



Production of alternative fuel in the sugar industry in Ukraine

Andriy V. Doronin¹, Lesya M. Karpuk^{*2}

¹*Department of Agriculture, Melioration and Mechanization,*

National Academy of Agrarian Sciences of Ukraine, Kyiv, Ukraine

²*Department of Agriculture, Agricultural Chemistry and Soil Science,*

Bila Tserkva National Agrarian University, Bila Tserkva, Kyiv region, Ukraine

Key words: Sugar Beets, Sugar, Biogas, Bioethanol, Diversification

<http://dx.doi.org/10.12692/ijb/9.5.78-85>

Article published on November 21, 2016

Abstract

The evaluation of the production efficiency of sugar beets and sugar in Ukraine for the period of 2001–2015 was made. The preconditions of negative changes in the sugar branch were studied. The output of sugar production in Ukraine depends on the gross harvest of sugar beets, their yielding capacity and the sown area under this crop. A polynomial model which describes the yielding capacity level of sugar beets in Ukraine in 1913–2015 has been worked out; the prediction of sugar beet yield for the year of 2017 has been made and its increase to 56 t/ha is expected. Diversification trends of the supply of sugar-mills which will favor the efficiency enhancement of sugar beet production have been explained. As the problem of supplying our country with power-carriers becomes urgent, it is expedient to speed up and diversify the manufacture of alternative fuel kinds, in particular, bio ethanol and biogas. The ways of the efficiency enhancement of sugar beet production to ensure stable business development in the branch which requires active government support of producers have been identified. The research results can help solve practical problems of farm enterprises and in agrarian business in general.

* **Corresponding Author:** Lesya Karpuk ✉ lesya_karpuk@ukr.net

Introduction

Current state of sugar beet production and sugar branch of Ukraine explains the necessity to create conditions to ensure efficient sugar beet production and their processing for sugar. However, the factors of the efficiency enhancement of the branch businesses are not coordinated well or they are not used to due extent, which makes economic situation at sugar market more complicated due to its over- or under-production and a low level of producers' efficiency does not provide extended reproduction.

The importance of the output of sugar and sugar beet production consists not only in the source of the production of the important foodstuff sugar. A market of alternative fuel kinds based on the use of sugar and starch-bearing agricultural crops and processed products is created across the world.

As the problem of supplying our country with power-carriers becomes urgent, it is expedient to speed up and diversify the manufacture of alternative fuel kinds, in particular, bio ethanol and biogas. The challenges of the development of the sugar beet production should be clearly determined at a national level – the use of sugar beets and the products of their processing for the manufacture of alternative fuel.

The issues of production and consumption of alternative kinds of fuel are discussed in the works of O. Varchenko, H. Kaletnik, M. Kodenska, V. Mesel-Veseliak, M. Royik, O. Shpychak, O. Zakharchuk, V. Bondar, A. Fursa, M. Yarchuk, O. Chetveryk and others. However, the issue of diversification trends of the supply of sugar-mills needs additional studying.

The purpose of the research is to ground diversification improvement of marketing policy of sugar-mills which will facilitate both competitive power of the output and the rebirth of the branch of sugar beet production.

Material and methods

Such practices as system analysis and logical generalization were used in the process writing this paper to study preconditions of negative changes in sugar beet production and sugar branch; comparative analysis to analyze statistical information; economic-mathematic modeling – to work out a polynomial model which describes the level of sugar beet yielding capacity in Ukraine; settlement constructive to determine the indicators of economic efficiency in sugar beet production; monographic method proved the necessity to diversify branch output; induction and deduction – to generalize the research results; abstract-logic – to make conclusions and suggestions

Results and discussion

In Ukraine in the early 90-ties of the XX century during the transition to market relations, the conditions for free pricing were created for all branches of the economy, and approximate prices were introduced for agriculture; the prices of farm products grew much slower than those of goods and services consumed in agriculture which resulted in price disparity in favor of farmers.

This, in turn, affected the structure of the sown areas, those under industrial crops (as they are more profitable) being increased (Statistics Annual Book of Ukraine of the year of 2014) (Table 1).

Table 1. Structure of the sown areas in Ukraine (farms of all categories).

Agricultural crops	Structure of the sown areas by the years, %	
	1990	2014
Grain crops	45.0	54.3
Industrial crops	11.6	31.0
Fodder crops	37.0	7.7
Potatoes and vegetable and melon crops	6.4	7.0

Thus, in the years of 1990- 2014 a noticeable increase of industrial crop share in the total sown area was observed in the structure of the sown area under agricultural crops 11.6% in 1990 to 31.0% in 2014, grain crops- 45.0 in 1990 to 54.3 in 2014, respectively.

A significant decrease of forage crop share – 37.0% in 1990 to 7.7% in 2014 was observed, it had a negative effect on the development of livestock production in Ukraine. Potatoes and vegetable and melon crops remain almost the same in the structure of the sown area- 6.4% in 1990 to 7.0% in 2014.

During the period of 2010- 2015 the level of production profitability of sunflower seed increased from 64.7% in 2010 to 80.5% in 2015. During the same period the profitability level increased, respectively rapeseed from 26.6% to 44.3%, soybean from 16.4% to 38.6%, sugar beet from 16.7% to 28.2%. Efficiency of corn production increased from 29.9% in 2010 to 50.3% in 2015, wheat 9.6% to 36.4%, respectively (Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year of 2010, 2011, 2012, 2013, 2014, 2015) (Table 2).

Table 2. Economic production efficiency of the main agricultural crops in Ukraine in 2010–2015 (agricultural enterprises).

Agricultural crops	Level of profitability by the years, %					
	2010	2011	2012	2013	2014	2015
Seed of sunflower	64.7	57.0	45.8	28.5	36.5	80.5
Rapeseed	26.6	32.1	21.4	8.6	29.2	44.3
Soybean	16.4	24.1	23.4	15.8	34.5	38.6
Sugar beet	16.7	36.5	15.7	2.7	17.9	28.2
Corn	29.9	38.6	19.8	1.5	26.2	50.3
Wheat	9.6	17.6	11.8	2.4	28.0	36.4

Ukraine is obliged to consider the European standards concerning the use of biofuels in the context of its entry to the European Energy Community. Therefore, the country has the obligation to bring the biological component in motor fuel up to 10% by the year of 2020.

Bio-ethanol production is possible at the ethyl and sugar factories re-equipped for this production. The manufacture in several areas is possible at sugar processing factories, namely: the workshop producing ethanol is mounted – the plant produces sugar by the traditional technology, and it manufactures bio-ethanol using the products of sweet root processing, or only the bio-ethanol production from sugar beet (crude juice) is planned.

Also the bio-ethanol production is possible when starch crops such as wheat and corn are used; the products of their processing are used for human nutrition.

At present sugar beet production and sugar branch of Ukraine are in a difficult situation. Due to the lack of circulating assets and proper logistics sugar-planting companies are not interested in growing sugar beets, and sugar-mills do not have enough sugar raw materials. The output of sugar production in Ukraine depends on the gross harvest of sugar beets, their yielding capacity and the sown area under this crop.

One of the ways to increase the efficiency of sugar beet production in Ukraine is to follow production technologies of growing sugar beets, their main elements are plant nutrition and pest management (pests, diseases and weeds); the latter together with soil-climatic conditions favor the yield increase and its harvest volume per hectare (Crop production of Ukraine: Statistical Bulletin of the year of 2015; Yarchuk M.M., 2015) (Table 3).

Table 3. Production efficiency of sugar beets in Ukraine.

Indicator	Year						2015 in % to	
	2001	2011	2012	2013	2014	2015	2001	2014
Sugar beet production, mln t	15.57	18.74	18.44	10.79	15.73	10.33	66.3	65.7
Yield, t/ha	18.26	36.33	41.08	39.89	47.65	43.58	238.7	91.5
Sugar content, %	15.17	16.63	16.11	16.26	17.05	17.63	-	-
Sugar harvest, t/ha	2.77	6.04	6.62	6.49	8.12	7.68	277.3	94.6

The yield increase of sugar beets resulted from the development of arable farming and better observance of the technologies. In 2001 producers applied 90 kg of acting substance (as) of mineral fertilizers per hectare, then in 2015 – 274 kg, i.e., three times more (Application of mineral and organic fertilizers under agricultural crops in 2015: Statistics Bulletin). Close direct correlation between the amount of mineral fertilizers applied and the root yield was determined. The correlation coefficient is 0.93. Recently special attention has been paid to the protection of sugar beets from pests and diseases which decrease their productivity considerably. In 2001, 8.9% of sugar beet area before harvesting was protected from diseases (mainly cercosporosis), in recent years all the field have been protected. Sugar beet fields were better protected from weeds as well. In 2001, 65.9% were treated with herbicides, and then in recent years every sugar beet field has been treated with herbicides three times.

As to soil potential, peculiarities of climatic conditions, a sugar belt was determined by the Institute of bio energetic crops and sugar beets of Ukraine's NAAS (Royik M.V., 2001).

The most favorable zone for sugar beet cultivation, where 55–60 t/ha can be harvested, is western regions of Ukraine – Volyn, Ivano-Frankivsk, Lviv, Rivne, Ternopil and Khmelnytsk. The less favorable zone, where 50–55 t/ha can be harvested, includes Vinnytsia, Zhytomyr, Kyiv, Poltava, Sumy, Kharkiv, Cherkasy and Chernihiv regions. The area where only 45–50 t/ha can be harvested is Kirovohrad and Chernivtsi regions. The rest of the regions, where sugar beets are grown and which are not included in a sugar beet belt, are unfavorable for sugar beet production because of their soil-climatic conditions.

Recently, integrated companies in the sugar branch have been created; they participated in the season of sugar beet processing of 2015–yield, as a result 75.7% of sugar was produced to the total production. Production concentration of sugar raw material in powerful specialized companies makes it possible to grow sugar beets using intensive technologies which in turn results in the increase of yield and gross output. In recent years the number of working sugar-mills for sugar beet processing has been reduced by four times. And the sugar output at Ukraine's sugar-mills increased from 11.4% in 2001 to 14.68% in 2015 (Yarchuk M.M., 2015) (Table 4).

Table 4. Indicators of sugar beet processing and sugar production in Ukraine.

Indicator	Year						2015 p. in % to	
	2001	2011	2012	2013	2014	2015	2001	2014
Number of working mills	147	77	63	38	48	36	24.5	75.0
Processed beets, mln t	14.57	17.36	17.17	9.06	14.81	9.72	66.7	65.6
Sugar produced from beets, mln t	1.33	2.33	2.14	1.26	2.05	1.43	107.5	69.8
Produced sugar, t/ha	1.56	4.52	4.77	4.66	6.22	6.03	386.5	96.9
Average daily amount of processed beets per 1 sugar mill, th t/day	2.71	3.12	3.38	3.62	3.75	3.75	138.4	100.0
Sugar output, %	11.40	13.46	12.95	13.35	14.04	14.68	-	-

Within the year of 2015 sugar mills of Ukraine received 9.91 mln t of sugar raw material or less by 34.6% compared with 2001, they processed 9.72 mln t of sugar beets and produced 1.43 mln t of sugar or 6.03 t/ha which does not satisfy the need of the internal market of Ukraine to its full scale.

It has to be mentioned that 25 sugar mills which operated in 2015–season consumed natural gas for their production needs. Total consumption at these mills was 214.4 mln m³ of natural gas, and natural gas consumption per 1 t of processed sugar beets was 34.07 m³ comparing to 34.4 in 2014. The share of fuel and power in processing production cost of 1 t of sugar beets is about 38%, and its share in sugar production cost is 27%. It encouraged sugar mills to look for alternative kinds of fuel to substitute natural gas.

According to the statistics of the National association of sugar producers of Ukraine “Ukrtsukor”, at the beginning of operation season 2015 some renovation work concerning the preparation of the systems for using furnace fuel oil was carried out at several sugar mills; a number of sugar mills started their operation with total or partial substitution of natural gas. In 2015 sugar mills consumed 15.6 th t of pellet, 6.1 mln m³ of biogas, 13.2 th t of peat, 68.5 th t of bituminous coal for their operation needs. It made it possible to substitute 100 mln m³ of natural gas with alternative fuels during the operation season. As the average price of 1000 cubic meters of natural gas is UAH (Ukrainian Hryvnia) 6600 (Decision of the National board which exercises public regulation in the spheres of power engineering and communal services “The establishment of price ceiling of natural gas for industrial consumers and other business entities” of August 27, 2015 № 2229) or USD (United States Dollar) 302, cost cutting is UAH 660 mln or USD 30 mln (The official exchange rate of the National Bank of Ukraine in 2015: USD 100 = UAH 2184.47).

The power balance of a sugar mill shows that 85–90% of the total fuel consumption goes for the manufacture of heat energy for technological needs, and 10–15% - for the manufacture of electric power,

lime and carbon dioxide. So, a significant way to reduce specific consumption of fuel-power resources is to reduce heat power consumption for sugar beet processing.

The necessity to diversify the supply of sugar mills is defined not only by high dependence of the country on power resource import, but also by the need to have reserve capacities to process the surplus of the produced output taking into account a cyclic and risky nature of sugar beet production. Based on a polynomial model which describes the yielding capacity level of sugar beets in Ukraine in 1913–2015, the prediction of sugar beet yield has been made and its increase by 28% is expected (Figure 1). So, the pre-conditions for the introduction of bio fuel exist in Ukraine, namely, by means of output diversification of the sugar branch.

Hence, the development of commodity policy and the extension of product range of sugar mills is one of the most promising and efficient ways which will facilitate the efficiency enhancement of sugar branch companies. The intensification of this trend is possible in the conditions of total and rational use of raw materials which come for sugar manufacture, and also in the conditions of complex processing of by-products of sugar production.

The importance of sugar beets is not limited to the manufacture of sugar. When sugar beet is processed, beet pulp and molasses are produced. Beet pulp is used to feed animals and to manufacture pectin glue, used in textile production. Molasses is widely used in animal feed manufacture. It is raw material for spirit/alcohol production as well as glycerin, good yeast for bakery industry (Sabluk P.T., Kodenska M.Yu., Vlasov V.I. *et al.* 2007).

Taking into consideration the world experience as to the use of sugar raw material to produce alternative fuel, it would be expedient to use it at sugar mills of Ukraine. It is possible to set up the production of bio ethanol from sugar beet processed products, and that of biogas – from beet pulp.

The use of sugar beets and their processed products to manufacture other items in addition to sugar makes them competitive compared with other agricultural crops.

In Ukraine the developed sugar beet production is a universal basis for the production of bioethanol (Table 5).

Table 5. The calculation of the output of bioethanol from various types of raw materials by the different yields.

Raw	The output of bioethanol from 1t of production, t	The output of bioethanol in calculating per 1 ha depending on the yields of culture, t	
		yield	output of bioethanol
Sugar beets (crude juice)	0.074–0.079	40.0	2.96–3.16
		50.0	3.70–3.95
		60.0	4.44–4.74
Molasses (processing of sugar beet into sugar)	0.222–0.237	1.56	0.35–0.37
		1.95	0.43–0.46
		2.34	0.52–0.55
Wheat	0.237–0.311	3.0	0.71–0.93
		4.0	0.95–1.24
		5.0	1.19–1.56
Corn	0.321–0.346	4.0	1.28–1.38
		5.0	1.61–1.73
		6.0	1.93–2.08

The greatest output of bioethanol per unit area at the appropriate level of yield can be obtained from the sugar beets. However, in the processing of sugar beet into sugar we get the molasses, and depending on its quality the output of bioethanol from 1t can be 0.222–0.237 t.

Considering the world experience of using sugar beets for bioethanol production as an alternative fuel, it would be appropriate to implement it at the sugar processing factories of Ukraine. The need to diversify a sub-complex of sugar beet production is determined not only by the country's high dependence on energy resource import, but also by the necessity to have additional facilities to process the excess production, taking into account the cyclical and risk nature of sugar beet production.

The production of bio ethanol is possible by using several schemes. The first option is to set up the workshop for bio ethanol manufacture at the sugar mill. The mill produces sugar with help of traditional technologies, and bio ethanol from molasses. The second option is to produce bio ethanol from syrup. This practice can be used at alcohol-producing plants situated near sugar-mills.

Another way to manufacture bio ethanol envisages the manufacture of sugar and bio ethanol from molasses and syrup. In this case two processes are combined at the mill, and correspondingly, its productivity increases and production cost of the output decreases.

The optimal practice is the construction of combined workshops at sugar-mills and alcohol-producing plants; during sugar beet harvesting season they will manufacture bio ethanol from processed products, and in-between season (shoulder period) – from grain wastes of headed grain crops or corn.

At present processing, storage and utilization of beet pulp present a problem for the majority of sugar mills in Ukraine. The economic conditions of running business in the regions of sugar beet processing and the availability of sugar beet processing companies affect the solution of this problem. The main promising trends in the consumption and utilization of beet pulp are: valuable fodder for cattle, pectin concentrate and pectin glue, biogas with further manufacture of electric power. One of the potential ways to create demand for beet pulp is its use as valuable fodder for cattle.

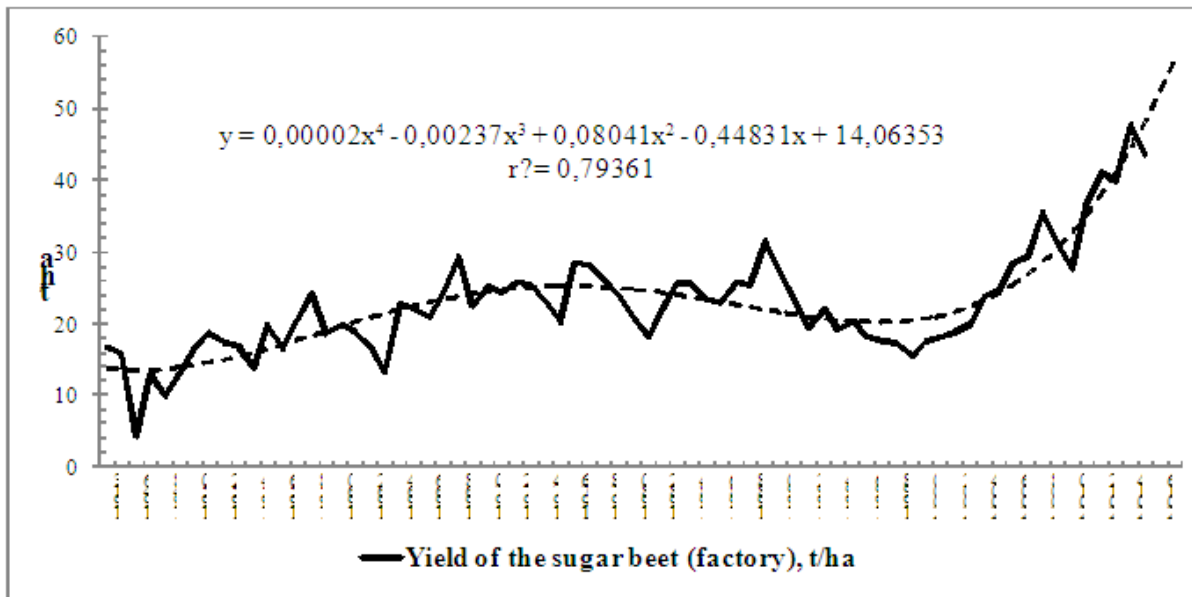


Fig. 1. The dynamics of the sugar beet (factory) yields in Ukraine by the years.

Alongside with this, a considerable amount of biogas will be consumed by sugar mills for their own needs, however, if proper equipment is used, then the remaining power can be sold to other consumers according to “green tariff”. It is possible to use units for simultaneous manufacture of electric power and heat, and also special equipment for biogas cleaning and using it as traditional fuel for vehicles and other agricultural machinery.

Among other kinds of alternative fuel sources for the companies of the sugar branch and sugar mills in particular, the use of biogas is the most economically advisable and acceptable one. However, producers face some difficulties in introducing biogas units, namely, large initial investment expenses (it costs UAH 200 mln or USD 9.1 mln to build and put into operation a biogas unit with power capacity equal to 2.25 MVt); low credit activity in the sugar industry; the necessity to get a license to produce biogas; the lack of standard documentation for design, construction and operation of biogas units, etc. The lack of building code for biogas reactors is a legal problem.

Conclusions

The increase of sugar beet productivity will satisfy the needs of sugar in the internal/domestic market, and it will result in the output diversification of sugar mills as well.

In addition to sugar, it is expedient to produce heat and electric power, bio ethanol and biogas at the sugar mills. Supply diversification of the sugar mills will allow: to set up the manufacture of ecologically clean alternative fuel bioethanol, biogas, and also that of electric power according to “green tariff”; to create jobs; to increase business profits; livestock production will receive additional fodder; to decrease the dependence on fuel import and to guarantee food security of Ukraine.

Acknowledgments. The authors wish to thank Maria Kodenska (Economist) for critical review and editing of the manuscript. The authors have no conflict of interest to declare.

References

Statistics Annual Book of Ukraine of the year. 2014. Kyiv: State statistics committee of Ukraine, 2015. 586 p.

Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year. 2010. Kyiv: State statistics committee of Ukraine, 2011. 88 p.

Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year. 2011. Kyiv: State statistics committee of Ukraine, 2012. 88 p.

Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year. 2012. Kyiv: State statistics committee of Ukraine, 2013. 88 p.

Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year. 2013. Kyiv: State statistics committee of Ukraine, 2014. 84 p.

Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year. 2014. Kyiv: State statistics committee of Ukraine, 2015. 84 p.

Basic economic indicators of agricultural production at agricultural enterprises: Statistics Bulletin of the year. 2015. Kyiv: State statistics committee of Ukraine, 2016. 48 p.

Crop production of Ukraine: Statistical Bulletin of the year. 2015. Kyiv: State statistics committee of Ukraine, 2016. 180 p.

Yarchuk MM. 2015. Work of the sugar mills of Ukraine when processing sugar beets in 2014. Proceedings of the international scientific-technical conference of sugar producers of Ukraine, devoted to the memory of academician I.S. Hulyi, (Kyiv, March 25-27, 2015). Kyiv: Sugar of Ukraine. P. 10–40.

Application of mineral and organic fertilizers under agricultural crops in Statistics Bulletin. 2015. Kyiv: State statistics committee of Ukraine, 2016. 52 p.

Royik MV. 2001. Beets / M.V. Royik. – Kyiv : XXI Vik-RIA TRUD–KYIV. 320 p.

Decision of the National board which exercises public regulation in the spheres of power engineering and communal services “The establishment of price ceiling of natural gas for industrial consumers and other business entities” of August. 2015. No. 2229 [Electronic resource]. Access mode: www.nerc.gov.ua/index.php?id=147115

Sabluk PT, Kodenska MYU, Vlasov VI. 2007. Sugar beet production of Ukraine: problems of rebirth, development trends. K.: NNTs IAE. 390 p.