. This climatic zone does not offer the conditions for the cultivation of Miscanthus.

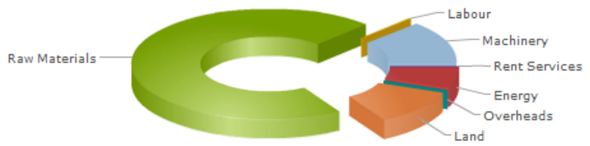
As in the case of the South of Holland (see above), the cost of establishing the crop and the cost of land, share almost the whole of the cost of production. However, with yields barely exceeding 15 tonnes per hectare under the best of circumstances, profitability is not possible and miscanthus does not seem to be a viable business proposition for any farmer.

MISCANTHUS in Romania in Continental zone planted in Agricultural Land with Low Level of Inputs.

Miscanthus Romania CON AL (20 yrs)

Country/Region:
Annual yield: 23.3 ton
Economic life: 20 yr
Selling Price: 40 €/ton

Sales: 932.00 €/ha
Cost: **758.88** €/ha
Profit: 173.12 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			80.46					*80.46*
Fertilization	0.43	0.08		1.02		1.59		*3.12*
Fertilization	0	0		0		0		*0.00*
Harvesting	37.34	1.74		83.04				*122.12*
Sowing	2.78	0.28		7.65		528.57		*539.28*
Spraying	0.22	0.04		0.49		6.34		*7.09*
Tillage	4.68	0.2		1.98				*6.86*
TOTAL (€/ha)	45.45	2.34	80.46	94.18		536.50		*758.93*

The low cost of land in Romania is the most important factor of maintaining the cost of Miscanthus production at very low levels. (Compare the land rent in the Netherlands with the cost of land in Romania). In spite of somewhat lower yields in each of the different land types being examined and the lower selling price (40 euros per tonne), the economic analysis of the crop shows that it is profitable to cultivate Miscanthus in all land types and input scenarios. Best results were estimated, in the case of cultivation on High input Agricultural land (AH).

The productivity of the crop in the Continental (CON) climatic zone is somewhat higher than ATC, with a high of almost 30 tonnes per hectare. This, in combination with a very low land rent in Romania, gives rewarding profits. The rent of agricultural land in Romania is five to six times lower than the corresponding rent in Holland, where land is the most expensive in Europe and so the only dominant element in the crop cost analysis is initial investment, i.e. the cost of rhizomes. (We have assumed the same cost of miscanthus rhizomes, which might have to be bought from the EU market, at least at the beginning).

We have identified very low rent of marginal land[11] in Romania (27 euros per hectare!), which is almost one third of the cost of agricultural land (see template above). Nevertheless, cultivation on

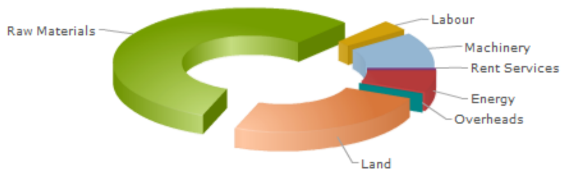
[11] De Wit M, and A Faaij, 2010.

marginal land only gives half the profit (111 euros per ha) when compared with the Agricultural High input (AH) case.

MISCANTHUS in the UK in Atlantic Central zone planted in Agricultural Land with Low Level of Inputs.

Miscanthus UK ATC AL (20 yrs)

Country/Region:	United Kingdom
Annual yield:	24.2 ton
Economic life:	20 yr
Selling Price:	50 €/ton
Sales:	1210.00 €/ha
Cost:	**958.08** €/ha
Profit:	251.92 €/ha
Subidies:	



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			232.43					*232.43*
Fertilization	0.58	1.02		1.02		4.58		*7.20*
Fertilization	0	0		0		0		*0.00*
Harvesting	50.14	23.08		83.04				*156.26*
Sowing	3.73	3.73		7.65		528.57		*543.68*
Spraying	0.29	0.51		0.49		6.34		*7.63*
Tillage	6.29	2.71		1.98				*10.98*
TOTAL (€/ha)	61.03	31.05	232.43	94.18		539.49		*958.18*

Miscanthus has been recently cultivated extensively in the UK as a feedstock for electricity generation in order to achieve goals regarding the introduction of certain percentages of green energy to the British energy balance. For this reason Miscanthus has been subsidised by a sizeable establishment grant by DEFRA, in order to cover some of the expenses of the first two years, when there is no significant production.

Our examination shows that the crop is profitable if planted on agricultural land, AH and AL. Its profitability per tonne of output is 10 euros and at a selling price of 50 euros per tonne the increased cost of inputs in the high input scenario (AH) is exactly compensated by the resulting additional yield of 3 t/ha of the low input case (AL).

Land in Britain is not as expensive as in Holland and as a result the dominating cost element is raw materials, which is mainly the cost of rhizomes, (10 to 15 thousand of rhizomes per ha at a price of 30 eurocents each[12]). The annuitized cost of initial investment equals 56% of total annual cost, while the second large cost element is land rent, which equals 24%.

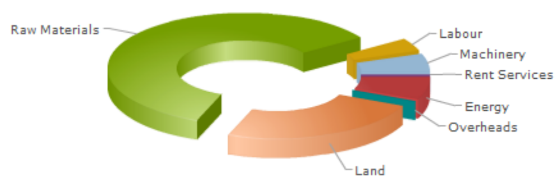
In view of the fact that we have assumed a relatively high annual yield (24 tonnes), the estimated profit from the cultivation of miscanthus may not give sufficient stimulus to British farmers and therefore the crop is still in need of state support.

MISCANTHUS in the UK in Atlantic North zone planted in Agricultural Land with Low Level of Inputs.

Miscanthus UK ATN AL (20 yrs)

Country/Region: United Kingdom
Annual yield: 12.5 ton
Economic life: 20 yr
Selling Price: 50 €/ton

Sales: 625.00 €/ha
Cost: **965.75** €/ha
Profit: -340.75 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			232.43					*232.43*
Fertilization	0.58	1.02		1.02		4.58		*7.20*
Fertilization	0	0		0		0		*0.00*
Harvesting	50.14	23.08		37.5				*110.72*
Sowing	3.73	3.73		7.65		528.57		*543.68*
Spraying	3.45	6.05		5.87		45.32		*60.69*
Tillage	6.29	2.71		1.98				*10.98*
TOTAL (€/ha)	64.19	36.59	232.43	54.02		578.47		*965.70*

Very much like in the case of Holland, the low miscanthus yields observed in the Atlantic North climatic zone are also undermining the profitability of the plant. Although the cost of production remains practically the same, revenues fall short due to reduced yields (half in the case of Agricultural land with Low inputs – AL, i.e. from 24.2 tonnes/ha down to 12.5 tonnes/ha)

The resulting cost per tonne of production is higher than the selling price of 50 euros and is equal to 68, 77 and 107 eur/t for the AH, AL and ML cases.

[12] Market prices and communication with Prof A. Monti, Bologna University and S. L. Cosentino, University of Catania

SWITCHGRASS

SWITCHGRASS in Netherlands in Atlantic Central zone planted in Agricultural Land with Low Level of Inputs.

Switchgrass Netherlands ATC AL (10 yrs)

Country/Region: Netherlands
Annual yield: 11.8 ton
Economic life: 10 yr
Selling Price: 50 €/ton

Sales: 590.00 €/ha
Cost: **635.31** €/ha
Profit: -45.31 €/ha
Subidies:

TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			475.56					*475.56*
Fertilization	0.8	2.16		1.64		11.86		*16.46*
Fertilization	0	0		0		0		*0.00*
Harvesting	42.82	30.34		37.5				*110.66*
Sowing	0.4	0.62		0.82		9.6		*11.44*
Spraying	0.34	0.93		0.69		4.07		*6.03*
Tillage	7.45	4.94		2.76				*15.15*
TOTAL (€/ha)	51.81	38.99	475.56	43.41		25.53		*635.30*

Switchgrass is not too different from miscanthus, but is thinner and smaller, more manageable crop with interesting long period of harvesting from July to the end of the year, which makes it more useful for the maintenance of continuous of biomass feedstock. Switchgrass yields though are much lower than Miscanthus and Arundo Donax.

The estimated economic results are not encouraging the cultivation in the Netherlands.

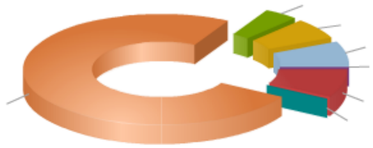
The Switchgrass cost is in effect the cost of land it covers, plus a mere 10-20% for everything else. Its establishment cost is very small because it does not require the planting of rhizomes, since it may be propagated with seeds at very low cost.

SWITCHGRASS in Netherlands in Atlantic North zone planted in Agricultural Land with Low Level of Inputs.

Switchgrass Netherlands ATN AL (10 yrs)

Country/Region: Netherlands
Annual yield: 9.9 ton
Economic life: 10 yr
Selling Price: 50 €/ton

Sales: 495.00 €/ha
Cost: **635.28** €/ha
Profit: -140.28 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			475.56					*475.56*
Fertilization	0.8	2.16		1.64		11.86		*16.46*
Fertilization	0	0		0		0		*0.00*
Harvesting	42.82	30.34		37.5				*110.66*
Sowing	0.4	0.62		0.82		9.6		*11.44*
Spraying	0.34	0.93		0.69		4.07		*6.03*
Tillage	7.45	4.94		2.76				*15.15*
TOTAL (€/ha)	51.81	38.99	475.56	43.41		25.53		*635.30*

The economic performance of Switchgrass in the Northern part of Holland is worse than in the South, due to lower yields.

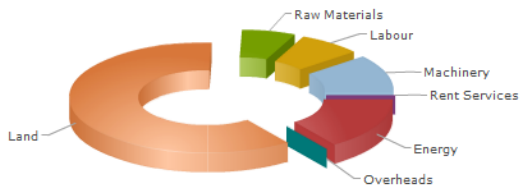
So, the farmer is losing in all cases examined, his losses ranging from 105 to 318 eur/ha. The fact that Switchgrass on marginal land is losing almost as much as the land rent, proves that the very low yield of this type of land barely earns the cost of inputs.

SWITCHGRASS in the UK in Atlantic Central zone planted in Agricultural land with Low Level of Inputs.

Switchgrass UK ATC AL (10 yrs)

Country/Region: United Kingdom
Annual yield: 11.8 ton
Economic life: 10 yr
Selling Price: 50 €/ton

Sales: 590.00 €/ha
Cost: **400.85** €/ha
Profit: 189.15 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			241.85					*241.85*
Fertilization	0.94	1.64		1.64		11.58		*15.80*
Fertilization	0	0		0		0		*0.00*
Harvesting	50.14	23.08		37.5				*110.72*
Sowing	0.47	0.47		0.82		9.6		*11.36*
Spraying	0.4	0.7		0.69		4.07		*5.86*
Tillage	8.72	3.75		2.76				*15.23*
TOTAL (€/ha)	60.67	29.64	241.85	43.41		25.25		*400.82*

The economic performance of Switchgrass in the UK is higher than in the Netherlands, due to a much lower cost of land, by around 50%. As in all cases with Switchgrass, it is proven that the plantation has only one important expense item (60% of total) which is *Land rent*, and a much lower cost of machinery including its energy consumption, mainly for harvesting (25%). The remaining costs add up to a mere 15% of total annuitized expense.

Switchgrass can be profitable in England and Wales (ATC). It may earn a profit between 15 and 3 euros per tonne of output, the former in the case of cultivation on Agricultural land with High inputs (AH), the latter in the case of Marginal land with Low inputs (ML), (see Table of Profits below).

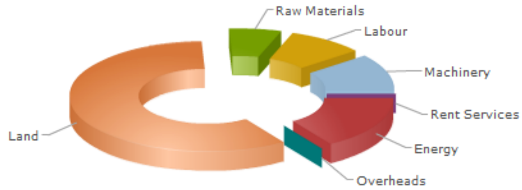
The UK has a tradition in supporting the expansion of biomass and the Department for Environment Food and Rural Affairs has for long subsidized the production of grasses for e.g. electricity generation. It still offers a grant to the growers in England, which has not been included in the above calculations. The effect of such a grant, being paid once under a *single payment scheme,* may not be very decisive, but it gives an extra positive push to the farmer and some cash-in when mostly needed.

SWITCHGRASS in the UK in Atlantic North zone planted in Agricultural land with Low Level of Inputs.

Switchgrass UK ATN AL (10 yrs)

Country/Region: United Kingdom
Annual yield: 10.2 ton
Economic life: 10 yr
Selling Price: 50 €/ton

Sales: 510.00 €/ha
Cost: **413.41** €/ha
Profit: 96.59 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			241.85					*241.85*
Fertilization	0.94	1.64		1.64		11.58		*15.80*
Fertilization	0	0		0		0		*0.00*
Harvesting	50.14	23.08		37.5				*110.72*
Sowing	0.47	0.47		0.82		9.6		*11.36*
Spraying	4.78	8.38		1.14		4.07		*18.37*
Tillage	8.72	3.75		2.79				*15.26*
TOTAL (€/ha)	65.05	37.32	241.85	43.89		25.25		*413.36*

As in all other previous cases, the Atlantic North climatic region yields less of the examined perennial grasses, and as almost all other cost items do not change much the result is a lower profit by the amount of yield forgone.

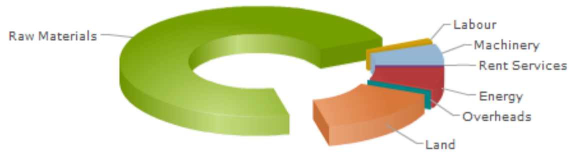
In this case, in comparison with the AH case above, with a reduction of about 2 tonnes of yield (almost 100 eur/ha), profit per ha drops from 189 to 97 euros and the consequent drop in profit per tonne is from 16 to 9 euros. See for details the Table of Profits below.

ARUNDO DONAX

ARUNDO in Portugal in Mediterranean North zone planted in Agricultural land with Low Level of Inputs.

Arundo Portugal MDN AL (20 yrs)

Country/Region:	Portugal
Annual yield:	46.8 ton
Economic life:	20 yr
Selling Price:	30 €/ton
Sales:	1404.00 €/ha
Cost:	**1004.33** €/ha
Profit:	399.67 €/ha
Subidies:	



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			150.86					*150.86*
Fertilization	0.49	0.34		1.02		9.15		*11.00*
Fertilization	0	0		0		0		*0.00*
Harvesting	53.58	9.52		46.88				*109.98*
Sowing	3.19	1.23		7.65		704.76		*716.83*
Spraying	0.25	0.17		0.49		6.34		*7.25*
Tillage	5.37	0.89		1.98				*8.24*
TOTAL (€/ha)	62.88	12.15	150.86	58.02		720.25		*1004.16*

Arundo (Giant Reed) is a herbaceous species native or naturalised in many regions of South Asia, South Europe, North Africa and Central America. It is tall with stems as thick as 3 or four centimetres.

Arundo is multiplied with rhizomes which are as expensive as the rhizomes of miscanthus, i.e. about 30 eurocents each, but even higher prices have been reported in the literature (A. Monti, et al., 2007). For this reason over 70% of its annuitized cost of production is due to this high initial investment cost (establishment cost) of almost 6,500 euros per hectare, of which over 6,000 is the cost of Arundo rhizomes.

Once established, the cost of maintenance is almost zero, there is only a cost of land rental depending on the type of land, and a harvesting cost of around 110 euros once a year.

However, its costly installation expense pushes the annuitized cost of production up to 1,000 euros, which means that at a selling price of 30 euros per tonne, the breakeven yield is over 30 t/ha.

The case of arundo cultivation on agricultural land – low inputs (AL) in Portugal, shows that it is somehow profitable. In effect the cultivation of arundo is profitable on all land types and under all examined regimes, although its profitability is not particularly wide. Its breakeven farm gate selling prices for the three cases that we examine, namely AH, AL and ML are 20, 21 and 26 euros per tonne respectively. This means that, for example in the AL case, if the selling price falls below 21 euros per tonne, then the profit turns into loss.

In general arundo in Northern Mediterranean areas could be an interesting proposition, since it also has a small number of other more traditional uses plus that it doesn't need any serious maintenance and therefore could grow in less fertile land.

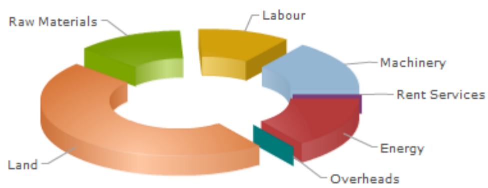
CARDOON

CARDOON in Spain in Mediterranean South zone planted in Agricultural land with Low Level of Inputs

Cardoon Spain MDS AL (15 yrs)

Country/Region: Spain
Annual yield: 14.2 ton
Economic life: 15 yr
Selling Price: 30 €/ton

Sales: 426.00 €/ha
Cost: **332.14** €/ha
Profit: 93.86 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			155.01					*155.01*
Fertilization	0.6	1.32		1.33		5.78		*9.03*
Fertilization	0	0		0		0		*0.00*
Harvesting	39.9	23		37.5				*100.40*
Sowing	0.3	0.38		0.67		1.97		*3.32*
Spraying	1.84	4.05		3.95		15.03		*24.87*
Spraying (Pests)	1.84	4.05		3.95		18.79		*28.63*
Tillage	5.6	3.02		2.23				*10.85*
TOTAL (€/ha)	50.08	35.82	155.01	49.63		41.57		*332.11*

Cardoon (Cynara Cardunculus) is a less demanding and cheap to grow crop mainly due to its long rooting system, which is capable of providing the needed water and other nutrients which are essential for the plant's growth. Half its total cost is the cost of land (land rent) and the major item of the remaining annual expense is its harvesting cost, equal to 100 euros per hectare. Its total annuitised cost is 332 euros per ha. Minimum selling prices for maintenance of profitability for the three cases that have been examined (AH, AL, ML) are respectively 21, 23 and 25 euros per tonne, or break even sales of 385, 332 and 328 euros/ha.

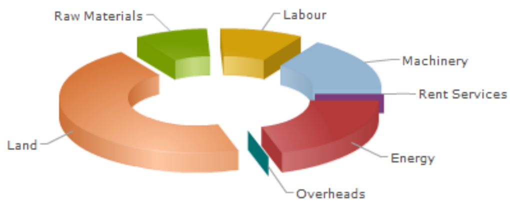
The case studies that have been examined in this project in the South of Spain have shown that the cultivation can be profitable for selling prices of 30 euros per tonne and above.

REED CANARY GRASS in Sweden in Nemoral zone planted in Agricultural land with Low Level of Inputs.

RCG Sweden NEM AL (10 yrs)

Country/Region: Sweden
Annual yield: 11.4 ton
Economic life: 10 yr
Selling Price: 50 €/ton

Sales: 570.00 €/ha
Cost: **280.67** €/ha
Profit: 289.33 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			127.9					*127.90*
Fertilization	1.64	2.75		3.12		14.01		*21.52*
Harvesting	46.12	20.26		37.5				*103.88*
Sowing	0.43	0.41		0.82		5.86		*7.52*
Spraying	0.37	0.62		0.69		4.07		*5.75*
Tillage	8.02	3.3		2.76				*14.08*
TOTAL (€/ha)	56.58	27.34	127.90	44.89		23.94		*280.65*

The financial viability of Reed Canary grass has been examined in Sweden in the Nemoral climatic region. Reed Canary Grass is traditionally used as forage and sometimes as ornamental plant. Its use as biomass for energy is new. It is today studied in several projects.

The productivity of the crop ranges between 10 and 14 t/ha depending on the case, and at 50 euros per tonne, sales also range between 500 and 700 euros per ha.

Reed canary grass in Sweden is probably the least cost grass, even cheaper than cardoon in the South of Spain. It practically needs no more than some minimal fertilisation and spraying. On the other hand the high selling price secures satisfactory profits for the grower both per tonne of product and per hectare of cultivated land.

Cultivation on different Land types with different inputs level

Based on the project's database, we have tested the cultivation of all crops in three different land types and input levels (AH= Agricultural land with high level of inputs, AL= Agricultural land with low level of inputs, and ML= Marginal land with low level of inputs). The use of more fertile agricultural lands and higher agricultural inputs result naturally in higher yields, but it is interesting to investigate whether the revenues from additional yields are paying for the extra cost of land rent and inputs.

As it is shown in the table below, in all cases, the choice of Marginal land- Low input (ML) gives lowest profitability, while in most cases cultivating in Agricultural land- High input (AH) is clearly the choice of preference. However, in many situations agricultural land may be used for essential food products and its availability may be constrained. Demand for fertile lands for the production of biomass may also push land prices up, putting pressure on food products, as it has already been observed several times in the last two decades. On the other hand, the main benefits of perennial grasses are based (a) on their environmental friendliness (sown only once in 10-20 years, small amounts of fertilizers, and other chemicals, etc), (b) no interference in the food chains with the use of available surplus land (marginal land) and (c) the little attention and human involvement they need. Therefore it seems that we are still in a period when some support is still required to maintain and establish new bioenergy chains based on perennial grasses.

Selling prices are based on observed actual prices that have been paid in the past, which are however distorted by whatever existing subsidies along the bioenergy chains. They also relate to the energy value of the biomass product and its behaviour in further treatment and use (e.g. cynara cardunculus was found difficult to burn without lots of ash melting, etc.).

The Profitability and selling prices for each of the biomass products of the crops under evaluation are shown in the following table.

Table of Profits

PROFIT VARIATION of CULTIVATION on DIFFERENT LANDS

				AH	AL	ML	Selling price
Miscanthus	Netherlands	ATC	*(EUR/t)*	4	3	-15	*50*
			(EUR/ha)	110	77	-273	
		ATN	*(EUR/t)*	-29	-45	-73	*50*
			(EUR/ha)	-446	-558	-693	
	Romania	CON	*(EUR/t)*	9	7	5	*40*
			(EUR/ha)	242	173	111	
	UK	ATC	*(EUR/t)*	10	10	-4	*50*
			(EUR/ha)	265	252	-83	
		ATN	*(EUR/t)*	-18	-27	-57	*50*
			(EUR/ha)	-275	-341	-535	
Switchgrass	Netherlands	ATC	*(EUR/t)*	-1	-4	-20	*50*
			(EUR/ha)	-11	-45	-183	
		ATN	*(EUR/t)*	-8	-14	-51	*50*
			(EUR/ha)	-105	-140	-318	
	UK	ATC	*(EUR/t)*	15	16	3	*50*
			(EUR/ha)	222	189	28	
		ATN	*(EUR/t)*	10	9	-17	*50*
			(EUR/ha)	128	97	-107	
Arundo Donax	Portugal	MDN	*(EUR/t)*	10	9	4	*30*
			(EUR/ha)	552	400	139	
Cardoon	Spain	MDS	*(EUR/t)*	9	7	5	*30*
			(EUR/ha)	162	94	73	
Reed Canarygrass	Sweden	NEM	*(EUR/t)*	26	25	23	*50*
			(EUR/ha)	359	289	237	

AH= Agricultural Land, High inputs
AL= Agricultural Land, Low inputs
ML= Marginal Land, Low inputs

ATC= Atlantic Central climatic zone
ATN= Atlantic North climatic zone
CON= Continental climatic zone
NEM= Nemoral climatic zone
MDN= Mediterranean North

PART VI – OTHER CROPS

Several other crops have been analysed in order to examine their cost effectiveness and profitability.

Hemp and Flax are fibre crops of interest although their economic significance is rather doubtful in many European regions, especially in the case of flax.

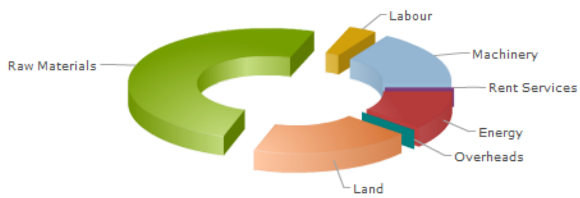
FLAX

FLAX in Poland in Continental zone planted in Agricultural Land with Low Level of Inputs.

Flax Poland CON AL

Country/Region: Poland
Annual yield: 5 ton
Economic life: 1 yr
Selling Price: 200 €/ton

Sales: 1000.00 €/ha
Cost: **667.80** €/ha
Profit: 332.20 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			125					*125.00*
Fertilization	4.45	2.14		10.05		111		*127.64*
Harvesting	24.16	9.18		56.26				*89.60*
Sowing	2.23	0.61		5.03		187.5		*195.37*
Spraying	1.91	0.92		4.19		39.72		*46.74*
Tillage	42.51	9.18		31.74				*83.43*
TOTAL (€/ha)	75.26	22.03	125.00	107.27		338.22		*667.78*

Fibre flax has two main products: long and short fibre which account for over 80% of the revenue, but less than 1/3 of the total production mix (in volume), which includes shives[13] and seeds.

However, although the above weighted average selling price corresponds to fibre and all other by-products, the above cost analysis does not include the cost of extraction of fibre. This cost in the case of Poland is almost 600 euros/ha which counterbalances the above recorded profits (322 euros/ha). The loss is partly recovered by the sales of by-products such as shives and seeds, but this does not change the picture much.

[13] Data communicated from the Institute of Natural Fibres, Poznan, PL, project partner.

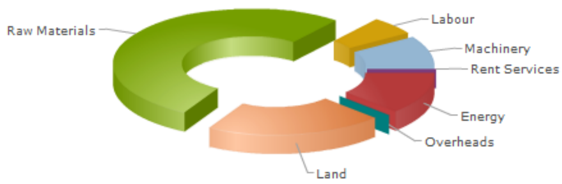
The cultivation of Flax in Poland is not favoured by local farmers much, because of its overall low economic performance.

FLAX in France in Atlantic Central zone planted in Agricultural Land with Low Level of Inputs.

Flax France ATC AL

Country/Region: France
Annual yield: 4 ton
Economic life: 1 yr
Selling Price: 200 €/ton

Sales: 800.00 €/ha
Cost: **661.12** €/ha
Profit: 138.88 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			137					*137.00*
Fertilization	4.87	6.66		10.05		119.9		*141.48*
Harvesting	26.44	9.52		23.43				*59.39*
Sowing	2.44	1.9		5.03		187.5		*196.87*
Spraying	2.09	2.86		4.19		39.72		*48.86*
Tillage	45.36	15.23		16.93				*77.52*
TOTAL (€/ha)	81.20	36.17	137.00	59.63		347.12		*661.12*

France is one of the major producers of flax worldwide. Flax yield, including various by-products is higher than other examined regions. As a result there is some moderate profitability (at product mix selling price) for the farmer.

Flax is moderately profitable in France with its best when planted in good agricultural land with high level of inputs. Its profitability is shown in the following table.

Flax profitability in France

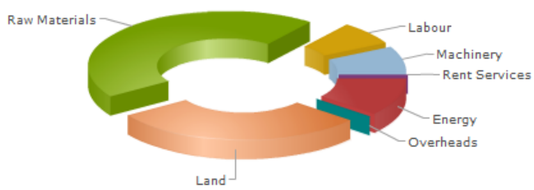
	Euros/tonne	Euros/ha
Agricultural land with high inputs	70	419
Agricultural land with Low inputs	35	139
Marginal Land with low inputs	-100	-239

FLAX in Italy in Mediterranean South zone planted in Agricultural Land with Low Level of Inputs.

Flax Italy MDS AL

Country/Region: Italy
Annual yield: 3.5 ton
Economic life: 1 yr
Selling Price: 200 €/ton

Sales: 700.00 €/ha
Cost: **778.19** €/ha
Profit: -78.19 €/ha
Subidies:



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			232					*232.00*
Fertilization	5.12	10.07		10.05		119.3		*144.54*
Harvesting	27.82	14.38		23.43				*65.63*
Sowing	2.56	2.88		5.03		187.5		*197.97*
Spraying	2.2	4.31		4.19		39.72		*50.42*
Tillage	47.7	23.01		16.93				*87.64*
TOTAL (€/ha)	85.40	54.65	232.00	59.63		346.52		*778.20*

Flax is not as productive in South Mediterranean regions and as a result its economic performance is not satisfactory. Even under cultivation with high inputs (AH) it is expected to underperform.

The following table is directly comparable with the one for France above.

Flax profitability in Italy

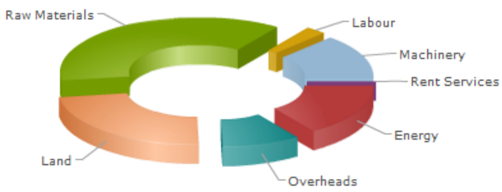
	Euros/tonne	Euros/ha
Agricultural land with high inputs	-10	-42
Agricultural land with Low inputs	-22	-78
Marginal Land with low inputs	-51	-158

HEMP

Hemp in Poland in Continental zone planted in Agricultural Land with Low Level of Inputs.

Hemp Poland CON AL

Country/Region:	Poland
Annual yield:	7 ton
Economic life:	1 yr
Selling Price:	120 €/ton
Sales:	840.00 €/ha
Cost:	**541.59** €/ha
Profit:	298.41 €/ha
Subidies:	



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			125					*125.00*
(Overheads)					50			*50.00*
Fertilization	4.45	2.14		10.05		40.4		*57.04*
Harvesting	24.16	3.06		23.43				*50.65*
Mechanical Weed Control	5.83	1.53		12.53				*19.89*
Sowing	2.23	0.61		5.03		160		*167.87*
Tillage	46.64	5.51		18.99				*71.14*
TOTAL (€/ha)	83.31	12.85	125.00	70.03	50.00	200.40		*541.59*

The cultivation of Hemp in Poland is more promising than the cultivation of Flax. Hemp is pretty profitable if grown on agricultural land with its best when supplied with high level of inputs when its yield reaches 9 tonnes per hectare and the corresponding profit as high as 471 euros/ha or 52 euros per tonne.

Raw materials and land rent are dominating the cost list, together accounting for over 50% of total annual cost.

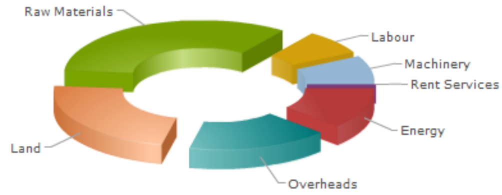
Hemp is producing a large number of products other than the fibre which naturally is the most valuable product and therefore their value is added.

Communications with the Institute of Natural Fibres in Poznan, Poland¸ verifies the above results.

Hemp in the UK in Atlantic North zone planted in Agricultural Land with Low Level of Inputs.

Hemp UK ATN AL

Country/Region:	United Kingdom
Annual yield:	7.5 ton
Economic life:	1 yr
Selling Price:	185 €/ton
Sales:	1387.50 €/ha
Cost:	**904.65** €/ha
Profit:	482.85 €/ha
Subidies:	



TOTAL ANNUAL EQUIVALENT COSTS INCLUDING INITIAL INVESTMENT(€/ha)

Operations	Energy	Labour	Land	Machinery	Overheads	Raw Materials	Rented Services	Total
(Land Rent)			208					*208.00*
(Overheads)					150			*150.00*
Fertilization	5.75	10.09		10.05		142.6		*168.49*
Harvesting	31.24	14.42		23.43				*69.09*
Mechanical Weed Control	7.53	12.98		12.53				*33.04*
Sowing	2.88	2.88		5.03		160		*170.79*
Tillage	60.28	25.96		18.99				*105.23*
TOTAL (€/ha)	107.68	66.33	208.00	70.03	150.00	302.60		*904.64*

Hemp is cultivated in the UK in small quantities. Today there are about 2,500 ha being cultivated under contract. Hemp has many uses as a fibre crop, but also as horse bed, production of furniture materials, and many other uses.

Land and raw materials are the major cost items. It is planted with seeds which are not too expensive and therefore sowing is not a significant expense. Overheads represent the cost to transport it to the nearest facility for treatment.

At a production level of 7.5 t/ha and selling price of 185 euros/t, hemp is sufficiently profitable to attract the attention of the farmers who cultivate it. (See also J. Nix, 2010)

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PART VII - ANNEXES

Annex 1. Operations, Machinery and Raw materials

Durum Wheat

Operation	Machinery Used	Raw Materials Used
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Harrowing	Disk harrow	
Basic Fertilisation	Fertilizer distributor	250 Kg/ha Fertilizer 20-10-10
Sowing	Grains seeder	50 kg/ha Seeds
Weed Control	Sprayer	1 l/ha 2.4D
Harvesting	Combine Harvester	

Barley

Operation	Machinery Used	Raw Materials Used
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Harrowing	Disk harrow	
Basic Fertilisation	Fertilizer distributor	250 Kg/ha Fertilizer 20-10-10
Sowing	Grains seeder	45 kg/ha Seeds
Weed Control	Sprayer	1 l/ha 2.4D
Harvesting	Combine Harvester	

Maize

Operation	Machinery Used	Raw Materials Used
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Harrowing	Disk harrow	
Basic Fertilisation	Fertilizer distributor	500 Kg/ha Fertilizer 20-10-10
Sowing	Maize seeder	27.3 kg/ha Seeds (70.000 plants/ha)
Weed Control	Sprayer	Bamvel 0.6 l/ha
Fertilisation	Fertilizer distributor	250 Kg/ha Ammonium nitrate (33% N)
Irrigation	Travelling Gun	Depending on regional climatic conditions
Weed Control	Sprayer	1 l/ha 2.4D
Harvesting	Combine Harvester	

Sunflower

Operation	Machinery Used	Raw Materials Used
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Weed Control	Sprayer	2 l/ha Trifluralin (Treflan)
Basic Fertilisation	Fertilizer distributor	250 Kg/ha Fertilizer 20-10-10
Sowing	Grains seeder	3,5 kg/ha Seeds
Mechanical Weed Control	Hoe	
Harvesting	Combine Harvester	

Rapeseed

Operation	Machinery Used	Raw Materials Used
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Weed Control	Sprayer	2 l/ha Trifluralin (Treflan)
Basic Fertilisation	Fertilizer distributor	250 Kg/ha Fertilizer 11-15-15
Sowing	Grains seeder	5 kg/ha Seeds
Fertilisation	Fertilizer distributor	250 Kg/ha Ammonium nitrate (33% N)
Mechanical Weed Control	Hoe	
Harvesting	Combine Harvester	

Alfalfa

Establishment Operations	Machinery Used	Raw Materials Used
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Harrowing	Disk harrow	
Basic Fertilisation	Fertilizer distributor	500 Kg/ha Fertilizer 11-15-15
Weed Control	Sprayer	Roundup 10l/ha
Harrowing	Disk harrow	
Sowing	Alfalfa seeder	20 kg/ha Seeds
Irrigation	Travelling Gun	Depending on regional climatic conditions
3x Pesticiding	Talstar	0,12 l/ha
4x Harvesting and Baling	Cutter and Round Baler	
Annual Operations	**Machinery Used**	**Raw Materials Used**
Irrigation	Travelling Gun	Depending on regional climatic conditions
3x Pesticiding	Talstar	0,12 l/ha
4x Harvesting and Baling	Self propelled Cutter+Round Baler	

Sugarbeets

Operations	Machinery Used	Raw Materials Used
Subsoil Tilling	Ripper	
Ploughing	Plough	
Cultivator	Medium Scale Cultivator	
Basic Fertilisation	Fertilizer distributor	750 Kg/ha Fertilizer 11-15-15
Harrowing	Disk harrow	
Seeding	Seeder	Seeds 1.35 U/ha
Fertilisation	Fertilizer distributor	250 Kg/ha Fertilizer 20-10-10
Hoeing	Hoe (simple)	
Hoeing	Hoe (simple)	
Weed and Pest Control (x10)	Sprayer	Agrochemicals

Annex 2. Data bases and Sources of Info

Machinery data base

Machinery	Purchase Cost (€) net of VAT	Economic Life (yrs)	Maintenance (€/yr)	Insurance (€/yr)	Average Annual Operation (hrs)	Fuel
Baler (Round)	25.000	20	100		200	
Cultivator (medium scale)	1.500	12			150	
Cutter - Alfalfa (sp)	59.000	20	1.000	200	400	diesel
Cutter (sp)	25.000	20	500	100	400	diesel
Cutter double	1.800	15			200	
Cutter simple	1.500	15			200	
Diesel pump	6.000	30	100		150	diesel
Diskharrow	1.300	12			100	
Fertilizer distributor	800	12			50	
Hoe monosem	5.500	15			150	
Hoe simple	2.500	15			150	
Leverer	1.000	15			70	
Plough	2.000	15			300	
Seeder – Alfalfa	9.000	20			150	
Seeder – Cotton	18.000	20			100	
Seeder – Grains	5.000	15			50	
Seeder – Maize	13.000	15			100	
Sillage Harvester	200.000	20	6.000	500	800	diesel
Sprayer	1.500	15			100	
Sub-How	1.400	15			300	
Ripper	1.300	10			100	
Tractor 100hp	53.000	25	1.500	170	800	diesel
Tractor 105hp	60.000	25	1.500	180	800	diesel
Tractor 110hp	80.000	25	1.800	200	500	diesel
Tractor 130hp	85.000	25	3.000	250	500	diesel
Tractor 50hp	25.000	25	500	150	300	diesel
Tractor 70hp	35.000	25	800	150	400	diesel
Tractor 80hp	40.000	25	800	160	400	diesel
Tractor 85hp	42.000	25	800	170	400	diesel
Tractor 95hp	45.000	25	1.500	170	800	diesel
Tractor pump	1.000	20			200	
Traveling gun	12.000	15			1000	
Cereals Combine Harvester	220.000	20	6000	500	1000	diesel
Lorry 10t	65.000	10	2000	1500	1500	diesel

Source: Greek market (2006 prices)

Raw Materials data base

	Price 2006	Source
2,4D	7 €/l	1
Weed seed	400 €/t	1
Maize seed	7,8 €/kg	1
Ammonium nitrate (33% N)	548 €/t	2
Urea	564 €/t	2
Rapeseed	9 €/Kg	1
Fertilizer 11-15-15	340 €/t	1
Fertilizer 20-10-10	323 €/t	2
Sulphuric Ammonia	240 €/t	1
Trifluralin	5 €/l	1
Sunflower Seeds	12 €/Kg	1
Fertilizer 22-11-0	266 €/t	1
Trifluralin	5 €/l	1

Sources: 1. Greek market (2006 prices), 2. Eurostat

Land Rent

EU Countries	Irrigated (€/ha)	Non-Irrigated (€/ha)	Year	Source
France	129,70	129,70	2006	Eurostat
Germany		197,00	2005	Eurostat
Greece	500,00	200,00	2006	V. Lychnaras - AUA data
Italy	450,00	300,00	2009	A. Monti, UNIBO data
Poland	61,70	61,70	2009	Ewa Ganko - EC BREC data
Portugal	143-454 average 299	17-156; average 95	2008	Ana Luisa Fernando-UniNOVA
Romania	100,00	100,00		Estimation
Spain	482,00	106,00	2009	INIA data
Sweden		109,90	2006	Eurostat
The Netherlands		639,00	2009	Wolter Elbersen - A&F data
UK		175,80	2006	Eurostat

Labour cost (skilled)

EU Countries	€/hr	Year	Source
France	13,70	2006	Previous Research
Germany	10,94	2006	Eurostat
Greece	7,10	2006	V. Lychnaras - AUA data

Italy	15,00	2009	A. Monti, UNIBO data
Poland	5,10	2009	Ewa Ganko - EC BREC data
Portugal	4,25	2008	Ana Luisa Fernando - UniNOVA data
Romania	3,00		Estimation
Spain	12,00	2009	INIA data
Sweden	13,00		Estimation
The Netherlands	12,00	2009	Wolter Elbersen - A&F data
UK	12,04	2006	Eurostat

Diesel price (2009)

EU Countries	€/l
France	1,03
Germany	1,04
Greece	1,09
Italy	1,29
Poland	0,94
Portugal	1,11
Romania	0,94
Spain	1,00
Sweden	1,20
The Netherlands	1,12
UK	1,29

Source: http://gasoline-germany.com/

Cost of water

EU Countries	€/m3	€/ha	Source – Notes
France	0,11	-	Rieu, T., 2005. "Water pricing for agriculture between cost recovery and water conservation: Where do we stand in France?", OECD Workshop on Agriculture and Water: Sustainability, Market and Policies, 14-18 November 2006, South Australia.
Germany	-	-	*Arable crops are non-irrigated*
Greece	-	100,00	AUA data (Central Greece)
Italy	0,15	-	A. Monti, UNIBO data
Poland	-	-	*Non-irrigated*
Portugal	0.0030-0.0404	31.5-115	Ana Luisa Fernando - UniNOVA data
Romania			
Spain	0,06		INIA data
Sweden	-	-	*Non-irrigated*
The Netherlands	-	-	*Non-irrigated*
UK	-	-	*Non-irrigated*

Annex 3. Yields (t/ha)

D. Wheat

Country	Yield (t/ha)	Source
France	6,8	FAO (average 2003-2007)
Germany	7,3	FAO (average 2003-2007)
Greece	2,3	FAO (average 2003-2007)
Italy	4,7	A. Monti, UNIBO data
Poland	3,8	Ewa Ganko - EC BREC data
Portugal	2,2	Ana Luisa Fernando - UniNOVA data
Romania	2,6	FAO (average 2003-2007)
Spain	2,4	INIA data
Sweden	5,9	FAO (average 2003-2007)
The Netherlands	8,3	Wolter Elbersen - A&F data
UK	7,8	FAO (average 2003-2007)

Barley

Country	Yield (t/ha)	Source
France	6,1	FAO (average 2003-2007)
Germany	5,8	FAO (average 2003-2007)
Greece	2,4	FAO (average 2003-2007)
Italy	4,0	A. Monti, UNIBO data
Poland	3,1	Ewa Ganko - EC BREC data
Portugal	1,0	Ana Luisa Fernando - UniNOVA data
Romania	2,3	FAO (average 2003-2007)
Spain	2,2	INIA data
Sweden	4,2	FAO (average 2003-2007)
The Netherlands	6,1	Wolter Elbersen - A&F data
UK	5,9	FAO (average 2003-2007)

Maize

Country	Yield (t/ha)	Source
France	8,4	FAO (average 2003-2007)
Germany	8,6	FAO (average 2003-2007)
Greece	10,0	FAO (average 2003-2007)
Italy	7,0	A. Monti, UNIBO data
Poland	5,7	Ewa Ganko - EC BREC data
Portugal	7,0	Ana Luisa Fernando - UniNOVA data
Romania	3,5	FAO (average 2003-2007)
Spain	9,7	FAO (average 2003-2007)
Sweden	-	
The Netherlands	11,3	Wolter Elbersen - A&F data
UK	-	

Rapeseed

Country	Yield (t/ha)	Source
France	3,2	FAO (average 2003-2007)
Germany	3,6	FAO (average 2003-2007)
Greece	1,7	FAO (average 2003-2007)
Italy	1,8	A. Monti, UNIBO data
Poland	2,6	Ewa Ganko - EC BREC data
Portugal	-	
Romania	1,3	FAO (average 2003-2007)
Spain	1,7	FAO (average 2003-2007)
Sweden	2,5	FAO (average 2003-2007)
The Netherlands	3,7	FAO (average 2003-2007)
UK	3,1	FAO (average 2003-2007)

Sunflower

Country	Yield (t/ha)	Source

France	2,3	FAO (average 2003-2007)
Germany	2,2	FAO (average 2003-2007)
Greece	1,5	FAO (average 2003-2007)
Italy	2,0	FAO (average 2003-2007)
Poland	1,5	FAO (average 2003-2007)
Portugal	0,6	FAO (average 2003-2007)
Romania	1,3	FAO (average 2003-2007)
Spain	0,9	INIA
Sweden	-	
The Netherlands	-	
UK	-	

Sugar beet

Country	Yield (t/ha)	Source
France	79,3	FAO (average 2003-2007)
Germany	59,5	FAO (average 2003-2007)
Greece	59,9	FAO (average 2003-2007)
Italy	47,2	FAO (average 2003-2007)
Poland	44,1	Ewa Ganko - EC BREC data
Portugal	71,8	FAO (average 2003-2007)
Romania	26,8	FAO (average 2003-2007)
Spain	68,8	FAO (average 2003-2007)
Sweden	48,9	FAO (average 2003-2007)
The Netherlands	63,8	Wolter Elbersen - A&F data
UK	56,6	FAO (average 2003-2007)

Alfalfa

Country	Yield (t/ha)	Source
France	-	
Germany	-	
Greece	14,5	V. Lychnaras - AUA data
Italy	14,0	A. Monti, UNIBO data
Poland	-	
Portugal	-	
Romania	14,0	Estimation
Spain	-	
Sweden	-	
The Netherlands	-	
UK	-	

Annex 4. Cost Analysis per hectare

Wheat (non-irrigated)

Wheat cost of production (€/ha)

EUR / ha	France	Germany	Greece	Italy	Poland	Portugal	Romania	Spain	Sweden	UK	Netherlands
Yield (t/ha)	**6,8**	**7,3**	**2,29**	**4,7**	**3,8**	**2,2**	**2,6**	**2,35**	**5,9**	**7,8**	**8,7**
SELLING PRICE (eur/t)	**103**	**109**	**140**	**160**	**106**	**132**	**126**	**140**	**104**	**117**	**97**
Energy	110	111	107	137	81	118	100	107	128	137	119
Labour	120	96	62	131	38	39	26	105	114	105	105
Land	130	197	200	300	62	95	100	106	110	175	639
Machinery	135	135	135	135	95	135	135	135	135	135	135
Overheads	30	30	30	30	30	30	30	30	30	30	30
Raw Materials	108	108	108	108	108	108	108	108	108	108	108
Rented Services					86						
Grand Total	**632**	**676**	**642**	**842**	**500**	**525**	**499**	**590**	**624**	**691**	**1136**
Land % on TOT	**21%**	**29%**	**31%**	**36%**	**12%**	**18%**	**20%**	**18%**	**18%**	**25%**	**56%**
Profits (€/ha)	68	119	-321	-90	-97	-235	-172	-261	-11	222	-292
Profits (€/ha) – Land	198	316	-121	210	-35	-140	-72	-155	110	397	347

Notes

- D. Wheat production in Greece, Portugal Romania and Spain is at reasonable cost levels. Nevertheless, the low average yield is the main reason for negative profits.
- For Italy and the Netherlands, the main cost item is the high land rent which increases the final cost of production.
- Positive profits only for UK, Germany and France.
- Positive profits for Italy, Sweden and The Netherlands when land rent is excluded.
- The yield is very high in The Netherlands, UK, Germany and France.
- The highest labour cost in Italy.
- High energy cost for Italy, UK and Sweden.

- The highest land rent for The Netherlands.
- Poland, Portugal and Romania have the lowest labour cost and land rent that leads to the lowest cost of productions.
- Harvesting is usually subcontracted in Poland. The cost is higher.

Barley (non-irrigated)

Barley cost of production (€/ha)

EUR / ha	France	Germany	Greece	Italy	Poland	Portugal	Romania	Spain	Sweden	UK	Netherlands
Yield (t/ha)	**6,1**	**5,82**	**2,39**	**4**	**3,1**	**1**	**2,3**	**2,15**	**4,15**	**5,85**	**6,7**
SELLING PRICE (eur/t)	**99**	**97**	**145**	**130**	**106**	**135**	**130**	**125**	**93**	**101**	**90**
Energy	110	111	107	137	81	118	100	107	128	137	119
Labour	120	96	62	131	38	39	26	105	114	105	105
Land	130	197	200	300	62	95	100	106	110	175	639
Machinery	135	135	135	135	95	135	135	135	135	135	135
Overheads	30	30	30	30	30	30	30	30	30	30	30
Raw Materials	106	106	106	106	106	106	106	106	106	106	106
Rented Services					86						
Grand Total	**630**	**674**	**640**	**840**	**498**	**523**	**497**	**588**	**622**	**689**	**1134**
Land % on TOT	**21%**	**29%**	**31%**	**36%**	**12%**	**18%**	**20%**	**18%**	**18%**	**25%**	**56%**
Profits (€/ha)	-27	-110	-293	-320	-169	-388	-198	-320	-237	-98	-531
Profits (€/ha) – Land	103	87	-93	-20	-107	-293	-98	-214	-127	77	108

Notes

- Barley production in Greece, Portugal Romania and Spain is at reasonable cost levels per ha. Nevertheless, low yields are the cause negative profits.
- For Italy and Netherlands, the main problem is the high cost for land the increases the final cost of production.
- Sweden has negative profits because many of the cost parameters are in higher levels compared to the other countries.
- Positive profits for France, Germany, UK and The Netherlands when the land rent is excluded.
- High productivity in France, Germany, UK and The Netherlands.
- The highest labour cost in Italy.
- High energy cost for Italy, UK and Sweden.
- The highest land rent for The Netherlands.
- Poland, Portugal and Romania have the lowest labour cost and land rent that leads to the lowest cost of productions.

- Harvesting is usually subcontracted in Poland. The cost is higher.

Maize

Maize cost of production (€/ha)

EUR / ha	France	Germany	Greece	Italy	Poland	Portugal	Romania	Netherlands
Yield (t/ha)	**8,35**	**8,56**	**10,03**	**7**	**5,7**	**7**	**3,5**	**8,1**
SELLING PRICE (eur/t)	**112**	**118**	**144**	**135**	**100**	**145**	**135**	**86**
Energy	123	115	127	154	86	149	104	124
Labour	178	104	124	203	43	117	29	114
Land	130	197	500	450	62	300	100	639
Machinery	206	151	262	206	118	318	151	151
Overheads	30	30	130	30	30	103	30	30
Raw Materials	764	544	544	844	544	940	544	544
Rented Services					92			
Grand Total	**1431**	**1141**	**1687**	**1886**	**975**	**1926**	**957**	**1602**
Land % on TOT	**9%**	**17%**	**30%**	**24%**	**6%**	**16%**	**10%**	**40%**
Profits (€/ha)	-496	-131	-243	-941	-405	-911	-485	-905
Profits (€/ha) – Land	-366	66	258	-491	-343	-611	-385	-266

Notes

- Maize was considered irrigated in France, Greece, Italy and Portugal and not irrigated for the rest.
- France, Italy and Portugal have increased cost of raw materials because water cost is included.
- For Greece, Italy and Portugal increased irrigated land rent is also considered.
- In Greece, the land rent for irrigated land is 2.5 times higher than the one for not irrigated.
- In Portugal, the irrigated land rent is 3 times higher than the non-irrigated land rent.
- In Greece the water cost is not included in raw materials. It is paid as an annual fee per hectare.
- For Portugal there is a €/m^3 charge of water and an additional irrigation fee per hectare.
- For Poland and Romania the low yields are the main reason for economic losses
- The land rent in the Netherlands is the highest.
- Positive profits only for Greece and Germany when the land rent is excluded.
- High yield in Greece, Germany, France and The Netherlands
- The highest labour and energy cost for Italy
- Harvesting is usually subcontracted in Poland. The cost is higher.

Rapeseed (non-irrigated)

Rapeseed cost of production (€/ha)

EUR / ha	France	Germany	Poland	Romania	Sweden	UK
Yield (t/ha)	**3,2**	**3,58**	**2,6**	**1,3**	**2,5**	**3,15**
SELLING PRICE (eur/t)	**218**	**224**	**215**	**185**	**211**	**224**
Energy	112	113	84	102	131	141
Labour	127	101	41	28	120	111
Land	130	197	62	100	110	175
Machinery	143	143	102	143	143	143
Overheads	30	30	30	30	30	30
Raw Materials	277	277	277	277	277	277
Rented Services			103			
Grand Total	**819**	**861**	**698**	**680**	**811**	**877**
Land % on TOT	**16%**	**23%**	**9%**	**15%**	**14%**	**20%**
Profits (€/ha)	-121	-59	-139	-439	-283	-171
Profits (€/ha) – Land	9	138	-77	-339	-173	4

Notes

- Rapeseed production in Poland and Romania is at reasonable cost levels. Nevertheless, the low average yield is the main cause of negative profits, (see eg. Romania).
- For Sweden also the main problem is the low yield.
- Positive profits for France, Germany and UK, when the cost of land is not considered.
- High average yield in France, Germany and UK.
- Harvesting is usually subcontracted in Poland. The cost is higher.

Sunflower (non-irrigated)

Sunflower cost of production (€/ha)

EUR / ha	France	Romania	Spain
Yield (t/ha)	**2,3**	**1,35**	**0,85**
SELLING PRICE (eur/t)	**226**	**195**	**235**
Labour	120	26	105
Land	130	100	106
Machinery	135	135	135
Overheads	30	30	30
Raw Materials	151	151	151
Grand Total	**675**	**542**	**633**
Land % on TOT	**19%**	**18%**	**17%**
Profits (€/ha)	-155	-278	-433
Profits (€/ha) – Land	-25	-178	-327

Notes

- All countries have reasonable cost levels.
- In Romania and Spain the yield is very low.
- In Spain there is the lowest yield, because of the dry conditions.
- High average yield and selling price in France.

Sugar beets (non-irrigated)

Sugar beets cost of production (€/ha)

EUR / ha	Germany	Poland	Sweden	Netherlands
Yield (t/ha)	**51,5**	**44,1**	**48,9**	**63,8**
SELLING PRICE (eur/t)	**41**	**35**	**43**	**47**
Energy	185	175	201	193
Labour	79	81	215	202
Land	197	78	110	639
Machinery	274	274	274	274
Overheads	30	30	30	30
Raw Materials	516	525	525	525
Rented Services	300	292	300	322
Grand Total	**1581**	**1456**	**1656**	**2186**
Land % on TOT	**12%**	**5%**	**7%**	**29%**
Profits (€/ha)	530	88	447	813
Profits (€/ha) - Land	727	166	557	1452

Notes

- For all countries the high yield and selling price are the cause of positive profits.
- For The Netherlands the results show the highest cost because of the high land rent and the highest profits because of the high average yield and selling price.
- Harvesting was considered as rented operation for all countries.

Alfalfa (irrigated) – 3 yrs economic life

Alfalfa annual equivalent cost of production (€/ha)

EUR / ha	Italy	Romania
Yield (t/ha)	**14**	**14**
SELLING PRICE (eur/t)	**120**	**120**
Energy	93	76
Labour	181	93
Land	450	100
Machinery	196	232
Overheads	25	25
Raw Materials	355	557
Grand Total	**1300**	**1083**
Land % on TOT	**35%**	**9%**
Profits (€/ha)	380	597
Profits (€/ha) - Land	830	697

Notes

- Alfalfa has an average life of 3 years with low inputs for the 2nd and 3rd year. This decreases its annual equivalent cost.
- Both the yield and the price are high enough to cover the cost.
- For Italy the irrigated land rent is very high and equals 35% of total cost.
- For Romania the raw materials is the highest cost item (baling net included).

Annex 5. Definitions

Agricultural area

Agricultural area is the sum of areas under (a) arable land - land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for *arable land* are not meant to indicate the amount of land that is potentially cultivable; (b) permanent crops - land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers, such as roses and jasmine; and nurseries (except those for forest trees, which should be classified under "forest"); and (c) permanent meadows and pastures - land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

Arable land

Arable land is the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for “Arable land” are not meant to indicate the amount of land that is potentially cultivable. Data are expressed in 1000 hectares.

Fallow land

Fallow land (temporary) is the cultivated land that is not seeded for one or more growing seasons. The maximum idle period is usually less than five years.
Land remaining fallow for two long may acquire characteristics requiring to be reclassified, such as "permanent meadows and pastures" (if used for grazing), "forest or wooded land" (if overgrown with trees), or "other land" (if it becomes wasteland). Data are expressed in 1000 hectares.

Source: *FAO Statistics Division*

Annex 6. Costing Methodology in brief

The analysis of costs identifies and distinguishes the significant from the unimportant in agricultural production and by doing so it reveals threats and opportunities in production and sales. In agriculture, where production is in many cases undertaken by small family holdings, there is some persistence in reporting *paid expenses*, which are easily identifiable and understood, and failing to identify the magnitude of imputed expenses or *opportunity costs*, such as the cost of own land or family labour and the like. This practice may estimate farm or family income, return to land, etc., but it hides the full cost of the business and hinders the attempts to improve efficiency.

The *costing methodology* adopted in this project, aims at the identification and classification of all costs incurred during the production of agricultural crops. It breaks down agricultural production into operations or activities. Each operation has needs, i.e. labour, machinery, raw materials, energy, water, etc. some operations may be rented (e.g. harvesting) or carried out by own means. The methodology applies to both annual and perennial crops, where operations and needs may vary from year to year. Expenses and other charges that may not easily be allocated to operations, appear under the heading of *overheads*.

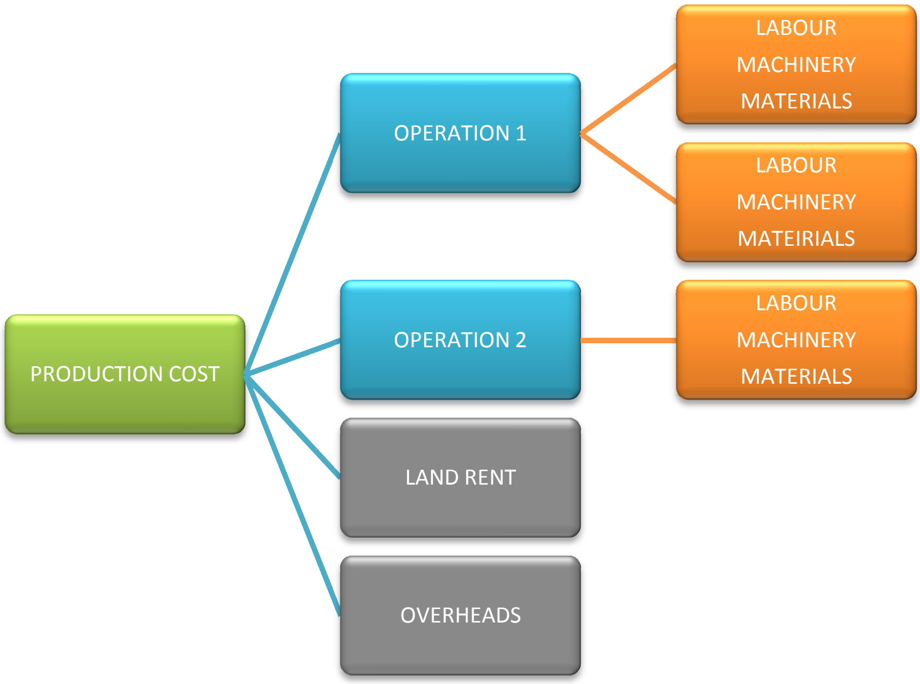
The *cost of land* is strongly related to the expected revenues and profits from the agricultural operation. In most cases land rents in Europe are determined by the market and are also related to land availability and potential for high yields. In south Europe for example, irrigated land in much more expensive then dry or marginal land. There is also a crop rotation issue which arises from the fact that, even in cases of a constant land rent in money terms, set aside or necessary crop rotations require some rent normalisation in order to take into account compulsory changes in plantations. For example, if the cultivation plan requires one year of set aside after every five years of crop cultivation, it means that the rent of the sixth year should be suitably allocated to the five years of continuous production.

The *cost of machinery* and other investments is first annualised by means of appropriate discount rate. Then, it is allocated to operations in each year of the production according to the machine-hours needed. This takes into account *depreciation* and interest on fixed assets. Machinery depreciation is based on expected economic life of the equipment. Alternatively it could be based on total operating hours during the life time of the machine. Investments in buildings and constructions (fences, roads, etc.) may have different life times.

The *timing* of income and expenses is important for capital budgeting decisions. Therefore, the annual equivalent methods (DCF) followed in this analysis take into account the time value of money.

Production costs differ from region to region and from country to country, because of soil-climatic-yield reasons and because of different prices and practices applicable in each country. Some of the most important cost items which have different values in different countries are *Yields, Land Rent, Labour Cost, Irrigation Needs,* and the *Cost of Fertilizers*.

The software package **ABC**© that has been developed by the Agricultural University of Athens is (a) managing all data of agricultural production into large databases, (b) performing all required calculations and (c) reporting cost analyses by operation and by factor / input of production in business like formats. The advantage of this approach is that all results are compatible and comparable, in the same format and consistent with only one set of rules. We have found several differences with other researchers' estimates, mostly due to the methodological approach.



COST ACCUMULATION DIAGRAMME

Annex 7: Land Use and Agricultural Production in EU27

This Annex presents statistical information a) about land use in EU-27 and b) the most important arable crops of EU countries. The following tables include statistical data for EU 27, as a total, and for each country separately.

EU 27 land categories 2005 (000 ha), per country *(Source: FAO)*

Countries	Country area	Agricultural area	Arable land	Temporary crops	Fallow land	Permanent crops	Forest area	Other land
Austria	8,387	3,263	1,387	1,215	95	66	3,862	1,120
Belgium	3,053	1,386	844		28	23	667	970
Bulgaria	11,100	5,265	3,173	2,617	490	201	3,625	1,974
Cyprus	925	165	120	100	20	41	174	585
Czech Republic	7,887	4,259	3,047			238	2,648	819
Denmark	4,309	2,589	2,237	1,777	20	7	500	1,154
Estonia	4,523	834	591		26	12	2,284	1,121
Finland	33,815	2,266	2,234		241	6	22,500	5,693
France	55,150	29,569	18,507		1,310	1,128	15,554	9,887
Germany	35,705	17,030	11,903	9,304	794	198	11,076	6,771
Greece	13,196	8,359	2,627		447	1,132	3,752	779
Hungary	9,303	5,864	4,600			207	1,976	1,121
Ireland	7,027	4,227	1,215			2	669	1,993
Italy	30,134	14,694	7,744			2,539	9,979	4,738
Latvia	6,459	1,734	1,092			13	2,941	1,554
Lithuania	6,530	2,837	1,906	1,248	156	40	2,099	1,332
Luxembourg	259	129	60		2	2	87	43
Malta	32	10	9			1	0	22
Netherlands	4,153	1,921	908		2	33	365	1,102
Poland	31,269	15,906	12,141	11,112	1,029	378	9,192	5,535
Portugal	9,212	3,680	1,262	888	374	649	3,783	1,687
Romania	23,839	14,513	9,288	7,951	517	540	6,370	2,115
Slovakia	4,903	1,941	1,391		10	26	1,929	940
Slovenia	2,027	508	176	149	2	27	1,264	242
Spain	50,537	29,030	13,700			4,930	17,915	2,974
Sweden	45,029	3,219	2,703		321	3	27,528	10,286
United Kingdom	24,361	16,956	5,729	4,396	140	47	2,845	4,392
EU 27 Total	433,124	192,154	110,594	40,757	6,024	12,489	155,585	70,948

EU 27 crops harvested area (2007) as a percentage of the total agricultural area, per country and total *(Source: FAO)*

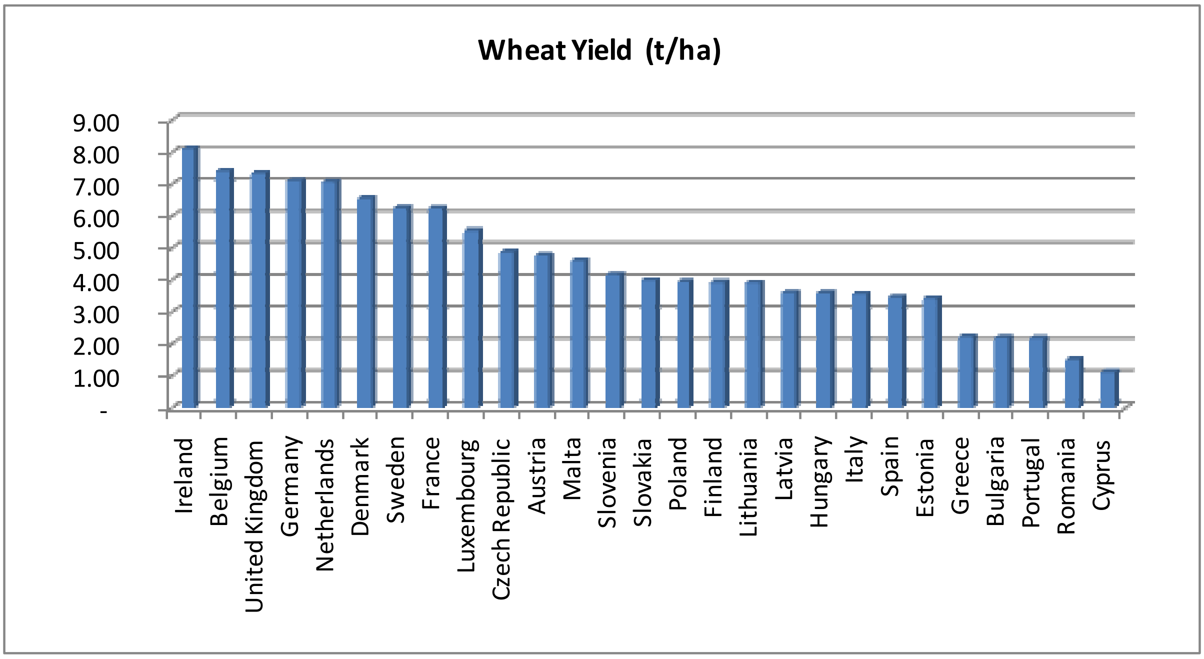
	Wheat	Barley	Maize	Rapeseed	Sunflower	Sugar beet
Austria	9%	6%	5%	1%	1%	1%
Belgium	14%	3%	4%	1%		6%
Bulgaria	21%	4%	4%	1%	11%	
Cyprus	5%	33%				
Czech Republic	19%	12%	2%	8%	1%	1%
Denmark	27%	24%		7%		2%
Estonia	11%	17%		9%		
Finland	9%	24%		4%		1%
France	18%	6%	5%	5%	2%	1%
Germany	18%	11%	2%	9%		2%
Greece	8%	1%	2%			
Hungary	19%	6%	21%	4%	9%	1%
Ireland	2%	4%				
Italy	14%	2%	7%		1%	1%
Latvia	13%	8%		6%		
Lithuania	12%	13%		6%		1%
Luxembourg	10%	7%		4%		
Malta	20%	4%				
Netherlands	7%	2%	1%			4%
Poland	13%	8%	2%	5%		2%
Portugal	2%	1%	3%			
Romania	13%	3%	15%	2%	6%	
Slovakia	19%	11%	8%	8%	3%	1%
Slovenia	6%	4%	8%	1%		1%
Spain	6%	11%	1%		2%	
Sweden	11%	10%		3%		1%
United Kingdom	11%	5%		4%		1%
EU 27 Total	13%	7%	4%	3%	2%	1%

Annex 8: Yields in EU-27

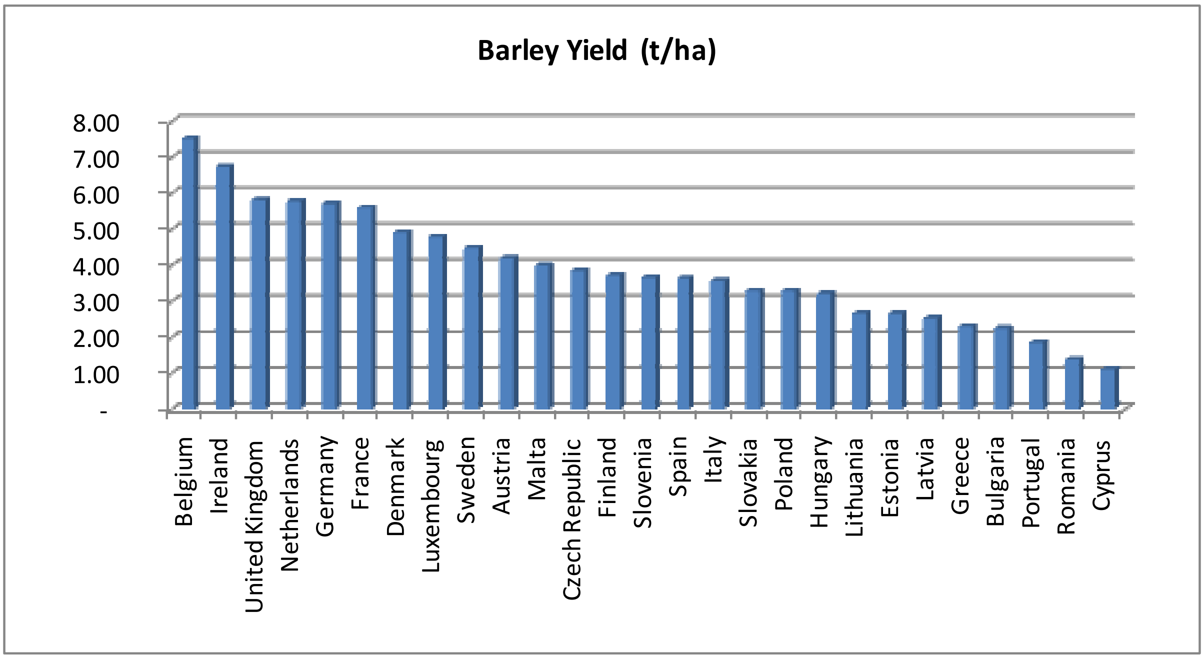
Yield of main arable crops (t/ha), year 2007

Country	Wheat	Barley	Maize	Rapeseed	Sunflower seed	Sugar beet
France	6.25	5.60	8.85	2.89	2.58	82.29
Portugal	2.18	1.86	5.54		1.83	74.42
Spain	3.46	3.64	10.01	2.02	1.23	69.95
Belgium	7.42	7.53	10.33	3.57		69.49
Germany	7.11	5.71	9.09	3.44	2.50	64.32
Netherlands	7.07	5.78	9.04	3.50		64.29
Austria	4.78	4.19	9.10	2.93	2.38	63.11
Greece	2.22	2.30	8.90	1.50	1.27	62.94
Denmark	6.56	4.92		3.33		57.24
Italy	3.57	3.57	9.14	2.08	2.13	54.09
United Kingdom	7.34	5.82		3.10		53.28
Hungary	3.59	3.21	6.72	2.23	2.04	50.00
Sweden	6.26	4.48		2.53		49.04
Czech Republic	4.88	3.85	6.53	3.08	2.12	47.88
Lithuania	3.92	2.66	4.81	1.79		47.33
Slovakia	3.99	3.30	4.27	2.17	2.08	45.33
Ireland	8.11	6.74		3.33		45.00
Poland	3.94	3.29	6.27	2.66	1.79	44.44
Finland	3.93	3.72		1.26		42.07
Slovenia	4.16	3.66	7.54	2.75	1.74	38.24
Latvia	3.60	2.52		2.13		36.00
Romania	1.50	1.38	1.74	1.00	0.63	26.01
Bulgaria	2.20	2.25	1.46	1.72	0.94	12.68
Luxembourg	5.54	4.80	6.33	3.41		
Estonia	3.43	2.65		1.81		
Malta	4.60	4.00				
Cyprus	1.13	1.10				
Average	**4.55**	**3.87**	**6.98**	**2.51**	**1.80**	**52.15**
Min	**1.13**	**1.10**	**1.46**	**1.00**	**0.63**	**12.68**
Max	**8.11**	**7.53**	**10.33**	**3.57**	**2.58**	**82.29**
Standard Deviation	**1.93**	**1.61**	**2.65**	**0.76**	**0.59**	**15.95**

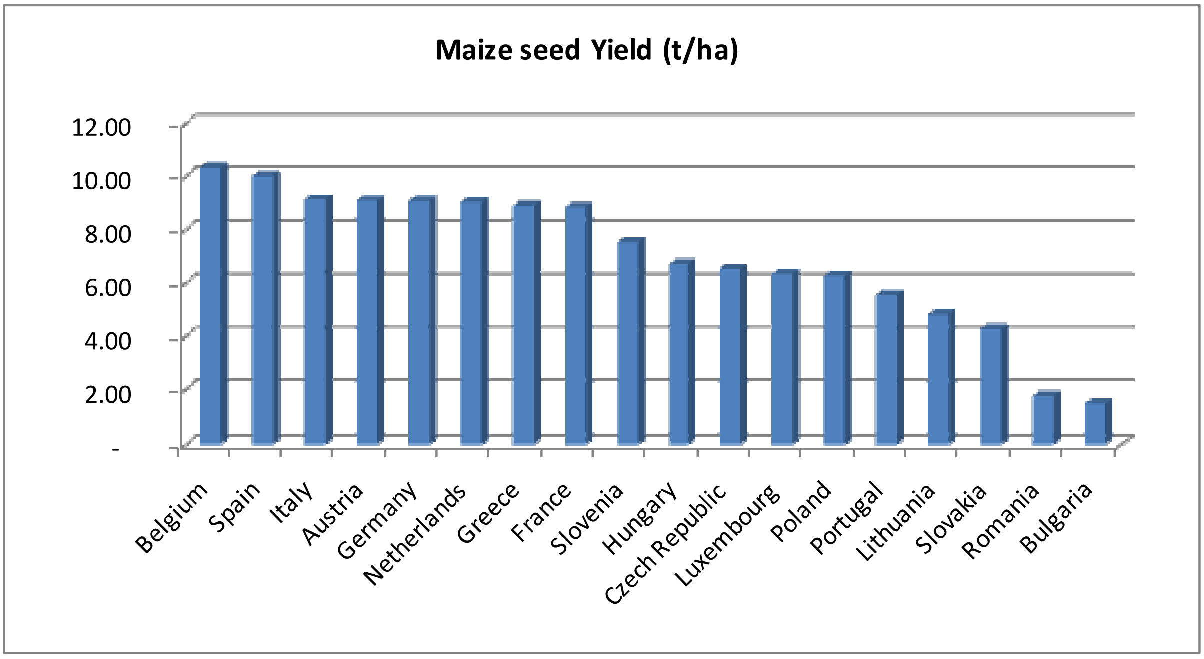
Source: FAO



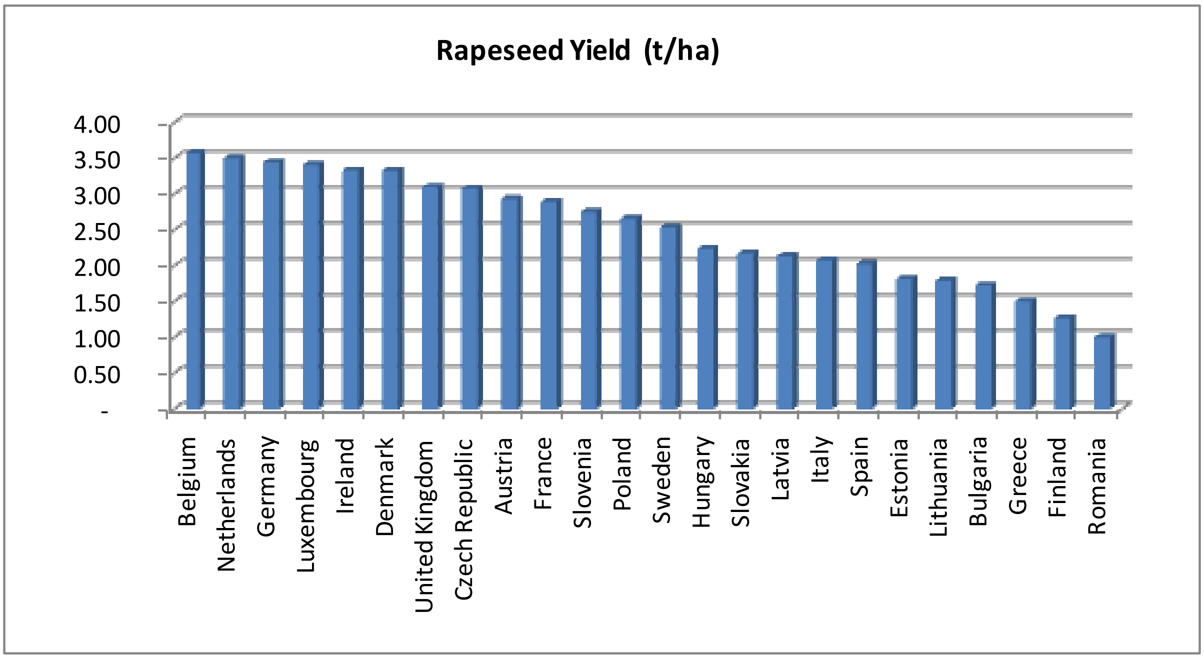
Wheat Yield, year 2007 (source: FAO)



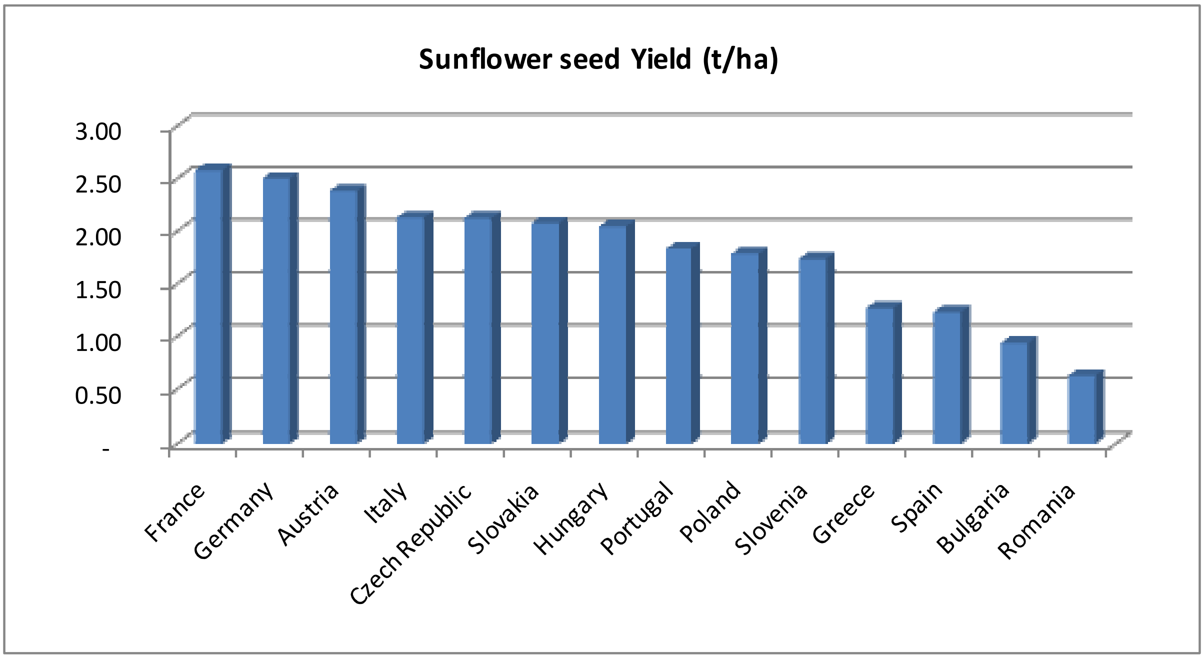
Barley Yield, year 2007 (source: FAO)



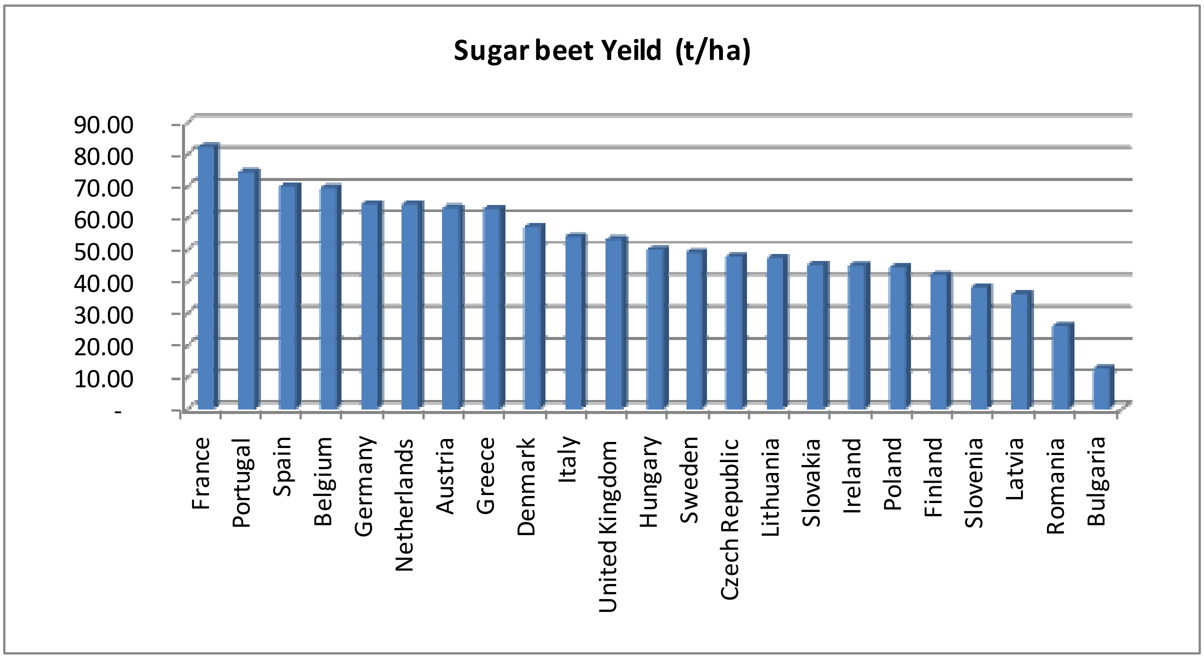
Maize Yield, year 2007 (source: FAO)



Rapeseed Yield, year 2007 (source: FAO)



Sunflower Yield, year 2007 (source: FAO)



Sugar beet Yield, year 2007 (source: FAO)

Annex 9: Agricultural Production Cost Data

This annex summarises the statistical information concerning the selling prices of agricultural products, as well as the prices of the factors of production in EU 27 countries. The basic categories presented in this annex are:

- Agricultural product prices
- Cost of land
- Cost of labour
- Prices of agricultural inputs

Main Arable crops product prices (2006)

	Soft wheat	Durum wheat	Rye	Barley	Oats	Maize	Rice	Sorghum	Triticale	Rape	Sunflower	Soya	Sugar beet
Belgium	119		87	109	89				90				32
Bulgaria	87	98	83	84	82	85	186	83	81	172	184	240	22
Czech Republic	109		101	101	116	102				234	219		36
Denmark	110		101	112	112				107	232			
Germany	109		101	102	95	131			103	235	798		33
Estonia	112		108	101	87					259			
Ireland	122			110	128								
Greece	141	141		152	204	159	162				162		25
Spain	140	139	126	126	128	152	218	150	140	208	221	214	41
France													
Italy													
Cyprus		156			365								
Latvia	112		96	96	85				91	234			32
Lithuania	129		109	106	86	149			92	244			35
Luxembourg	126		101	102	88	94			100	219			
Hungary	100	115	76	96	83	99	188	105	84	214	200	196	36
Malta													
Netherlands	102		109		126				110				47
Austria	105	140	117		86	124			86	222	173	184	37
Poland	115		99	103	90	115			95	240			33
Portugal	124	126	120	128	102	162	223		118		215		43
Romania	96			113	128	108				210	199	162	26
Slovenia	109		108		128	109			118	198			33
Slovakia	99	113	97	104	97	101			88	220	194	191	30
Finland	111		140	102	107					244			35
Sweden	112		112	99	111					235			
United Kingdom	119			108	112					226			
Average	**113.33**	**128.39**	**104.72**	**107.73**	**118.07**	**120.71**	**195.40**	**112.43**	**100.09**	**224.60**	**256.50**	**197.68**	**33.75**
Min	**86.80**	**97.50**	**76.10**	**84.20**	**82.10**	**85.20**	**162.40**	**82.80**	**81.20**	**171.50**	**162.00**	**161.70**	**21.50**
Max	**140.70**	**156.30**	**139.80**	**151.90**	**364.70**	**161.80**	**222.80**	**149.70**	**139.60**	**258.60**	**797.60**	**239.90**	**47.10**
Standard Deviation	**13.08**	**19.04**	**14.88**	**14.35**	**58.71**	**25.62**	**25.04**	**34.10**	**16.02**	**19.98**	**191.09**	**26.74**	**6.44**

Source: Eurostat

Main Arable crops product prices (2007)

	Soft wheat	Durum wheat	Rye	Barley	Oats	Maize	Rice	Sorghum	Triticale	Rape	Sunflower	Soya	Sugar beet
Belgium	177		89	180	95				124				33
Bulgaria	153	153	130	123	100	143	201	127	103	203	226	245	22
Czech Republic	165		158	142	192	151				267	269		31
Denmark	166		159	178	184				167	279			
Germany	179		167	169	159	190			182	287	894		30
Estonia	183		173	154	140					319			
Ireland	202				187								
Greece	235	234		225	226	254	175				250		23
Spain	203	230	178	184	158	205	271	198			394		32
France													
Italy													
Cyprus		155			360								
Latvia	189		164	167	142				146	271			34
Lithuania	187		154	182	149	219			154	264			34
Luxembourg	203		193	171	140	210			150	266			
Hungary	174	222	163	151	166	182	250	147	148	252	340	272	30
Malta													
Netherlands	190		167		192	195			188	304			42
Austria	165	218	158		135	210			143	260	316	248	31
Poland	187		159	169	140	174			162	253			29
Portugal	179	210	160	180	155	219	281		164		325		32
Romania	183			201	228	231				237	252	234	27
Slovenia													
Slovakia	163	183	173	170	149	171			117	247	341	244	27
Finland	160		192	146	150					285			32
Sweden	206		201	173	163					332			
United Kingdom	160			135	134					277			
Average	**182.17**	**200.45**	**163.24**	**168.36**	**167.10**	**196.60**	**235.44**	**157.27**	**149.78**	**270.76**	**360.68**	**248.72**	**30.59**
Min	**152.50**	**152.60**	**89.40**	**123.30**	**95.30**	**143.20**	**174.80**	**126.80**	**103.20**	**203.30**	**225.90**	**234.00**	**22.26**
Max	**235.10**	**233.80**	**201.00**	**224.80**	**360.40**	**253.60**	**280.80**	**198.10**	**187.50**	**332.40**	**893.60**	**271.60**	**42.00**
Standard Deviation	**19.44**	**32.87**	**24.70**	**23.48**	**53.20**	**30.57**	**45.91**	**36.76**	**24.26**	**30.48**	**194.34**	**13.89**	**4.69**

Source: Eurostat

Land Prices and Land Rent

	Price (€/ha)					Land Rent (€/ha)		
	Agricultural land	Arable land	Meadow	Irrigated land	Non-irrigated land	Agricultural land	Arable land	Meadow
Malta	303					932	932	
Denmark	25,745	26,858	13,561			551	579	237
Netherlands	34,969					444		
Luxembourg	18,001	18,365	16,571			179		
Spain	11,070	13,259	4,475	29,134	8,132	167	192	79
Hungary						87	92	39
Slovakia	1,121					17		
Lithuania	241					12		
Finland	6,250							
Sweden	3,957							
Latvia	2,500							
Czech Republic	1,867							
Belgium								
Bulgaria		1,202					102	
Germany								
Ireland								
Greece				12,024	4,952		508	
France								
Italy								
Austria							305	154
Poland		848	574				26	18
Romania								
United Kingdom								
Average	**9,638**	**12,106**	**8,795**	**20,579**	**6,542**	**298**	**342**	**105**
Min	**241**	**848**	**574**	**12,024**	**4,952**	**12**	**26**	**18**
Max	**34,969**	**26,858**	**16,571**	**29,134**	**8,132**	**932**	**932**	**237**
Standard Deviation	**11,731**	**11,222**	**7,515**	**12,099**	**2,249**	**322**	**311**	**90**

Source: Eurostat

Average Hourly Labour Cost (€)*

	2000	2001	2002	2003	2004	2005	2006
Austria							
Belgium					29.19	29.67	30.56
Bulgaria	1.20	1.28	1.35	1.42	1.51	1.61	1.71
Cyprus	9.88	10.24	10.86	11.44	12.03	12.71	13.13
Czech Republic	3.69	4.46	5.24	5.47	5.78	6.56	7.14
Denmark						30.74	31.80
Estonia	2.84	3.19	3.62	3.98	4.25	4.71	5.49
Finland	22.13		23.40	24.36	24.87	26.15	26.83
France							
Germany	25.10	25.70	26.30	26.80	26.90	27.10	27.50
Greece							
Hungary				5.34	5.72	6.57	6.52
Ireland							
Italy							
Latvia	2.24	2.34	2.50	2.49	2.64	2.91	3.58
Lithuania	2.60	2.73	2.90	3.11	3.26	3.62	4.27
Luxembourg					30.34	31.40	32.39
Malta			8.52	8.77	8.68	9.51	9.69
Netherlands							
Poland	4.51	5.39	5.38	4.88	4.92	5.78	6.28
Portugal					11.30	11.70	12.13
Romania	1.39	1.52	1.64	1.60	1.78	2.38	2.82
Slovakia	2.84	3.04	3.32	3.85	4.23	4.59	5.15
Slovenia	9.56	10.44	10.36	11.36	11.12	11.49	12.01
Spain	14.38	13.28	13.84	14.47	15.03	15.53	16.15
Sweden					29.00	29.44	30.21
United Kingdom	23.27	23.93	24.66	23.19	24.49	24.89	
European Union 27	**n/a**	**n/a**	**n/a**	**n/a**	**18.05**	**18.50**	**-**
Min	**1.20**	**1.28**	**1.35**	**1.42**	**1.51**	**1.61**	**1.71**
Max	**25.10**	**25.70**	**26.30**	**26.80**	**30.34**	**31.40**	**32.39**

Source: Eurostat

****All NACE branches except agriculture, fishing, private households with employed persons***

Hourly Labour Cost (€) in services

	2000	2001	2002	2003	2004	2005	2006
Austria	22.38	22.73	22.89	23.95	24.10	25.02	25.49
Belgium	25.51	26.71	27.92	28.53	29.07	29.49	30.29
Bulgaria	1.12	1.20	1.24	1.31	1.39	1.52	1.64
Cyprus	9.01	9.36	9.79	10.49	10.90	11.37	11.62
Czech Republic	4.10	4.94	5.66	5.74	6.21	7.25	7.48
Denmark	27.30	29.86	29.72	31.01	31.34	32.70	33.66
Estonia	2.90	3.33	3.86	4.23	4.38	4.73	5.61
Finland	22.34	23.69	22.90	23.90	24.61	25.78	26.35
France	24.81	26.01	27.08	27.69	28.38	29.24	30.36
Germany	23.20	23.70	24.20	24.90	24.90	25.20	25.30
Greece	11.04	11.74	12.67	13.71			
Hungary				5.27	5.75	6.30	6.67
Ireland							
Italy		19.90	20.52				
Latvia	2.24	2.29	2.43	2.41	2.55	2.81	3.45
Lithuania	2.65	2.82	2.98	3.22	3.29	3.68	4.24
Luxembourg	26.74	28.26	29.28	30.53	32.39	33.64	34.58
Malta			8.08	8.03	8.22	8.98	9.22
Netherlands	21.57	23.35	24.68	26.00	26.64	26.78	
Poland	4.72	5.57	5.55	4.94	4.94	5.76	6.21
Portugal	9.34	9.90	10.60	11.30	12.00	12.60	13.03
Romania	1.42	1.57	1.72	1.67	1.80	2.37	2.72
Slovakia	3.12	3.44	3.79	4.05	4.44	5.04	5.48
Slovenia	10.07	10.84	10.82	11.83	11.25	11.64	12.35
Spain	13.97	12.84	13.36	13.84	14.34	14.82	15.36
Sweden	29.14	27.94	29.22	30.85	30.88	31.39	32.18
United Kingdom	23.81	24.64	25.25	23.48	24.45	23.81	
European Union 27	**18.17**	**18.79**	**19.41**	**19.13**	**19.59**	**19.81**	**-**
Min	**1.12**	**1.20**	**1.24**	**1.31**	**1.39**	**1.52**	**1.64**
Max	**29.14**	**29.86**	**29.72**	**31.01**	**32.39**	**33.64**	**34.58**

Source: Eurostat

Prices of agricultural energy inputs, 2007

	Electicity €/MWh	Heating gas oil €/m3	Residual fuel oil €/ton	Motor spirit €/m^3	Diesel oil €/m^3
Belgium	109		298	481	485
Bulgaria	78	923		968	944
Czech Republic					
Denmark		556			584
Germany					
Estonia					
Ireland				1,107	
Greece	40	586		1,017	961
Spain					592
France					
Italy					
Cyprus	258	584		584	172
Latvia					752
Lithuania	705	456		665	473
Luxembourg	1,307	4,824			4,724
Hungary		874	322	917	874
Malta					955
Netherlands					651
Austria	154	553			862
Poland					
Portugal	120				627
Romania		397	308	987	945
Slovenia					
Slovakia					
Finland	82	519			
Sweden					849
United Kingdom				1,377	588
Average	**317**	**1,027**	**309**	**900**	**943**
Min	**40**	**397**	**308**	**584**	**172**
Max	**1,307**	**4,824**	**322**	**1,377**	**4,724**
Standard Deviation	**466**	**1,512**	**10**	**268**	**1,094**

Source: Eurostat

Prices of agricultural energy inputs, 2006

	Electicity €/MWh	Heating gas oil €/m3	Residual fuel oil €/ton	Motor spirit €/m^3	Diesel oil €/m^3
Belgium	102		277	484	473
Bulgaria	63	847		857	858
Czech Republic	75	463	214	1,044	1,022
Denmark		553			583
Germany					
Estonia					
Ireland		622	475	1,096	
Greece	38	576		975	926
Spain					584
France					
Italy					
Cyprus	261	591		591	174
Latvia					
Lithuania	691	390		617	464
Luxembourg	1,252	4,788			4,688
Hungary		689	559	797	726
Malta					982
Netherlands		650	360	1,232	650
Austria	145	571			841
Poland	113	663			987
Portugal	114				606
Romania		358	239	962	933
Slovenia	80	516		835	801
Slovakia					
Finland	79	523			
Sweden					873
United Kingdom				1,340	592
Average	**251**	**853**	**354**	**902**	**935**
Min	**38**	**358**	**239**	**591**	**174**
Max	**1,252**	**4,788**	**559**	**1,340**	**4,688**
Standard Deviation	**406**	**1,225**	**139**	**257**	**1,047**

Source: Eurostat

Prices of fertilizers, 2007

	Sulphate of ammonia	Ammonium nitrate (26% N) (in sacks)	Ammonium nitrate (26% N) (in bulk)	Ammonium nitrate (33% N) (in sacks)	Urea	Superphosphate (18% P205)	Triple Superphosphate (46% P205)	Muriate of potash	Sulphate of potash
	€/ton of nutritive substance								
Belgium	117	202				164		208	298
Bulgaria	634			591	457	1,101	421	499	
Czech Republic									
Denmark									
Germany			749		595		262	407	
Estonia									
Ireland			851		682			427	
Greece	215	259		270	335	215	379		385
Spain	769	822		757	653	896	531	383	739
France	1,097		915	831	749	987	699	455	643
Italy									
Cyprus	258	292		343	378		343		240
Latvia				24		182		243	
Lithuania		747		572	457	797	692	374	
Luxembourg			727				543	395	
Hungary				631	558	895		338	
Malta									
Netherlands		847	730		790	991	635	501	579
Austria			207		288			231	
Poland									
Portugal	925	990			754	1,027		456	
Romania				746	620				
Slovenia									
Slovakia	79		184		264	169			375
Finland		782							
Sweden		1,002							
United Kingdom				711	880		700	403	
Average	**512**	**660**	**623**	**548**	**564**	**675**	**520**	**380**	**466**
Min	**79**	**259**	**184**	**24**	**264**	**169**	**262**	**231**	**240**
Max	**1,097**	**1,002**	**915**	**831**	**880**	**1,027**	**700**	**501**	**739**
Standard Deviation	**426**	**288**	**300**	**272**	**198**	**378**	**168**	**81**	**190**

Source: Eurostat

Prices of fertilizers, 2006

	Sulphate of ammonia	Ammonium nitrate (26% N) (in sacks)	Ammonium nitrate (26% N) (in bulk)	Ammonium nitrate (33% N) (in sacks)	Urea	Superphosphate (18% P205)	Triple Superphosphate (46% P205)	Muriate of potash	Sulphate of potash
				€/ton of nutritive substance					
Belgium	107	180				126		157	225
Bulgaria	546			510	422	952	376	499	
Czech Republic	111	184		174	276	173	233	214	326
Denmark									
Germany			691		528		211	384	
Estonia									
Ireland			827		674			412	
Greece	205	251		256	316	204	347		366
Spain	695	795		726	582	849	485	352	721
France	1,045		866	786	644	918	538	420	609
Italy									
Cyprus	226	278		313	347		330		226
Latvia				194		187		216	
Lithuania		690		507	393	742	605	313	320
Luxembourg			667				453	385	
Hungary	545			558	483	535		327	524
Malta									
Netherlands		808	691		663	958	554	488	555
Austria			190		278			215	
Poland				201	247	147	217		227
Portugal	819	919			649	920		429	
Romania	1,256			713	561				1,577
Slovenia		708			534				
Slovakia	70		168		237	145			343
Finland		749							
Sweden		960							
United Kingdom				643	788		475	335	
Average	**511**	**593**	**586**	**465**	**479**	**527**	**402**	**343**	**502**
Min	**70**	**251**	**168**	**194**	**237**	**145**	**211**	**215**	**226**
Max	**1,256**	**960**	**866**	**786**	**788**	**958**	**605**	**488**	**1,577**
Standard Deviation	**425**	**254**	**288**	**231**	**172**	**356**	**138**	**82**	**398**

Source: Eurostat

Prices of fertilizers, 2007

	Binary fertilizers 1 - 1 - 0	Binary fertilizers 0 - 1 - 1	Binary fertilizers 0 - 20 - 20	Ternary fertilizers 1 - 0;5 - 0;5	Ternary fertilizers 20 - 10 - 10	Ternary fertilizers 1 - 1 - 1	Ternary fertilizers 17 - 17 - 17	Ternary fertilizers 1 - 1 - 1 (in bulk)	Ternary Fertilizers 17 - 17 - 17 (in bulk)	Ternary fertilizers 1 - 1 - 2	Ternary fertilizers 9 - 9 - 18	Ternary fertilizers 1 - 2 - 2	Ternary fertilizers 10 - 20 - 20
							€/ton merchandise						
Belgium	267		198										
Bulgaria	225						309						
Czech Republic													
Denmark													
Germany	253	189						246					273
Estonia													
Ireland		235						274		288			
Greece	279					199							
Spain				343	343	193	286			175		175	
France		332	260			319	319	303	303	330	276		
Italy													
Cyprus			292		343	343							
Latvia					284	311	257						
Lithuania		246							194				277
Luxembourg	221	199							234			265	
Hungary							243		245				
Malta													
Netherlands	278					250	319					288	
Austria													
Poland													
Portugal	338							229		239			
Romania	288			243		243		308	288				
Slovenia													
Slovakia											230		
Finland													
Sweden													
United Kingdom		266		254		848	848			251		262	
Average	**269**	**245**	**250**	**280**	**323**	**338**	**369**	**272**	**253**	**257**	**253**	**248**	**275**
Min	**221**	**189**	**260**	**243**	**284**	**193**	**243**	**229**	**194**	**175**	**230**	**175**	**273**
Max	**338**	**332**	**292**	**343**	**343**	**848**	**848**	**308**	**303**	**330**	**276**	**288**	**277**
Standard Deviation	**39**	**52**	**22**	**55**	**34**	**213**	**232**	**34**	**44**	**58**	**33**	**49**	**3**

Source: Eurostat

Prices of fertilizers, 2006

	Binary fertilizers 1 - 1 - 0	Binary fertilizers 0 - 1 - 1	Binary fertilizers 0 - 20 - 20	Ternary fertilizers 1 - 0;5 - 0;5	Ternary fertilizers 20 - 10 - 10	Ternary fertilizers 1 - 1 - 1	Ternary fertilizers 17 - 17 - 17	Ternary fertilizers 1 - 1 - 1 (in bulk)	Ternary Fertilizers 17 - 17 - 17 (in bulk)	Ternary fertilizers 1 - 1 - 2	Ternary fertilizers 9 - 9 - 18	Ternary fertilizers 1 - 2 - 2	Ternary fertilizers 10 - 20 - 20
	€/ton merchandise												
Belgium	239		159										
Bulgaria	200						269						
Czech Republic	305						239				246		
Denmark													
Germany	231	169						226					320
Estonia													
Ireland		225						271		283			
Greece	266					189							
Spain				353	353	165	256	162	162	284	284		
France		277	216			288	288	274	274	303	254		
Italy													
Cyprus			278			295							
Latvia					227		199						
Lithuania						151			200		214	194	
Luxembourg	196	159							216			245	
Hungary						212	214					218	
Malta													
Netherlands	266					236	307					275	
Austria													
Poland					288		265				257		
Portugal	265							207		220			
Romania	248			233		233		288	243				
Slovenia													
Slovakia											202		
Finland													
Sweden													
United Kingdom		197		220		673	673			215		222	
Average	**246**	**205**	**218**	**269**	**289**	**271**	**301**	**238**	**219**	**261**	**243**	**231**	**320**
Min	**196**	**159**	**216**	**220**	**227**	**151**	**199**	**162**	**162**	**215**	**202**	**194**	**320**
Max	**266**	**277**	**278**	**353**	**353**	**673**	**673**	**288**	**274**	**303**	**284**	**275**	**320**
Standard Deviation	**28**	**48**	**44**	**74**	**63**	**159**	**163**	**48**	**42**	**41**	**34**	**31**	**-**

Source: Eurostat

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