

Sugar beet production in the European Union and their future trends

H. Řezbová, A. Belová, O. Škubna

Faculty of Economics and Management, Czech University of Life Sciences in Prague, Czech Republic

Anotace

Hlavním cílem příspěvku je analýza naturálních výnosů bílého (polarizačního) cukru a výrobních nákladů na tento cukr a cukrovou řepu v rámci hlavních evropských producentů za účelem identifikace hlavních vývojových trendů. Dílčím cílem je analýza výrobních (variabilních) nákladů na jednu tunu cukrové řepy ve Francii, Německu, Polsku, Velké Británii a České republice, komparace výnosů cukrové řepy ve společnostech Tereos France a Tereos TTD a.s. Základními metodami, užitými v příspěvku, jsou řetězové a bazické indexy a regresní analýza časových řad. Na základě regresní analýzy je stanovena predikce vývoje výnosů cukru (t/ha) u hlavních evropských producentů. Na základě analýzy primárních dokumentů a na základě regresní analýzy je možno stanovit závěr, že hlavní producenti v Evropě nedosáhnou v roce 2015/2016 výnosu cukru 15 tun z hektaru při variabilních nákladech na jednu tunu cukrovny v maximální výši 15 EUR. Článek byl zpracován v rámci VZ MSM 6046070906 „Ekonomika zdrojů českého zemědělství a jejich efektivní využívání v rámci multifunkčních zemědělskopotravinářských systémů“.

Klíčová slova

Cukrová řepa, produkce cukru, výnosový potenciál, variabilní náklady.

Abstract

The main aim of this paper is to analyze the yield (t/ha) and the production costs of white (polarized) sugar and sugar beet in the main European producer countries in order to identify main development trends. The partial objectives of this study are: to analyse the production costs (variable costs) of sugar and sugar beet of the main European producers (France, Germany, Poland, United Kingdom, Czech Republic), to compare sugar beet yield of Tereos France and Tereos TTD a.s., to analyse sugar beet yield potential and their trends. The used methods are chain and basic indexes and regression analysis of time series/trend data - for predicting on next tree years. The main producers of sugar beet in the European Union (i.e. France, Germany, Poland, United Kingdom, and Czech Republic) can not achieve goal of sugar yield 15t/ha while maintaining the amount of variable (direct) costs at 15 EUR/tonne of sugar beet in the business year 2015/2016. Pieces of knowledge introduced in this paper resulted from solution of an institutional research intention MSM 6046070906 „Economics of resources of Czech agriculture and their efficient use in frame of multifunctional agri-food systems“.

Key words

Sugar beet, sugar production, yield potential, variable costs.

Introduction

Sugar is produced in over 100 countries worldwide. In most years, over 70% of world sugar production is consumed domestically which allowed the development of a large export market. However, a significant share of this trade takes place under bilateral long-term agreements or on preferential terms.

Total world sugar trade is projected to increase

by 19.9% from 34.5 million metric tons to 37.9 million metric tons between 2010 and 2020. Brazil's exports are projected to increase from 21.6 million metric tons in 2010 to 25.6 million metric tons in 2020 even though Brazil uses a substantial amount of sugar cane for ethanol production. World sugar prices are projected to decrease from 27.3 cents/lb in 2010 to 18.4 cents/lb in 2020 (Pylor, Koo, 2011).

Twenty percent of the world's supply of sugar is derived from sugar beet, mainly cultivated in industrialized countries, while the remaining 80% of the world's sugar supply is derived from sugar cane, mainly cultivated in tropical climates in developing countries (FAO, 2009).

Production and trade in sugar are very closely linked with the policies of sustainable development (Smutka, Rumánková, Pulkrábek, Benešová, 2013).

Global sugar production for 2013/14 is forecast at 175 million (metric) tons, narrowly setting a record with growth in Brazil and Thailand more than offsetting sharply lower production in India. International raw sugar prices are at levels not seen in nearly three years with prices less than half the peak set in February 2011. Low prices are expected to stimulate global consumption and trade, with exports forecast 4 percent higher at 59 million tons (USDA, 2012).

Brazil's sugar production for 2013/14 is forecast at a record 40.4 million tons, up 1.8 million on higher yields as a result of good weather and adequate sugarcane renewal. Record exports are forecast at 29.3 million tons despite mills likely expanding ethanol production to fill a domestic increase in the ethanol content blended with gasoline. The share of the sugarcane crop for sugar is down slightly to 48 percent, as opposed to an even 50/50 sugar to ethanol split the prior year. China is Brazil's top market, though risk exports to the United Arab Emirates, Algeria, Indonesia, Russia and India are expected to continue (FAO, 2009).

The growth of the world sugar production relies on the increase in the sugar crops cultivation. In the years 2008/2009 - 2011/2012 alone the worldwide sugar beet production reached nearly 272 million tons, with an average growth rate of production standing at about 2.5% per year. In the case of sugar cane, during the same period its production reached the level of about 1 794 million tons, and the rate of the production growth achieved an average of 2.7% per year. (Svatoš, Belova, Maitah, 2013).

While sugar cane still remains the world's no.1 crop for sugar production, its use for this purpose has been stagnating. Sugar beet, on the other hand, continues to show both qualitative and quantitative growth potential. Last year's (i.e. 2011/2012) world sugar production was in excess of 172 million metric tons; its consumption amounted to 169 million metric tons. Sugar consumption is up by about 2%, i.e., by 3 million metric tons. Since the Sugar

Common Market Organization reform, the EU has been showing an annual deficit of 3-4 million mt. The Commission deals with this by importing sugar from third countries. Importation is done on the basis of reduced-duty tenders, duty-free imports, and industrial sugar imports (Reinberger, 2012).

EU sugar production for 2013/14 is forecast to rebound slightly to 15.9 million tons on higher yields, most of which will be added to ending stocks. Consumption is steady at 18.1 million tons, nearly unchanged over the last several years. Imports are forecast to remain at 3.8 million tons while exports, limited by the EU's WTO sugar export ceiling, remain unchanged at 1.5 million tons (USDA, 2012).

The sugar content in sugar beet can vary from 12% to 20%. It is the sugar that gives value to the sugar beet crop. The by-products of the sugar beet, such as pulp and molasses, give an added value of up to 10% of the value of the sugar. The sugar extraction rate depends on the sugar content of the sugar beet at the moment of its arrival in the processing plant. European norms define the sugar beet as marketable if it contains 14% sugar or more (in Ukraine, for instance, the average sugar content is only 11.2%). The standard sugar beet should have a sugar content of 16%, which would yield 130 kg of sugar per 1 ton of standard sugar beet processed at a sugar plant - ideal efficiency is 82.5%.

In Europe, the total production cost of beet sugar (16% sugar content) is around EUR 20–30 per ton in competitive countries and EUR 30–40 per ton in noncompetitive countries (FAO, 2009).

Question number one is sustainability of sugar beet growing and beet sugar industry. This sustainability has a fundamental economic aspect regarding competitiveness with cane sugar, and an environmental aspect including mainly the current issue of emissions and foreign chemical substances. The principle of sustainability also sets other relevant research directions: yield potential, resistant breeding (with the aim to decrease the consumption of biocides), alternative uses of sugar beet (sugar, ethanol, methane), growing technologies decreasing the input of chemicals, fertilizers, energy, limiting soil erosion, the position of sugar beet within an agricultural enterprise. Nowadays, a full extent research is done only in big sugar beet growing countries in the Europe (i.e. France and Germany); in the Czech Republic

the research concentrates on individual issues such as sustainability and growing technologies and is financed exclusively by beet growers and sugar producers (Chochola, Pulkrábek, 2012).

Sugar beet has been selectively bred since the early nineteenth century with the principle objective to develop varieties with the maximum root and sucrose yield potential at the lowest economic and environmental costs possible (Richardson, 2010).

Historically, the most productive developments in sugar beet breeding have been monogerm seed, male-sterility and subsequent hybrid development, and pest and disease resistance (Biancardi, McGrath, Panella, Lewellen, Stevanato, 2011).

In order to maximize yields, it is important to look at the plant water requirement which highly depend on the atmospheric water demand and the settlement conditions. Sugar beet is generally neither irrigated in northern Europe, in central Europe it is commonly necessary to irrigate 100-200 mm water per year (Rodrigo, Morillo-Velarde, 2010).

Production quota reduction was achieved through buy-outs and some efficiency gains were realized as efficient producers were allowed to buy renounced quota within member states. Under this system, support payments to growers became decoupled from production, with the purpose of allowing farmers more freedom to produce to market demand (Haley, Polet, 2011).

According to Robert Ohlson, researcher at NBR association – Nordic Beet Research, the main points of sustainable development of sugar beet production in Europe are:

- i. Profit, reducing the cost of 1 tonne of sugar beet and 1 tonne of sugar (low-cost production)
- ii. Environment, growing conditions, use of yield potential of sugar beet cultivars
- iii. Personnel, the quality of management
- iv. Integrity and mutual cooperation between sugar beet industry and sugar beet growers.

The basic prerequisite for a competitive and sustainable cultivation of sugar beet in Europe, according to the scientists above are three magical “15’s” as objectives to fulfill – by the year 2015 the European growers should reach sugar yield of 15 t/ha while maintaining variable (direct) costs at 15 EUR/tonne of sugar beet.

The main aim of this paper is to analyze the yield and the production costs of white (polarized) sugar

and sugar beet in the main European producer countries in order to identify main development trends.

Materials and methods

The basic research question is whether the main producers of sugar beet in the European Union (i.e. France, Germany, Poland, United Kingdom, and Czech Republic) can achieve goal of sugar yield 15 t/ha while maintaining the amount of variable (direct) costs at 15 EUR/tonne of sugar beet in the marketing year 2015/2016.

The main aim of this paper is to analyze the yield and the production costs of white (polarized) sugar and sugar beet in the main European producer countries in order to identify main development trends.

In farming, economic goals such as profit or output maximisation may be the growers primary goal, however the non-economic goals are also important. Production efficiency is the ability of the farmers to produce an output at minimum cost and to combine outputs for maximum profit.

The partial objectives of this study are:

- i. To compare prices of sugar from sugar beet and sugar cane (time series 1996-2006) and to determine the ratio between these prices
- ii. To compare sugar beet production costs (EU and U.S.) and their relation to the sugar cane production costs (Base 100 = sugar cane production costs)
- iii. To analyse the production costs (variable costs) of sugar and sugar beet of the main European producers (France, Germany, Poland, United Kingdom, Czech Republic).
- iv. To compare sugar beet yield of Tereos France and Tereos TTD a.s.
- v. To analyse sugar beet yield potential and their trends

Data used in this paper comes from the following sources: CEFS SUGAR STATISTICS 2012, Gain Report Number E80045: EU-27 Sugar Semi-annual Report 9/2013, The John Nix Farm Management Pocketbook, 42th edition: 2012, Agribenchmark (agribenchmark.org), Section Cash Crop, 2011-2012, Tereos – Annual Report 2012, FAOSTAT database Online, Crops (2011,2012).

The first used statistical methods are the Fixed Base Index Numbers and Chain Base Index Numbers. For Fixed Base Index Numbers (usually just called Index Numbers), the Base is given the value 100 and everything after that is given relative

to the Base, going above 100 for higher values or below 100 for values which drop below the original. For Chain Base Index Numbers, each value is given an Index based on the previous value being used as the Base.

The second used statistical method is simple regression analysis of time series/ trend data, for predicting on next two years (2014-2015). Linear prediction is a mathematical operation where future values of a discrete-time signal are estimated as a linear function of previous samples. Linear regression can be used to fit a predictive model to an observed data set of y and x values. Simple linear regression predicted values of one variable.

The data are pairs of independent and dependent variables $\{(x_i, y_i): i=1, \dots, n\}$. The fitted equation is written $y = ax + b$, where y is the predicted value of the response obtained by using the equation. Regression coefficient represents the rate of change of one variable ($y =$ million hectares) as a function of changes in the other ($x =$ year); it is the slope of the regression line. The simple linear regression is counted by STATISTICA 10 Software.

Production costs (sugar, sugar beet) may be classified by their behavior as fixed, variable or semivariable costs. Fixed costs do not change with the level of production (e.g. rents, insurances, salaries of certain executives); variable costs are in direct proportion to the volume of production (e.g. materials, wages, packaging); semi-variable costs increase or decrease as volume of production changes but not in direct proportion.

In relation to products or services provided by a manufacturing company, costs may be direct or indirect. Direct costs can be identified with and allocated to products/units (e.g. materials, labour charges including related social costs, expenses such as lease of special equipment

required for manufacturing certain products); indirect costs – often referred to as overheads or burdens – cover materials, labour and expenses which it is either impossible or inconvenient to charge direct to the product/unit (e.g. supervision, administration, maintenance, utilities).

Results and discussion

1. Basic overview

Beet and sugar production in the EU is based on a market organization, known as the common market organization of the sugar sector or Sugar

CMO. In 2006, this CMO was thoroughly reformed leading to a large reduction in quota sugar production of around 6 Mio tons (-30%). This left a remaining quota sugar production of around 13.3 Mio tons. In the years leading up to and following the adoption of the CMO reform, the number of EU sugar factories has fallen sharply as the industry has undergone major restructuring driven by the need to improve efficiency. Virtually every country and region of the EU has been affected. Today beet sugar production is distributed among 18 EU countries, as opposed to 23 before the restructuring, with 70% of the production concentrated in 7 countries (CEFS, 2012).

Reform of the EU Sugar Protocol began in 2006, with full liberalisation of the EU sugar market scheduled for 2015, including abolition of production quotas. Reform was driven by the need to reduce EU budgets and align the sugar market with the EU's overall move towards a market-oriented CAP (Common Agricultural Policy), which would also enhance the competitiveness of EU sugar production by eliminating unprofitable production capacity. Between 2006 and 2010, the EU had to reduce domestic production and also gradually reduce guaranteed beet prices and reference prices for imports of in-quota white and raw sugar by 36 per cent (Commodity Briefing, 2013).

The sugar reform in 2006 affected the sugar industry in many European countries. The volume of sugar beet and white sugar production was significantly reduced. The size of sugar industry in EU decreased and many production capacities were closed down. The number of sugar factories decreased more than 50 % and also the number of people working in sugar industry decreased significantly (cca 50%). The reform affected more production capacities in new EU member countries, while in the case of old EU members the reduction of both sugar beet and refined sugar production capacities was much lower (Smutka, Benešová, Pulkrábek, Belova, Urban, 2013).

2. Costs of sugar : sugar beet and sugar cane

One way to measure the effect of reform on current European Union sugar productivity and efficiency is examine costs of sugar production before and after reform. LMC International provides estimates of world sugar and high fructose syrup (HFS) costs of production. The data go back to 1979/80 and extend through 2009/10, with a preliminary forecast for 2010/11. Field, factory, and administrative costs are detailed for 35 beet producing countries

and for 61 cane producing countries. The lowest cost areas are in The Netherlands and the United Kingdom – under \$525 per tonne. The three largest producing countries of France, Germany, and Poland are in the intermediate cost set with costs between \$525 and \$625. The high cost areas are in the Czech Republic, Hungary, Slovakia (between \$625 - \$850 per metric ton) and very high areas are in the Bulgaria, Finland, Greece, Italy, Portugal, Romania (Sugar and Sweetener Outlook, 2011).

The sugar beet belongs to the products with high production (so called highly intensive) but it is necessary to admit that the earnings are appropriate (Strnadová, 2009).

The total composition of sugar beet costs is in contrast with other products very different. For example the sugar beet and the rape are the products with high production costs related to the application of chemicals. By contrast, the rape is a product where we can buy relatively cheap seeds, while regarding the sugar beet, it is other way round. Purchase of quality seed pelleting and dosing means very high purchasing costs (for example in 2009: 12.5–14.5%). Also the harvest costs are high. Into the costs items, it is necessary to include also the contribution for the sugar beet transport in the sugar-refinery or settlement of production allotments.

The subsidy SAPS (Single Area Payment Scheme) and CNDPs (Complementary National Direct Payments) per 1 hectare of sugar beet have a positive impact on its economics though not sufficient enough. In practice, it means that it is highly probable that the break-even point will not be achieved and thereby it is highly probable that the fixed costs are not covered and the update of machines is significantly limited. If the agricultural companies count on the separate sugar payment, the sugar beet growing is (in all regions of the Czech Republic) with acceptable risk (Pulkrábek, Kavka, Rataj, Humpál, Nozdrovický, Trávníček, Pačula, 2012).

The price of sugar beet is a contractual price agreed between a sugar beet processor and a sugar beet farmer. Sugar beet prices depend on sugar prices. The price of sugar is fixed by the sugar producer according to market conditions and governmental agreements (FAO, 2009).

The price is also seriously affected by many technical factors that include beet yield, the sugar content of the beets and the sugar yield. Table 1 contains detailed information on production costs

of both beet sugar and cane sugar in a range of selected countries in the time period 1996-2006.

In Europe, the production cost of beet sugar (16% sugar content) is around EUR 20–30 per ton in competitive countries and EUR 30–40 per ton in noncompetitive countries. As can be seen from Table 1, the production cost of beet sugar is more than twice as high as the production cost of cane sugar. The production cost of beet sugar is significantly offset by the revenue from the sale of the by-products, i.e. molasses, pulp, beet particulate matter and carbonation lime.

Brazilian sugar production costs rose in recent years due to factors such as adverse weather, which cut cane throughput in mills, but this trend is now set to reverse as mills ramp up production of a huge harvest in 2013/14. Sugar mills in Brazil have substantial fixed costs and need to produce at near full capacity to keep their marginal costs to a minimum.

Graph 1 shows beet sugar production costs in the European Union and the United States relative to the world weighted-average cane sugar production costs. European Union costs are higher than those in the United States but costs in both regions have been declining since 2003/04 relative to cane sugar production costs. Although the most significant European Union cost declines started after the reform began, United States costs were declining as well.

3. European Union: production costs of sugar beet

Sugarbeet growers in Europe face the challenge of keeping up their financial yields. Due to the reform of the European Union sugar regime, the EU minimum price for quota beet fell from 43.63 EUR/tonne sugarbeets (EC 1260/2001; Zeddies, 2006) to 26.29 EUR/tonne from 2009 onwards (EC 318/2006), implying a 39.7% decrease. Growers have to raise their yield by the same percentage to compensate for this price drop, if the costs remain on the level of 2006. Another strategy is to reduce costs. Possibilities to save up to 20% of the costs without yield loss in sugarbeet production were identified (Pauwels, 2006). However, to compensate for the beet price drop by cost savings, costs should decrease much more to keep the absolute difference between costs and payment the same. Therefore, cost saving still leaves a need for raising sugar yield. A combination of both raising yield and saving costs would be profitable for the growers, too. The potential

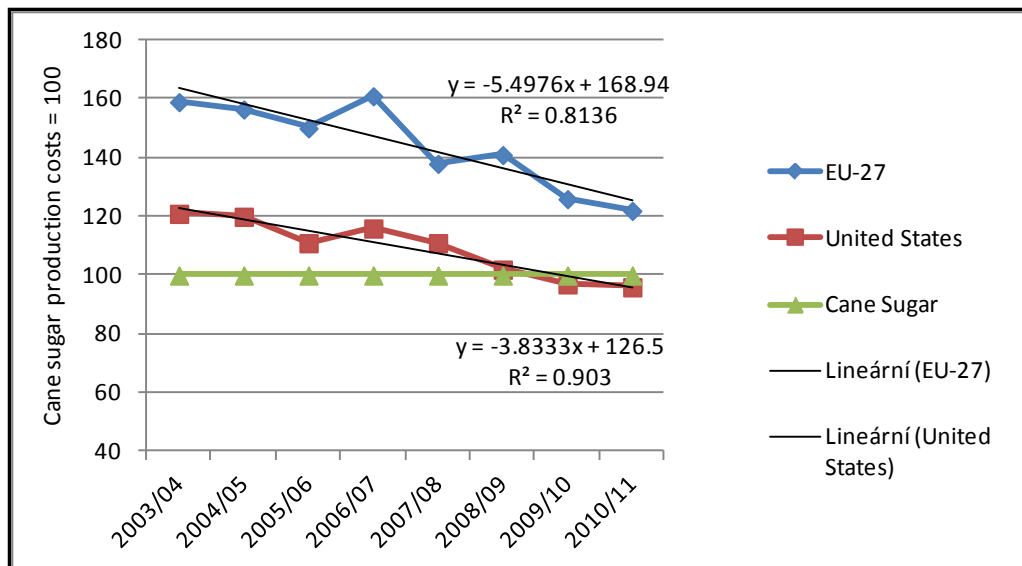
		SUGAR BEET				SUGAR CANE					
		Poland	Ukraine	United States	Germany ¹⁾	Brazil ²⁾	Australia	Thailand	S.Africa	India	United States
Yield of beet/cane	ton/ha	39.5	19.5	46.1	60.3	68.5	97.7	42.5	53.6	73.8	74.4
Sugar content	%	13.9	11.2	14.6	16.6	11.5	14.0	10.0	11.5	9.9	11.7
Sugar yield	ton/ha	5.5	2.2	6.7	10.0	7.9	13.7	4.3	6.2	7.3	8.7
COSTS	EUR/ha	945	262.5	1,877.5	2,542	762.5	1,564.5	665.5	951.5	860	2,501.5
COSTS	EUR/100 kg beet (cane)	3.29	1.35	4.1	4.22	1.12	1.60	1.55	1.77	1.16	3.36
COSTS	EUR/100 kg sugar	17.18	11.93	28.17	25.4	9.65	11.42	15.3	15.35	11.78	28.75
Cost of labour	EUR/100 kg sugar	4.40	2.80	5.42	4.49	2.35	2.55	5.10	4.20	5.98	8.68
Labour required	hour/ha	180	150	30	24	200	35	400-500	400-500	x	50
Labour costs	EUR/ha	1.35	0.31	12.50	18.70	1.05	10.70	0.50	0.60	0.23	15.00
Cost of machinery	EUR/100 kg sugar	6.23	3.35	5.99	7.50	17.50	3.67	1.07	2.85	0.83	6.85
Cost of land	EUR/100 kg sugar	0.635	0	4.96	5.32	1.65	1.83	2.33	2.01	0	4.85
Cost of lease	EUR /ha	35	0	332.5	425	100	250	100	125	0	355.5
PROFIT	EUR/ha	1,011	355	2,082	3,253	548	1,686	6,36	1,072	1,454	2,176
PROFIT	EUR/100 kg beet (cane)	2.56	1.82	4.51	5.39	0.80	1.175	1.50	2.00	1.97	2.92
PROFIT	EUR/100 kg sugar	18.38	16.13	31.06	32.55	6.99	12.30	14.83	17.30	19.91	25.00

Note : 1) Database operated by the Association of South German land (Beet Growers, 1996-2006),

2) Centre/south region: strong devaluation of the Brazilian currency

Source: Association of South German Beet Growers, USDA, 1996-2006

Table 1: Production profits and costs of beet sugar compared with cane sugar (1996-2006).



Note: Axis Y: Proportion (Cane sugar production costs = 100, Base)

Source: LMC International, Sugar and Sweetener Outlook, April 2011, own calculation

Graph 1: Sugar beet production costs (EU and U.S.) and their relation to the sugar cane production costs.

sugar yield in The Netherlands was calculated at a maximum of 23 t/ha (De Wit, 1953), more recent research found 24 t/ha sugar for Germany. However, the average sugar yield achieved by Dutch growers was 10.6 t/ha in the period 2002-2006 (Van Swaaij, 2007), only 46% of theoretical potential.

Considering the above mentioned, the IRS (Institute of Sugar Beet Research, The Netherlands) formulated the 3 x 15 target. In 2015 the present EU sugar regime may be canceled and the target for sugar beet cultivation is national sugar yield of 15 t/ha (equivalent to 60% of the sugar beet potential) and 15 EUR/tonne sugar beet of total variable costs. The costs per tonne of sugar depend on the sugar beet yield and the sugar content. This reality has been reflected in the rate of sugar beet profitability.

Graph 2 shows sugar beet production costs (EUR/tonne, year 2011) of the main European producers – France, Germany, Poland, United Kingdom and Czech Republic. Graph 2 presents comparison of the cost structure of sugar beet growing based on Agri-benchmark Cash Crop network. Based on that, cost and revenues for the individual crops on “typical farms” are calculated for the various locations (member countries).

France and Germany are the main European producers of sugar beet with 393,000 and 358,000 hectares (FAS Statistics, 2013/2014).

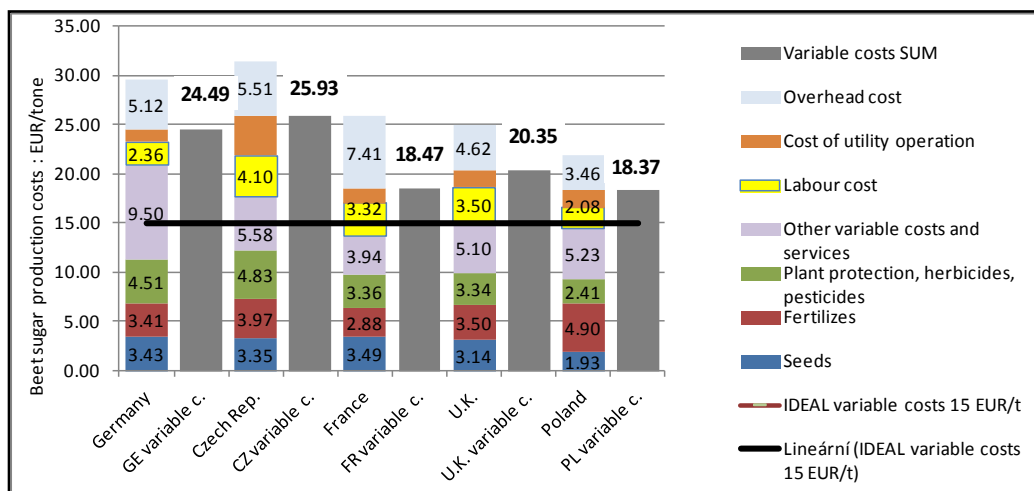
Germany and Czech Republic total costs and

variable costs (EUR/tonne) are higher than those in France, United Kingdom and Poland. Substantial differences are between cost of plant protection (in the Czech Republic and Germany 4.51-4.83 EUR/tonne, in the France, United Kingdom and Poland 2.41-3.36 EUR/tonne).

The average spent on sugarbeet herbicides in the United Kingdom in 2001 was around £105/ha (ca.158 EUR/ha). The cost of each application was about £6/ha (9 EUR/ha).

The total cost of growing sugar beet in the United Kingdom is around £1100/ha. Crop protection is an essential element and cost around £25 million (approximately £150/ha) in 2000 (British Sugar Annual Crop Surveys, 2000). Average spend per hectare on herbicides is usually between £105 and £120 /ha, on insecticides approximately £40 /ha, whilst around £15/ ha is spent on fungicides (but usually only half the crop area requires treatment against fungal leaf diseases). Average yields in the United Kingdom in 2001 are usually around 55 t/ha of roots at 16% sugar.

In France, the national average cost for herbicides used in sugarbeets is approximately 130 EUR/ha. In France, for a number of different plant species, non-transgenic herbicide-tolerant varieties (HTVs) are beginning to be cultivated or are currently the object of petitions for inclusion in the Official Catalogue of Agricultural Species and Varieties (INRA, 2011). In this context, the public authorities and evaluative bodies in France are considering the various perspectives



Source: AGRIBENCHMARK, (agribenchmark.org), Section Cash Crop, 2011-2012, own calculation

Graph 2: Structure of sugar beet production costs (EUR/tonne, year 2011).

for future development of herbicide-tolerant varieties. The Ministries of Agriculture and Ecology wish to avail themselves of analytical elements with regard to the real effects, both medium- and long-term, of the cultivation of herbicide-tolerant varieties and their compatibility with existing environmental policies, notably the French plan for the reduction of the use of pesticides (Ecophyto 2018).

Total amount of variable costs per tone of sugar beet in main European producer countries (see Graph 2) are higher than 15 EUR (ie 18.37-25.93 EUR/tone) – member countries can not reach goal 15 EUR/tone of sugar beet in the marketing year 2015/2016.

4. Czech Republic and Tereos TTD a.s.: sugar beet yield potential and beet sugar campaign 2012/2013

Assortment of present genetically single-germ sugar beet cultivars is quite wide and their yield potential and technological and growing characteristics are being improved by breeding; however, the use of these characteristics in operation conditions is very often low. The use of the yield potential in operation conditions is suitably defined by comparison of average data with the results reached in small plot trials (Pulkrábek et. al., 2008). In the period 1983-2008 the root yield in the Czech Republic increased at operation area by 0.8 tons per year and in small plot trials by 1 ton per year. During 2001-2007 the yield potential use was 71.1%. The highest use is in obtained sugar content. The use of yield potential of white sugar production reached 66.5%. The yield of white sugar increased very intensively in the time period 2001-2007 at the operation areas, yearly it increased by 0.2%. The yield of roots converted to 16% sugar content increased in the last decade very significantly, yearly in experiments by 2.35 t per ha and in operation conditions by 2.01 t per ha. The results, published in Pulkrábek et. al. (2008) prove very high production intensity and standard of new sugar beet cultivars. Production potential of sugar beet root yield reaches in the Czech Republic 110-130 tonnes from hectare, polarization sugar yield potential reaches 18-22 tonnes.

The results based on database from the Institute of Agricultural Economics and Information (IAEI) and published in Špička and Janotová (2013) show decreasing average costs per tonne of root, especially staff costs, and increasing profitability

of Czech sugar beet producers between 2007 and 2011. Most producers are highly economically effective. However, there is potential in efficiency of material costs and sugar yields. Sugar beet seems to maintain its irreplaceable position in the Czech agriculture.

The sugar campaign 2012/2013 in the Czech Republic was characterized by excellent technological quality of the processed beet and favorable climatic conditions throughout the growing and treatment seasons. A total of 4.293 mil. tons of beet were processed in the campaign with average root yield 66.99 t/ha and polarized sugar yield 11.41 t/ha. The weighted average sugar content has surpassed 17.61% (range 18.07–16.61 %) in the Czech Republic. The campaign took 110.9 days; the amount of sugar from beet was 535.5 kt in white sugar. Intensive and extensive quantities reached predominantly positive values which prove that within the European Union Czech Republic is a producer of high quality sugar beet and high quality sugar. In 2012/2013 investments in Czech sugar factories concentrated mostly on improving ecology, technology and increasing efficiency of beet products.

In the marketing year 2012/2013 operates in the Czech Republic 5 sugar companies, among which is divided quota 372 459.207 tons. Tereos TTD a.s. sugar company has a quota of 208 715.651 tons, which is 56.04 percent of national quota.

Cukrovary TTD (owned jointly by Tereos and German sugar group Nordzucker), which was bought over in the early 1990s, controls a significant part of the Czech sugar market, and its management has also been raving enthusiastically about expansions and acquisitions and producing lots of ethanol from sugar beet and selling some of it to Germany. In France and the Czech Republic Tereos is the leading sugar producer. All activities combined, Tereos sold 2.3 million tons of sugar across Europe in 2011/12.

Tereos has been supporting its cooperative growers for a long time with a view to further strengthening the quality and competitiveness of their beet production. Tereos France advises growers throughout the sugar beet growing journey, from fertilising to weed and disease control.

Tereos's results include the operations of Tereos Internacional and its original activities of sugar beet processing in Europe, which remain within the unlisted cooperative which groups 12,000

farmers. Tereos is the largest beneficiary of European Union farm subsidies in the 27-member bloc.

The company aims to raise French average yields to 110 tonnes per hectare by 2020, which combined with energy costs savings, would allow it to raise its competitiveness against sugar cane.

According to Tereos Annual Report (2012), Tereos TTD a.s. in the Czech Republic, in 2012/13, followed on from the previous year with another outstanding performance. Favourable weather conditions, increase in growing areas, efficient facilities: all indicators have progressed or been maintained. The 2012/13 Tereos TTD a.s. campaign made it possible to achieve abundant production again, with a sugar beet yield of 79.5 tons per hectare at 16%, benefiting from the favorable weather conditions.

Table 2 and Graph 3 shows sugar beet yield

in the marketing year 2006/07 - 2012/13. Used statistical methods are the Fixed Base Index Numbers and Chain Base Index Numbers.

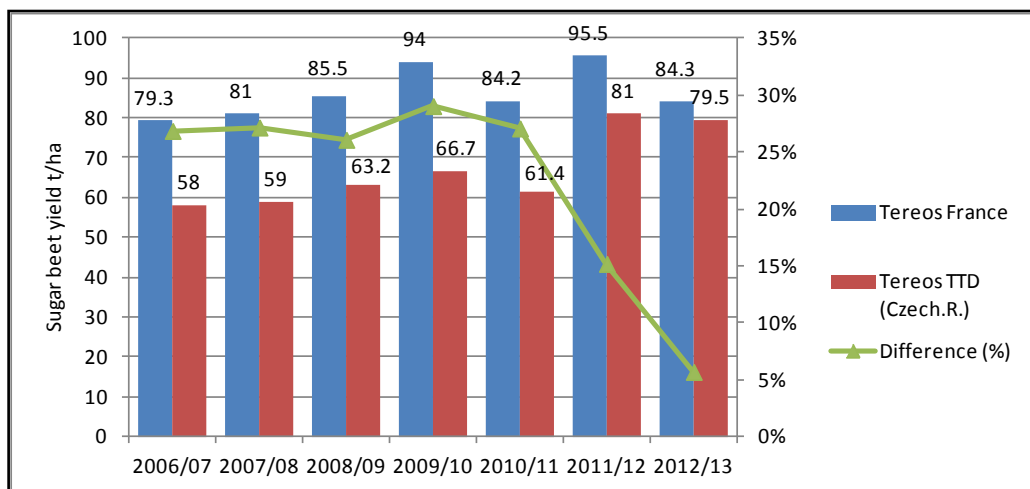
Table 2 shows the Fixed Base Index Numbers and Chain Base Index Numbers of described companies: Sugar beet yield per hectare of Tereos France and Tereos TTD a.s. (Czech Republic). Important is the dynamic in last analyzed years (2009/10 - 2012/13), because it shows the trend for next years. The Chain Base Index Numbers is higher for Tereos TTD a.s. (31.92 % in the marketing year 2011/2012) than for Tereos France (nearly 13.42% in the same period).

Graph 3 shows the difference (%) between sugar beet yield of Tereos France (Base, 100 %) and Tereos TTD a.s. (Czech Republic). In the marketing year 2006/07, the difference of yields (per hectare) was 26.86 percent, in 2012/13 difference dropped to 5.69 percent.

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Tereos France	79.3	81	85.5	94	84.2	95.5	84.3
Tereos TTD a.s.(Czech.R.)	58	59	63.2	66.7	61.4	81	79.5
Difference (%)	26.86%	27.16%	26.08%	29.04%	27.07%	15.18%	5.69%
Base index Tereos France	1	1.021	1.078	1.185	1.061	1.204	1.063
Base index Tereos TTD a.s.(Czech R.)	1	1.017	1.089	1.150	1.058	1.397	1.371
Chain index Tereos France	x	2.14%	5.56%	9.94%	-10.43%	13.42%	-11.73%
Chain index Tereos TTD a.s.(Czech R.)	x	1.72%	7.12%	5.54%	-7.95%	31.92%	-1.85%

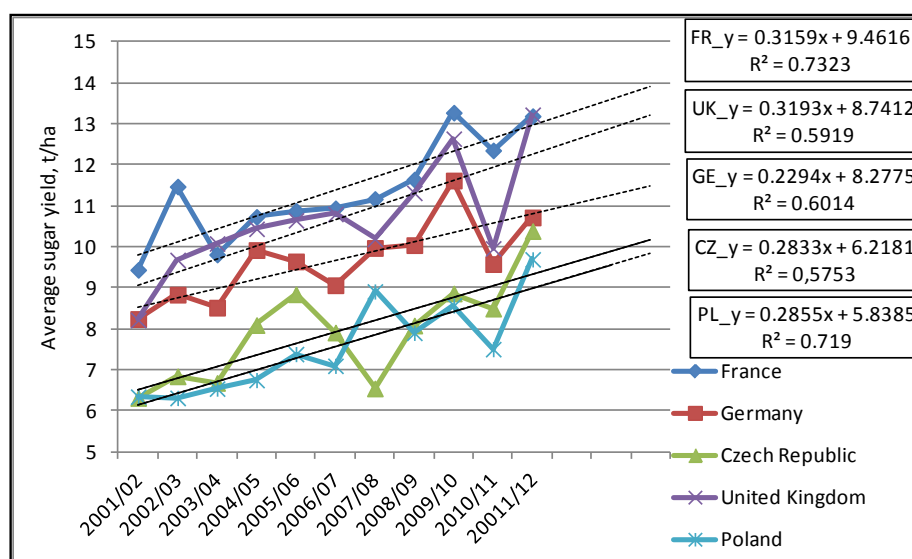
Source : TEREOS Annual Report 2012, Tereos' Communications Department, 2013, own calculation

Table 2: Sugar beet yield in the marketing year 2006/07 - 2012/13, tons per hectare, 16% sugar content.



Source: TEREOS Annual Report 2012, Tereos' Communications Department, 2013, own calculation

Graph 3: Difference (%) between sugar beet yield of Tereos France (Base, 100 %) and Tereos TTD a.s. (Czech Republic), t/ha.



Note: In statistical significance testing, the p-value is under 0.015 by all countries. The results are statistical significant.

Source : CEFS SUGAR STATISTICS 2012, Comité Européen des Fabricants de Sucre, , STATISTICA 10 Software, own calculations

Graph 4: Average sugar yield, t/ha, regression analysis of time series.

5. Future trends in beet sugar sector – regression analysis of average sugar yield (t/ha)

Regression line, calculate in the Graph 4 is linear ($y = ax + b$) and the regression coefficient is the constant (a or Beta). Regression coefficient represents the rate of change of one variable ($y = \text{sugar beet yield t/ha}$) as a function of changes in the other ($x = \text{year}$); it is the slope of the regression line.

The highest value of regression coefficient includes United Kingdom sugar yield line, Beta = 0.3193, i.e. year-to-year prediction growth is 0.3193 tons of sugar per hectare. In 2014/2015 can be achieved 13.14 t/ha of sugar yield.

The second highest value of regression coefficient includes France sugar yield line, Beta = 0.3159, i.e. year-to-year prediction growth is 0.3159 tons of sugar per hectare. In 2014/2015 can be achieved 13.97 tons of sugar per hectare.

The third highest value of regression coefficient includes Czech Republic and Poland sugar yield line, Beta = 0.2833 (0.2855), i.e. year-to-year prediction growth is 0.2833 (0.2855) tons of sugar per hectare. In 2014/2015 can be achieved in the Czech Republic 10.14 t/ha of sugar yield (Poland 9.85 t/ha).

The lowest value of regression coefficient includes Germany sugar yield line, Beta = 0.2294, i.e. year-to-year prediction growth is 0.2294 tons

of sugar per hectare. In 2014/2015 can be achieved in the Germany 11.55 t/ha of sugar yield.

The conclusions made from simple linear regression are statistically significant and correct, but there is necessary to compare the linear trends to real European situation.

The main producers of sugar beet in the European Union (i.e. France, Germany, Poland, United Kingdom and Czech Republic) can not achieve goal of sugar yield 15t/ha while maintaining the amount of variable (direct) costs at 15 EUR/1t of sugar beet in the marketing year 2015/2016.

Conclusion

The sugar beet is the strategic and energetic crop, which can multiply (by the best way) the invested energy. Sugar crops are improving the soil fertility and the growing of sugar beet increasing the yield of crops produced after the sugar beet within the crops rotation cycle. Sugar beet is not only raw material for food industry. It is used for food production (white sugar, alcohol), it is also used as a renewable source of energy (dehydrated alcohol, raw material for biogas units), feed materials (fresh beet pulp and granulated beet pulp, distiller's grains), fertilizers (green parts, carbonation lime) and CO₂ (liquid carbon dioxide for both alcoholic and nonalcoholic beverages production).

The energy balance of beet is very positive, with beet producing 15-16 times more energy than is required to produce it. Beet is playing a more significant role in the bioeconomy than before 2006 and is contributing to the aims of the Europe 2020 strategy. The sugar quota, allocated to beet growers through delivery rights, gives farmers an opportunity for stable diversification of rotation crops.

Because of its character sugar is one of the strategic commodities. Its position within the frame of global market is becoming to be more and more important especially because of the permanent growth of global consumption. The average inter annual growth rate of consumption is about 2%, i.e. about 3.9 mil. t/year. The importance of sugar in nowadays is even multiplied because of the growth of its consumption for the production of the renewable sources of energies. The expected World production of sugar in the period 2012/2013 is 177 mil. t.

The reform restricted the sugar production in the EU by about 30% (for 5.1 mil. t), it caused the reduction of number of farmers growing sugar beet by about 19 % (i.e. 150 000 sugar beet producers/farmers) and the number of sugar producing capacities by about 41 % sugar producers (i.e. 83 sugar refineries were closed). After the reforming the total area of sugar beet production in the European Union was reduced to about 1.5 – 1.6 mil. ha. The above mentioned reform is the reason why the European Union lost self-sufficiency in sugar production. The restriction of own production reduced the European Union's position on the world sugar market. The current world sugar price is dependant primarily on the demand for the sugar cane. The cane sugar production represents about 84% of the total world sugar production.

The year 2013 is crucial for the future of beet sugar production in the European Union. Regardless of its minor share, sugar beet as a raw material – compared to sugar cane – has a potential of further qualitative production growth. In the European Union, sugar beet yields reach 800-110 t/ha and white sugar yields reach 10-11 t/ha. This growth potential is also one of the main arguments for prolonging the current form of sugar regime in the European Union until 2020.

The accession of the Czech Republic into the European Union affected the Czech sugar production. The sugar reform made by the European Union in 2006 significantly influenced the Czech

sugar and sugar beet production capacities. This reform did not influence only Czech sugar industry but it has a direct impact on the whole EU sugar production capacities.

During the last two years 2011 – 2012, yields of Czech sugar beet production reached the high level. The year 2011 represented a record, the average yield of Czech sugar beet producers reached more than 70 t/ha (16% sugar content is taken in consideration for calculation of average yield volume). The same trend was recorded in the year 2012. In the year 2012, the significant differences between particular regions were recorded – producers in Czech region harvested on average cc 80 t/ha, in Morava region the yields were oscillated between 50-70 t/ha (weather was a key factor influencing the volume of yield and harvest).

During the last ten years (2002 – 2012) the average volume of Czech sugar beet yields per hectare recorded about 61 t/ha. In the same period the average yields of sugar beet per hectare increased by 57% in the Czech Republic (for example in France it was only by 39.7%). During the analyzed time period, the average growth of Czech yields per hectare (in the case of 16% sugar content) reached 2.85 t/ha the Czech Republic (for example in France it was around 2.45 t/ha).

According to the Ministry of Agriculture of the Czech Republic, it is important for the Czech Republic to keep the competitive sugar production. The reason for the keeping of competitiveness is the ability of the Czech Republic to ensure an influence on sugar price development in neighbouring countries in the moment when the EU market will be liberalized. It is necessary to use historically good experiences of Czech sugar beet and sugar producers. To be able to keep a good position on the market, it would be suitable to set the system of subsidies according to the document issued by Ministry of Agriculture “Strategy for growth for the period 2014 till 2020”. Sugar beet belongs among the stabilizing crops in crops rotation process in the Czech Republic.

Weeds can grow very well in sugar beet stands and if they are not controlled, the yield can decrease dramatically. In the Czech Republic, a system of several (normally three) post-emergent herbicide applications is currently used. For particular terms of application, herbicides and their rates are chosen according to weed spectrum and growth stages

of both the weeds and the crop. Weed management in sugar beet is relatively expensive, which is one of the main reasons why management based on herbicide tolerant (HT) sugar beet varieties has been massively used outside the European Union. The most frequently used is Roundup Ready system based on crop tolerance to glyphosate. Roundup Ready sugarbeet is an important relatively new biotech crop first commercialized in the USA and Canada in 2007, and an increased adoption rate of 59% in 2008, and 95% in 2009 when acreage

reached more than 1 million hectares (in 2011) - this makes it the fastest adopted biotech crop since the genesis of commercialization in 1996.

Acknowledgements

Pieces of knowledge introduced in this paper resulted from solution of an institutional research intention MSM 6046070906 „Economics of resources of Czech agriculture and their efficient use in frame of multifunctional agri-food systems“.

Ing. Helena Řezbová,

Department of Economics, Faculty of Economics and Management,

Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague 6, Czech Republic

Phone: +420 2 2438 2087, E-mail: rezbova@pef.czu.cz

References

- [1] Binacardi, E., McGrath, M. J., Panella, L. W., Lewellen., Stevanato., Sugar Beet (Chapter) in Root and Tuber Crops: Handbook of Plant Breeding, ed. J. E. Bradshaw, Springer Science, 2011, vol. 7., p.173–219, ISBN: 0387927646.
- [2] CEFS Sugar Statistics 2012, Comitee Europeen des Fabricants de Sucre, Brussels, 2012, [Online], Available: <http://www.comitesucre.org/userfiles/CEFS%20SUGAR%20STATISTICS%202012.pdf>, [Accessed: 5.8. 2013].
- [3] Commodity Briefing, Fairtrade and Sugar, Fairtrade Foundation, London, 2013, [Online], Available: http://www.fairtrade.org.uk/includes/documents/cm_docs/2013/F/Fairtrade%20and%20Sugar%20Briefing%20Final%20Jan13.pdf, [Accessed : 5.10. 2013].
- [4] Chochola, J., Pulkrábek., Výzkum cukrové řepy ve světě, Sugar Beet Research in the World, Listy cukrovarnické a řepářské, 2012, 128, 5-6, p.177–179, ISSN: 1210-3306.
- [5] De Wit, C.T. A physical theory on placement of fertilizers. Dissertation, 1953, Verslagen.
- [6] Landbouwkundige Onderzoekingen (59-4), Dissertation, Landbouwhogeschool Wageningen, The Netherlands.
- [7] FAO, 2009, Sugar Beet White Sugar, FAO Investment Centre Division, Rome, Italy, [Online], Available: [http://www.fao.org/fileadmin/user_upload/tci/docs/AH1\(eng\)Sugar%20beet%20white%20sugar.pdf](http://www.fao.org/fileadmin/user_upload/tci/docs/AH1(eng)Sugar%20beet%20white%20sugar.pdf) [Accessed : 25.7. 2013].
- [8] Haley, S., Polet, Z., Post-Reform European Union Sugar - Prospects for the Future, Gain Report No. E60078, 2011, [Online], Available : http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Post-Reform%20European%20Union%20Sugar%20-%20Prospects%20for%20the%20Future_Brussels%20USEU_EU-27_12-21-2011.pdf, [Accessed : 10.10. 2013].
- [9] Pauwels, J.B., Teeltkosten kunnen 20 procent lager. IRS Informatie. In: CosunMagazine, 2006, No. 8, 2006, pp. 14-15 and CSM Informatie No. 555, pp. 14-15., ISSN: 0165-9375.
- [10] Pylor, R. D., Koo, W. W. Outlook of the U.S. and World Sugar Markets, 2010-2020, 2012.
- [11] Agribusiness & Applied Economics Report 692, North Dakota State University, Available: <http://ageconsearch.umn.edu/bitstream/128037/2/AAE692.pdf> [Accessed : 14.8. 2013].
- [12] Pulkrábek, J., Kavka, M., Rataj,V., Humpál, J., Nozdrovický, L., Trávníček Z., Pačula V. The assessment of the economic risks level of sugar beet growing for the farm economy, Agricultural Economics – Czech, Czech Academy of Agricultural Sciences, 2012 (1), 58, p.41-48, ISSN 0139-570X (Print).

- [13] Pulkrábek, J., Černý, I., Pačuta, V., Urban, J., Erhartová, D. Use of yield potential of sugar beet cultivars in the the Czech Republic, *Acta fytotechnica et zootechnica*, 2008, Vol. 11, No. 2, pp, ISSN 1335-258X.
- [14] Reinbergr, O. Výroba cukru 2011/2012 – svět, Evropa, Česká republika (Sugar production 2011/2012 – World, Europe, Czech Republic, in Czech), *Listy cukrovarnické a řepařské*, 2012, 128, 7-8, p.218-222, ISSN: 1210-3306.
- [15] Richardson, K., Traditional Breeding in Sugar Beet, *Sugar Tech*, September and December 2010, 12 (3-4), p. 181-186, DOI 10.1007/s12355-010-0050-4, ISSN: 0972-1525, 0974-0740 (Print).
- [16] Rodrigo, Morillo-Velarde, Water Management in Sugar Beet, *Sugar Tech*, September and December 2010, 12 (3-4), p.299-304, DOI 10.1007/s12355-010-0038-0, ISSN: 0972-1525, 0974-0740 (Print).
- [17] Smutka, L., Rumánková, L., Pulkrábek, J., Benešová, I. Hlavní determinanty nabídky a poptávky na světovém trhu s cukrem (Main Determinants of Supply and Demand on World Sugar Market, in Czech), *Listy cukrovarnické a řepařské*, 2013, 129, 4, p.142-145, ISSN: 1210-3306.
- [18] Smutka L., Benešová I., Pulkrábek J., Belova A., Urban J.: Vývoj a postavení cukrovarnictví v zemích EU v letech 2000-2011 (Development and Position of Sugar Industry in the European Union in 2000-2011, in Czech), *Listy cukrovarnické a řepařské*, 2013, 129, 1, p.22-27, ISSN: 1210-3306.
- [19] Strnadová, H. Dosavadní vývoj a perspektivy trhu s cukrovkou a cukrem (Actual progress and perspective of sugar-beet and sugar market, in Czech), *Listy cukrovarnické a řepařské*, 2009, 125, p.334-340, ISSN: 1210-3306.
- [20] Sugar and Sweetener Outlook, April 2011, World Sugar and High Fructose Syrup Production Costs: 2000/01-2009/10, Economic Research Service [Online], Available: http://www.ers.usda.gov/media/572790/sssm272_1_.pdf#page=13, [Accessed : 12.9. 2013].
- [21] Svatoš, M., Maitah, M., Belova, A., World Sugar Market – Basic Development Trends and Tendencies, *Agris on-line Papers in Economics and Informatics*, Prague, 2012, Vol. 4, No. 2, p.73-88, ISSN 1804-1930.
- [22] Swaaij, A. C. P. M. Opbrengstprognose. In: *Betatip*, 7. IRS, Bergen op Zoom, 2006, The Netherlands, p. 11-13.
- [23] Špička, J., Janotová, B. Náklady pěstování cukrové řepy v ČR a jejich mezinárodní srovnání (Costs of Sugar Beet Growing in the Czech Republic and International Comparison, in Czech), *Listy cukrovarnické a řepařské*, 2013, 129, 7-8, p.210-213, ISSN: 1210-3306.
- [24] USDA, 2012, Foreign Agricultural Service, Sugar: World Markets and Trade, [Online], Available: <http://www.fas.usda.gov/psdonline/circulars/sugar.pdf>, [Accessed: 20.6.2013]
- [25] Zeddies, J., 2006. Die neue EU-Zuckermarktordnung - Beschlüsse, Auswirkungen und Bewertung. *Agrarwirtschaft* 55, 97-99., ISSN: 0002-1121.

Databases:

- [1] CEFS SUGAR STATISTICS 2012, Comité Européen des Fabricants de Sucre, [Online], Available: <http://www.comitesucre.org/userfiles/CEFS%20SUGAR%20STATISTICS%202012.pdf>, [Accessed: 9.9.2013-12.10.2013].
- [2] The John Nix Farm Mangement Pocketbook, 42th edition 2012, Agro Business Consultants Ltd., 2011, 280 p., ISBN 978-0-9514588-8-4.
- [3] TEREOS Annual Report 2012, Tereos' Communications Department, 2013, [Online], Available: <http://tereos.com/annual-report-2012/>, [Accessed : 12.10.2013].
- [4] AGRIBENCHMARK, (agribenchmark.org), Section Cash Crop, 2011-2012, [Online], Available: <http://www.agribenchmark.org/cash-crop.html>, [Accessed : 7.10.2013]

- [5] GAIN Report Number E80045: EU-27 Sugar Semi-annual Report 9/2013, USDA Foreign Agricultural Services, prepared by Polet, Y., 2013, [Online], Available : http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Sugar%20Semi-annual_Brussels%20USEU_EU-27_9-27-2013.pdf, [Accessed : 12.9.2013].
- [6] FAOSTAT dabase, Crops (2011,2012), [Online], Available: <http://faostat.fao.org/site/567/default.aspx#ancor>, [Accessed : 11.8.2013].