UDC 620.952:658.589(447)

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TECHNICAL, ECONOMIC AND ENVIRONMENTAL ASPECTS OF BIOETHANOL PRODUCTION IN UKRAINE

According to the conclusions of the leading Ukrainian and foreign scientists, Ukraine ranks the third place in the area of agricultural land in Europe and possesses 25% of the world's black soil. By the State Land Committee the agricultural land area of Ukraine is 42,813.7 hectares, including the area of farmland - 41,596.4 hectares, arable land - 32.4 hectares.

Soil and climatic conditions of Ukraine are favorable for cultivation of many energy crops, namely maize, triticale, wheat, various kinds of sorghum and millet, potatoes, rice, sunflower, canola, soybean and flax. Currently, Ukraine annually grows and gathers about 45-50 million tons of grain. According to the forecasts, in the 2011-2012 marketing year, the export of Ukrainian grain will be 21.5 million tons, that is 1.8 times more than the last season.

As Ukraine collects such high yields of bioenergy crops and exports a large number of them, we can provide the replacement of about 30% of traditional fuel energy sources by biofuels without the threat of food and environmental safety of the state, if it recycles them into bioethanol and biodiesel inside the country.

Bioethanol production in Ukraine can be provided both by building new factories, and through conversion of existing sugar and alcohol plants.

By the Law "On the development of the production and the consumption of biofuels," which was adopted in Ukraine in 2012 the use of mixed gasoline and motor fuels containing ethanol in the following proportions is provided: in 2012 – at least 2% in 2013 – at least 5.75 % in 2014 – at least 15% in 2015 – at least 20%. This will

allow Ukraine to reduce the dependence on imported petroleum fuel energy sources and join the modern world trends in climate protection.

Keywords: *bioethanol, energy crops, environmental safety, food safety, resource saving technologies, energy balance.*

Introduction. Increasing pollution of the environment, infringement of thermal balance of the atmosphere leading gradually to global climate changes, and also deficiency of energy and limitation of fuel resources have shown the inevitability of progress towards non-conventional alternative energy sources with more increasing sharpness.

For Ukraine, strategic goal of which is EU integration, the development of bioenergy is especially important. At the present stage of the development of the state the alternative fuels are the main catalyst for the new global trends at the market of agricultural products of Ukraine. It is caused by the reduction of the mineral resources, high dependence on oil imports, the change of the structure of agricultural production and the continuing increase in disparity in prices for energy, industrial and agricultural products.

Today the share of fossil fuel in the world power consumption makes 82-85% of the general power consumption, of atomic energy more than 6% and renewed energy sources about 15%, but without taking into account large Hydroelectric Power Stations it is 12% (Saliev, 2010).

According to the statement of British scientists (Ramage & Scurlock, 1996), the share of biomass energy in the whole world reaches about 14%. The agricultural sector of Ukraine has the great potential to supply raw materials that are required for the bioenergy production. Nowadays the share of biomass of the energy supply in our country is about 2.5%. In recalculation on oil it is about 0.7 million tons of equivalent fuel. However, the research of the Institute of Technical Thermodynamics of Ukraine has found that the biomass in Ukraine can meet 30% of the amount of primary energy consumption without threat to food security of the country (Kaletnik, 2008).

Problem statement. The energy factor in today's conditions of globalization of the international economic and geopolitical relations becomes of the dominant value because it is the most important social and industrial infrastructure of each country, and is the most important field of the international business, significant items and means of cooperation between the countries.

Energy cooperation on international and regional levels is a way to secure the use of energy resources for sustainable development in the interests of both the international community and individual countries. Global energy security – is a comprehensive concept that includes not just a reliable providing of global economy with the different kinds of energy at reasonable prices and with minimal losses to the environment (minimal negative impact), but the state of security of the international community and all its members against the possible risks and threats to the political stability in the world and their steady social and economic development that is associated with both current and future status of the global energy sector.

Usually, the position of the country in the world is characterized by the energy power supply factor representing relation of its own manufacture of power resources to their consumption. If the factor is less than a unit – the country satisfies the requirements at the expense of import of power resources. If the factor is greater than a unit – the country exports the resource. Another research (Saliev, 2010) has shown that in compliance with the operative data of security, power resources factor of the countries called the “Big Eight” looks as follows: Canada – 1,5; France – 0,5; Germany – 0,4; Italy – 0,16; Japan – 0,2; Great Britain – 1,2; the USA – 0,74; the Russian Federation – 1,6; and in Ukraine the power security factor is 0,77.

Ukraine has a great potential to become one of the world leading countries in the global market of biological resources. Intensification of the problem of the environmental pollution by the organic waste and the increasing shortage of energy resources are the main motives in Ukraine for the intensification of the domestic and international developments in the field of the production and the effective use of biofuels in general and in particular of bioethanol.

Materials and methods. This research was conducted with the aim to examine technical and environmental aspects of bioethanol industry in Ukraine and to identify economic advantages of its production from the main traditional and new perspective sugar and starch-containing energy crops. The materials for research include statistical and analytical data which were subject to mathematical and graphic processing. Economic and technical aspects of bioethanol production in Ukraine was researched with subsequent quantative results and environmental security was calculated by means of scientifically-based mathematical methods.

Quantitative results. Ukraine is characterized by unequal distribution of rainfall, their annual amount decreases from the west to the south and southeast from 650-600 mm to 300 mm. Most of precipitation is in the mountains - more than 1200 mm. In the south, in the steppe zone, there is a lack of moisture and in some years droughts may happen. The average annual temperature ranges from - 8 º C in January to + 20 º C in July. A frequent change of weather is associated with cyclones (average quantity during a year is 45) and anticyclones (36). However, in Ukraine days of clear and sunny weather dominate - on the average of 230-235 per year. The duration of frost-free period ranges from 150-160 days in the north to 200-210 days in the south.

Ukraine should use its favorable conditions for biomass cultivation. Biomass is defined as all plant materials, including wood, grass and by-products which are produced at their harvesting and processing. (Gover & Mishra, 1996). Due to a moderately continental climate and large stockpiles of the world's black soil, energetic crops for biofuel production in Ukraine can be placed as follows: corn, triticale, wheat, various kinds of sorghum and millet, sunflower, canola, agriculture and forestry wastes. The most perspective crops for the production of ethanol fuel in Ukraine should be considered agricultural crops and their primary processing products high in sugar or starch - corn, feed grains, sugar and grain sorghum, sugar beets, wastes and sugar production intermediates, such as molasses, amount of which is about 2 million tons / year. The raw materials for ethanol fuel can also be potato, Jerusalem artichoke and special industrial crops. Energy crops for ethanol production

in the European climatic zone are considered high sugar- and starch- containing plants such as grain, potato, sugar beets, corn grain (Kaletnik & Pryshliak, 2010) (Table 1).

Table 1

Possible output of bioethanol from growing different agricultural crops

Crop	**Yield, t/ha**	**Bioethanol yield, litteres/ha**
Sugar beets	50	4878
Jerusalem artichokes	30	2610
Chicory	35	3248
Potatoes	32,4	3693
Corn (grain)	6,9	2874
Wheat	7,2	2854
Barley	5,8	2150

Table 1 shows that corn grain has the highest output of bioethanol per unit of production – on average to 400 l from 1 t of grain. However, Shiyan, Sosnitsky, & Oliynichuk, (2009) have shown that the output of ethanol can differ depending on the technology that is used: in "dry" milling from 1 ton of corn 401 l of ethanol, 325 kg of dry matter; in "wet" grinding from 1 ton of corn 28 kg of corn oil, 241 kg gluten feed, 47 kg of gluten flour, 580 kg of starch is received, from which 386 liters of ethanol can be obtained.

Bioethanol market in Europe is growing annually, which means a significant increasing of energy crops import from the developing countries (Sloboda, 2010). As for Ukraine, it has a large potential of biomass suitable for energy production. Nowadays Ukraine doesn’t process all amount of energy crops harvested inside the country. That is why the export of the agricultural products from Ukraine was 19% in 2011 (available at: www.minagro.com.ua).

In the statistical bulletin of the State Statistics Committee of Ukraine are presented the results of the final accounting acreage under crop harvest in 2012 for all

categories of households, indicating that the placement of acreage of energy crops in Ukraine were: grain – 16,2 mln. Hectares (from which corn – 4,8 mln. hectares, sunflower – 4,6 mln. hectares,barley – 2,2 mln. hectares, soybean – 1,3 mln. hectares); sugar beets – 291,3 thousand hectares, potatoes – 1,38 mln. hectares (available at: www.ukrstat.gov.ua). Growing and harvesting of grains and row crops intended for processing into bioethanol do not differ from their production for food needs. Value of demand is usually defined by the quality parameters of these crops and economic indicators of production and sales.

Cultivation of crops due to natural climatic conditions can not be possible all over the world. For many years Ukraine has been the leading producer of grain in Europe. Annually Ukraine is able to produce consistently more than 60 million tons of grain. It is expected to bring the yield of grain up to 80 million tons, and further to 100 million tons in 2020.

Despite the complicated weather conditions, the Ministry of Agricultural Policy and Food Supply of Ukraine projected corn exports from Ukraine in 2013/14 MY will increase to 15,5 million tons, which will allow Ukraine to become the third largest world corn export country.

In recent years the export of grain is 50-60% of the total amount of grain produced in Ukraine. In the traditional successful harvest years the quantity of grain excess the domestic consumption in about 1,5-1,6 times in Ukraine.

Important grain crop in Ukraine for the bioethanol production is corn, which holds a special place in the domestic and world grain production. By a potential yield level and multifaceted use it is the most distinguished crop.

Corn, as one of the few crops, has a widespread use in the area of food, starch-molasses, biofuel, microbiological, medical and other industries and has good forage properties.

There is a gradual increase in production of corn in Ukraine. In particular, 2011 was a record year for the last 12 years in this positive trend. So, the sown area, which was over 3.6 million hectares and crop yield at 4.39 t / ha made it possible to form the largest gross yield, which reached 15.8 million tons of corn. The dynamics of

production of corn grain in dependence of sown area and crop capacity during the years 2000-2011 in Ukraine is given in Figure 1.

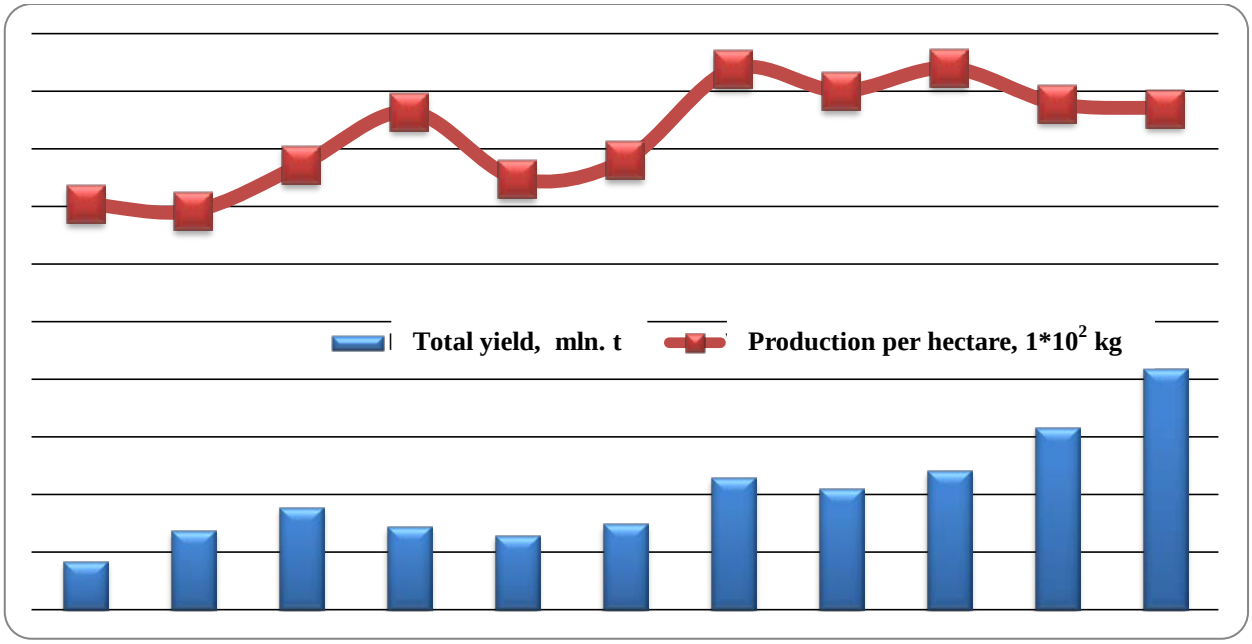

Figure 1. Dynamics of production of corn grain in Ukraine, 2000-2012

The increased production of corn will not effect its domestic use, as a food consumption of this grain is minimal and will not affect the general market conditions. Another study (Pryshliak, Vsemirnova, & Pryshliak, 2011) shows that a slight increase of gross yield of corn and annual fluctuations of its amount is caused, above all, by the market instability, that had led to instability in the size of acreage.

For Ukraine corn is the third major export-oriented crop after wheat and barley. According to Dow Jones the recovery of external sales will enable Ukraine to overtake Brazil and to become the third largest exporter of corn after the USA and Argentina. According to the news of "APK-Inform" agency, in 2011 Ukraine has exported 7.8 million tons of corn comparing to 4.05 million tons in the previous 2010.

Experts believe that, the Ukrainian corn can meet the needs of the consumers of Egypt and reduce the pressure on prices. Constraining of corn supply from Ukraine to the world market can be caused only by existing export taxes and processing it into bioetanol inside the country. The export of corn from Ukraine in 2006-2012 is presented in Figure 2 (according to data of state customs service of Ukraine).

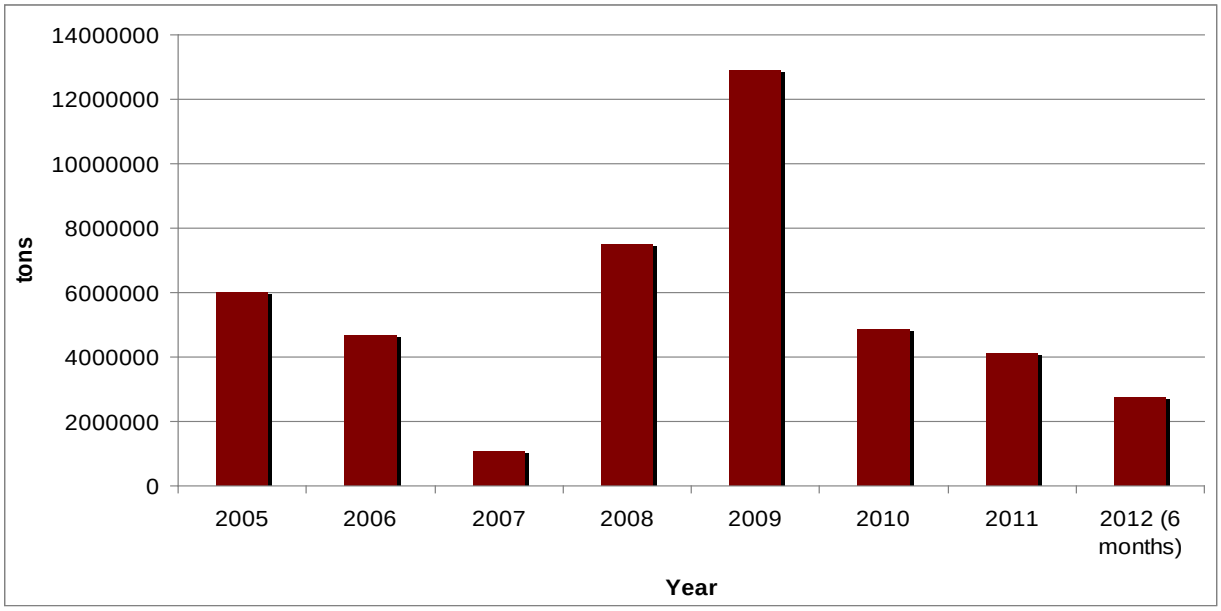

Figure 2. Corn export from Ukraine, 2006-2012

As it was mentioned before the export of corn grain in 2011 was about 7.8 million tons. Therefore, due to the output of 400 liters of ethanol from 1 t of corn grain (Table 1), after processing corn in Ukraine, we would have 2.8 million tons of bioethanol. According to the Ukrainian Agribusiness Club Association (UACA) sown area under corn for harvest of 2012 was expanded to 4.7 million hectares (+25% of the area in 2011), and the gross yield may reach 25 million tons (available at: www.ukab.com.ua).

If we process the exported grain into bioethanol inside Ukraine, that could not only ensure agricultural production with biofuels, but also provide an opportunity to produce additional animal products.

However, the increasing production of fuel ethanol from grain crops creates a deficiency of grain and generally increases its cost.

That is why, the most perspective raw material for bioethanol production is traditional crop for Ukraine - sugar beets and sugar production intermediates. Although sugar beet is a high-technology crop, still for a considerable period it remained highly profitable. In Ukraine, sugar beet was predominant traditionally technical crop. According to the Ukrainian SRI of Alcohol and biotechnology of food products, from 1 ton of sugar beets 80-100 liters of bioethanol can be obtained. So to

produce 1 ton of bioethanol we need 12,6-15,7 tons of sugar beets (Shiyan et al., 2009).

Instability of purchase prices for beet roots and wholesale prices of sugar, their artificial underestimation or overestimation leads to instability in profits, constant changes of low profitability and its loss. So, the lowest profitability of sugar beet production in the last 10 years was noted in 2007 - 11.1%, and in 2011, the level of profitability of the sugar beets production was 36.5%. Thus, the average profitability of sugar beet industry in 2000 - 2011 years was 8.87%.

If in the year 2006 and 2007 acreage under sugar beet was about 788 and 584 thousand hectares, in 2009 it decreased under the 329 thousand hectares, but already during 2010 and 2011 it increased up to 501 thousand hectares and 532 thousand hectares respectively, which in its turn led to an increase the gross yield. Comparison of the dynamics of potato and sugar beets production in Ukraine during years 2000-2011 is presented in Figure 3 (available at: www.ukrstat.gov.ua).

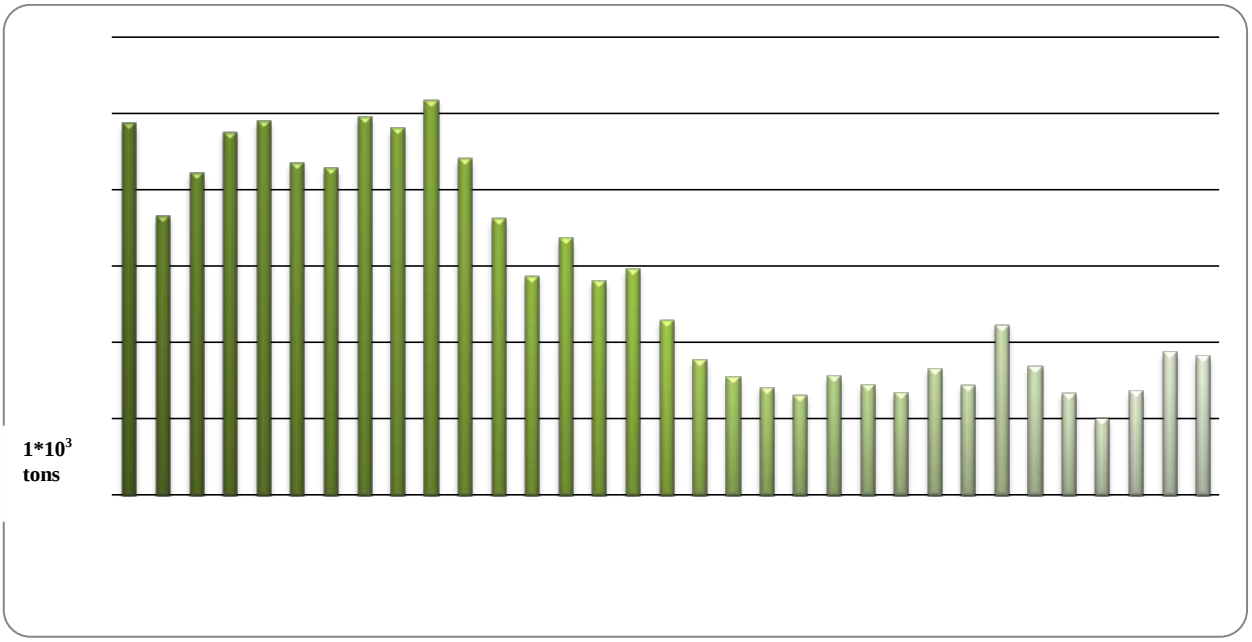

Figure 3. Dynamics of sugar beets production in Ukraine, 2000-2012

Figure 2 shows that the total gross yield of sugar beets and potato production in Ukraine wasn’t of the same increasing tendency. Production of potatoes was at a stable level with minor fluctuations and reached a maximum value in 2011 - 22.5 million tons, while the total gross yield of sugar beets had a tendency to increase over

the last two years with the rate of 18.7 million tons in 2011, what was the best result after a record-high harvest of 22.4 million tons in 2006.

The adjustment of production and consumption of biofuels obtained from sugar beets can serve as stabilizing factor for the steady development of domestic sugar beet production. Experience of the leading world and European Union countries shows that, along with clear, understandable and flexible legislative levers of government regulation of the economic relations in the sugar industry, launched production and use of ethanol produced from sugar beets and sugar production intermediates (molasses, sugar syrup, diffusion juice of first and second carbonation) plays an important role in these countries.

According to calculations made by Kaletnik (2008), the energy efficiency of bioethanol production from sugar beets, taking into account their cultivation, is 173% (the ratio of produced energy to consumed energy). This is due to the high potential of energy accumulation in comparison with other crops (Dyshlyuk, 2008) (Table 2).

Table 2

Characteristics of Energy Balance of the crops at the production of bioethanol

Energy indicators GJ / ha	Type of biomass of the crop			
	sugar beets	wheat	corn	potato
Utilized energy	97,8	56,1	53,7	84,1
Produced energy	159,8	64,2	63,9	87,5
Correlation	1:1,63	1:1,14	1:1,28	1:1,04

Ethanol produced from sugar beets contains a high content of organic compounds that boost octane number and prevent stratification of gasoline-ethanol mixes. Production of bioethanol from sugar beets requires at 20 - 30% energy less comparing to grain (Shiyan et al., 2009).

In addition, another study (Ukrainets, Homichak, Shiyan, & Oliynichuk, 2007) shows that the production of biofuels from sugar beets doesn’t require malt or enzyme compounds, the share of which in the total cost of bioethanol is up to 5%.

In Ukraine according to scientists calculations in order to replace 10% of gasoline with bioethanol we need to process sugar beets to ethanol from the area of approximately 200 thousand hectares with an average yield of 27,68 t / ha for the last 10 years.

Comparing actual yield of energy crops on average in 2005 - 2010 with 2012 we can talk about the positive dynamics of this indicator. Productivity of agricultural energy crops in Ukraine is generaly in 1.2 - 2 times lower than that of the EU countries, but in the leading households of our state crop productivity is at the same level as in Europe, and for some crops even exceeds it source (available at: www.ukrstat.gov.ua) (Table 3).

Table 3

Yield of energy crops in Ukraine and in EU countries, t/ha

Energy crop	The average yield in all categories of households					Forecast yield of energy crops in Ukraine for 2020
	Ukraine 2005 - 2010	Ukraine 2012	In the leading households of Ukraine	EU-27, 2005-2010	EU-27, 2011	
Grain	2,74	31,2	5,27	4,88	5,13	5,36
Corn	4,36	43,5	8,68	6,735	7,6	6,53
Sugar beets	29,62	411,0	55,2	64,75	68,8	43,75
Potato	13,38	161,0	38,0	28,65	31,59	16,15
Rice	5,076	63,0	6,0	5,89	3,06	7,0
Sorghum	2,065	21,1	4,51	5,31	5,55	4,73

Table 3 shows that, in the Ukraine, as well as in the EU, for bioethanol production not only the main starch energy crops can be used, but also high-yield varieties of potatoes, sorghum and rice. Potato is a valuable industrial crop used in industry for the production of starch and alcohol. During the processing from 1 ton of potato with an average amout of starch at the level of 17.6% we can get 112 liters of

alcohol. Potato tubers occupy the 4th place after wheat, corn and barley for the content of energy reserves.

In its turn, from 1 ton of sorghum grain we can get 650-700 kg of starch or 300-350 liters of alcohol, which is 35 liters more than from 1 ton of corn (Chernenkov, Ostapenko, & Perhayev, 2005).

Specialty of rice cultivation in Ukraine depends on agro-climatic conditions and complex of waterworks - rice engineering irrigation systems (on an area over 63 thousand hectares). Farms with the acreage of more than 1000 hectares get the highest yields of rice.

New perspective bioenergetic crops are also chicory and Jerusalem artichoke. From 1 ton of chicory root during processing we can get 100 liters of ethanol that meets all requirements and standards.

From 1 ton of chicory, with an average yield of 20.0-25.0 t / ha we can get 2 tons of alcohol. But with the introduction of new technologies of chicory and Jerusalem artichoke production, this indicator can be doubled.

Another highly productive energy crop that requires additional research is sugar containing crop - sugar sorghum. At an average yield of 60.0-70.0 t of green mass per hectare up to 70% of the total mass of sugar juice may be allocated. That is twice more than from the mass of the traditional sugar beets. This drought-resistant plant with height to 4 meters contains up to 20% of sugar in its leaves and stems. Considering the large selective potential and unpretentious growing conditions sugar sorghum can be regarded as perspective raw material. An important economic benefit is that the processing of sweet sorghum for ethanol is not necessary to carry out the conversion of starch into sugary substance as this is wih grain and corn. Sugar sorghum is good biological material for ethanol producing. If you build a plant that will recycle green fodder sorghum mass into syrup, then into ethanol and carbon dioxide, the utility waste (about 70%) would be used for animal feed and grain would be used as seed material. This could solve many important problems in southern Ukraine.

Usage of perspective crops has a significant energy potential in the domestic economy and could guarantee the reserve in the future.

Production of bioethanol in Ukraine is possible as on new plants for the bioethanol production, as at the upgraded sugar mills and alcohol plants.

The concept of bioethanol production in Ukraine includes several areas:

1. Reconstruction of existing alcohol plants;
2. Construction of new plants of small capacity (up to 5 tons of ethanol per day) on the basis of processing industry enterprises and directly in agricultural households;
3. Production of bioethanol at existing sugar mills; at their base alcohol shops can be involved in sugar production between the seasons;
4. Retrofit of sugar mills with corresponding production lines.

Annual total capacity of alcohol plants is around 700 million liters of ethanol, including 340 million liters from the factories of molasses processing (Kaletnik, 2008)

In Ukraine, the production of bioethanol from molasses is mainly converted to the reconstructed alcohol plants. Total capacity of 12 local alcohol plants involved in ethanol production is more than 300,000 tons of bioethanol per year. However, quite recently, in Kyiv on an area of almost 2.5 ha a new complex was established. With effective use it can process 70 tons of molasses per day, while receiving 30 tons of ecologically clean fuel. This in its turn, will reduce emissions of harmful and hazardous substances into the atmosphere by 40%.

Reconstruction of existing alcohol plants will bring the production of ethanol fuel in Ukraine to 0.3 million tons / year. Retrofit of sugar mills with appropriate production lines will make it possible to receive 1.65 million tons of ethanol per year. Thus, taking into account all trends of the biofuel market development in Ukraine it could be received 2 million tons of bioethanol / year.

Expansion of bioethanol market in Ukraine is possible in two ways: providing of economic interest of oil refineries in the production of mixed gasoline and the introduction of compulsory use of mixed gasoline with specific categories of

consumers or setting compulsory quotas for consumption of high-octane oxygen supplements by producers of gasoline.

In case of full loading of all existing facilities of alcohol plants it can be produced up to 500 thousand tons of biofuel per year, what is more than 10% of high-octane gasoline from the total gasoline consumption in Ukraine.

In the case of use bioethanol, produced in Ukraine, as an additive to mineral fuelthe annual demand for bioethanol will be 1 million tons. To produce this amount of fuel it should be used around 450-500 thousand tons of molasses and 2.8 million tons of corn (Kirillov & Guba, 2010).

Increasing the competitiveness of biofuels at the market may be done by reducing the cost price of energy of raw materials used for its production. This can be achieved by upgrading of crop productivity to the level of leading European countries through the use of highly productive varieties of domestic and foreign selection and implementation of intensive technology of cultivation.

The cost price of bioethanol except yield indicator is also affected by several factors, including: the cost of biomass, starch content in grain and sugar in sugar-containing energy crops, the output of alcohol from specific kind of agricultural production, the quality of the technological process and others.

Nowadays widespread scientific researches and practical application of bioenergy crops cultivation technology with minimum expenses of financial resources are held in Ukraine. The base of these technologies is worldwide famous No-Till technology, which provides a significant reduction in number of agricultural operations almost to 2 - sowing and harvesting process. It is important to optimize crop rotations at the scientific level, provide soil preservation and measures to improve their fertility.

The most important in No-Till technology is a technical support of bioenergy crops cultivation as harvesters are used the same as with any other crop growing technology and sowing-machines need fundamental changes. With modern sowing technologies at the scientific level all technological operations are combined around the main operation which is crop sowing with prepared seeds. Along with sowing

process, fertilizing and chemical protection of crops from pests, diseases and weeds are also held. At the same time favorable physical and mechanical properties of soils are improved in order to reach 100% seed germination and to create optimum conditions for the growth of agricultural crops. There were done another researches on the application in the fields of Ukraine such combined sowing-machines of zero and minimum cycle of foreign and Ukrainian production as HORSCH ADT 9.35, FLEXI KOIL ST820 and GRETE PLAINS 3S4000.

Studies that took place at farms of Ukraine had shown that the best technical, economic and environmental characteristics were detected in HORSCH sowing-machines that were produced in Ukraine (Dnipropetrovsk), in conjunction with the Canadian manufactures.

HORSCH sowing-machine has a high sowing speed, precision computations of sowing material and it is easily serviced when replacing of functional working details is need.

Separate supply system of fertilizers and seeds for sowing keel reduces the risk of clogging of seed wires and if the clogging still happened the operator receives a signal on a control unit and number of sensor mounted on seed wires is also displayed.

Compaction of sown seeds is carried out by 28 small wheels that are set back of the sowing-machine.

Through the application of innovative No-till technologies for bioenergy crop production the cost price of biomass on the Ukrainian fields is reduced by 37-39%. This is a good reason for the obtaining of high-quality cheap bioethanol, which soon will replace gasoline outside of the agricultural market of Ukraine.

Conclusions. In our country, due to the favorable soil and climatic conditions a powerful base of raw materials is formed, which includes basic sugar-and starch containing crops (grain, corn, sugar beets) and perspective crops (Jerusalem artichoke, chicory, sugar sorghum), that are giving high output of bioethanol from the unit. Complex solution of social and economic, technological and environmental problems of alcohol production is a prerequisite for the organization of large-scale

production of ethanol fuel in Ukraine based on bioconversion of renewable plant materials.

Not all developed countries have a strong agricultural sector. That is why Ukraine has a lot of competitive advantages in the production of fuel ethanol such as nutritious black soil, favorable agricultural infrastructure and tradition of growing grain.

The main condition for the functioning of the Ukrainian bioethanol market is the legislative regulation of compulsory use of ethanol fuel in the production of motor gasoline mixtures that gives an opportunity to create a high demand for bioethanol at the domestic biofuel market and involve the power of state alcohol plants and sugar mills for its production.

Introduction of new innovative technologies in the field of energy supply will reduce the dependence on economy of Ukraine from petroleum and gas exporting countries that will respectively increase its energy and national security and will lead our country to a whole new qualitative level in relations with foreign states, and position ourselves as a state with a European level of economic and environmental security.

References

1. Калетнік Г.М. Розвиток ринку біопалив в Україні: Монографія / Г.М. Калетнік. – К.: Аграрна наука, 2008. – 464 с.

2. Калетнік Г.М. Біопаливо: ефективність його виробництва та споживання в АПК України: Навч. посіб. / Г.М. Калетнік, В.М. Пришляк. – К.: “Хай-Тек Прес”, 2010. – 312 с., іл.

3. Пришляк В.М. Інноваційні технології виробництва та особливості використання біопалива у Франції / В.М. Пришляк, Н.В. Пришляк // Збірник наукових праць Інституту біоенергетичних культур і цукрових буряків “Біоенергетика: вирощування біоенергетичних культур, виробництво та використання біопалива”; за ред. акад. НААН М.В. Роїка, вип. 12. – К.: ЗАТ “Віпол”, 2011. – С. 68-73.

4. Інтернет ресурс. – Точка доступу: http://www.minagro.com.ua.

5. Інтернет ресурс. – Точка доступу: http://www.ukrstat.gov.ua.

6. Шиян П.Л. Інноваційні технологій спиртової промисловості. Теорія і практика: Монографія / П.Л. Шиян, В.В. Сосницький, С.Т. Олійнічук. – К.: Видавничий дім "Асканія", 2009. – 424 с.

7. Victor Pryshliak**.** Resource potential of Ukraine for the production of biofuels / Victor Pryshliak, Veronika Vsemirnova, Natalia Pryshliak // Book of abstracts – Second International Conference Sustainable postharvest and food technologies – INOPTER 2011, Velika Plana, Serbia, – P. 107.

8. Інтернет ресурс. – Точка доступу: http://www.ukab.com.ua.

9. Українець А.І. Спиртова галузь України на шляху до інноваційного розвитку / А.І. Українець, Л.М. Хомічак, П.Л. Шиян, С.Т. Олійнічук // Харчова і переробна промисловість. – 2007. – №12. – С. 16-19.

10. Інтернет ресурс. – Точка доступу: http://www.ukrstat.gov.ua.

11. Інтернет ресурс.– Точка доступу: http://www.secretariat@coceral.com.

12. Черненков А.В. Сорго – резерв кормової бази в посушливих умовах Присивашшя / А.В. Черненков, М.А. Остапенко, О.А. Пергаєв // Бюлетень інституту зернового господарства. – 2005. – № 26-27. – С. 169-171.

13. Калетнік Г.М. Соціально-економічне значення розвитку ринку біопалива в Україні / Г.М. Калетнік // Економіка АПК. – № 6. – 2008. – С. 128-132.

14. Кирилов Ю.Є. Виробництво та ринок біопалива: світові тенденції / Ю.Є. Кирилов, М.І. Губа // Збірник наукових праць Херсонського ДАУ. – Вип. 1. – 2010. – С. 31-33.

Анотація

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Техніко-економічні та екологічні аспекти виробництва біоетанолу в Україні

Наведено результати досліджень з технологічних, економічних та екологічних питань вирощування біоенергетичних культ, їх переробки для виробництва і споживання біопалив. Проаналізовано фактори, такі як: земельний потенціал і ґрунтово-кліматичні умови України, масштаби виробництва біосировини, розвиток структури біопаливної індустрії, енергозберігаючі та екологічно доцільні технології сільськогосподарського виробництва

Ключові слова: *біоетанол, біоенергетичні культури, екологічна безпека, продовольча безпека, ресурсозберігаючі технології, баланс енергії.*

Аннотация

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Технико-экономические и экологические аспекты производства биоэтанола на Украине

Приведены результаты научных исследований технологических, экономических и экологических вопросов выращивания биоэнергетических культур, их переработки для производства и потребления биотоплива. Проанализированы факторы, такие как: земельный потенциал и почвенно-климатические условия Украины, масштабы производства биосырья, развитие структуры биотопливной индустрии, энергосберегающие и экологически целесообразные технологии сельскохозяйственного производства

Ключевые слова*: биоэтанол, биоэнергетические культуры, экологическая безопасность, продовольственная безопасность, ресурсосберегающие технологии, баланс энергии*