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BIORESOURCE POTENTIAL OF UKRAINE IN SETTLING OF PRODUCTION AND ENERGY SECURITY

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Industry conditions and needs of main food products consumption in the world and Ukraine are being analyzed. Significant prospects of biomass production as a raw material for industry and biofuel without reduction of production volumes of main food products and insuring production and energy security of Ukraine due to bio diversity and other factors are considered in the article.

The key problem of XXI century in Ukraine and worldwide will be providing of food and energy safety and sovereignty. Can "green world" of Earth be productive enough to satisfy needs of Mankind in food and fuel raw material to substitute fossil oil in production? The staple of Earth live layer is phytosphere with unique phenomenon of photosynthesis, which gives man and animal food, industrial, medical products and oxygen and provide biosphere stability (pic. 1).

From more than three hundred thousand discovered species of plants about 75 thousands are edible. In everyday life man uses just few dozen of crops. Flora of higher and inferior plants of Ukraine counts more than 10000 species and more than 4500 of them are higher plants. We become more and more annoyed with decrease of biodiversity. Nowadays Earth loses several species daily.

Species loss caused by technological factors exceeds natural elimination rates in 100–1000 times. With unreasoned human activity in nearest 50–100 years we can lose from 25 to 50 % of modern species diversity.

Alongside with growth of world population the production volumes also increase and roughly affect Biosphere. The new technologies enhancing photosynthesis efficiency, nitrogen fixation can mitigate this effect and provide creation of high productive and drought and diseases resistant varieties of plants and races of animal. Each of three "Green revolutions" caused by the development of science, provide doubling in yields. First started in middle of XVIII century, when role of legume plants in enriching soils with immobilized nitrogen was discovered. Second started in the middle of XIX century and was the result of invention of mineral nutrition theory and wide usage of fertilizers. The third one took place in 50–60th of XX century and was rather complex due to achievements in genetic, selection, new agrobiotechnologies, plant protection. It is possible nowadays to construct fast developing plants with improved assimilation of solar radiation and obtain renewable energy sources and other valuable industrial raw (pic. 1). But experience gained by human affirmed that each of "Green revolutions" required increase in energy and resources consumption per production unit and led to increase of environmental impact.

The total area of agricultural lands makes up more than 1.5 billion hectares or 11% of Earth surface [5]. Photosynthetic products of plants and trees estimated as $1.5 \cdot 10^{13}$Wt, that exceeds consumption at the time, but that is just a little part of available solar energy [6]. Energy of sunrays, which comes to Earth surface makes about $668 \cdot 10^6$ billion kWt*h per year. Conversion of solar energy into plant biomass due to photosynthesis can reach to 9–10 %, but energy consumption in processes of primary and secondary metabolisms in plants reduce volumes of possible energy accumulation. Modern crop cultivation technologies

provide solar energy accumulation at level of 1,5–4,0 %, thus a significant part of energy coming to our planet is wasted [4]. If to presume possibility of getting biomass from all arable lands then it is possible to have about 15 billion tons of biomass just due to arable lands. Ukraine has significant renewable energy resources potential (tabl. 1)

1. Energy potential of renewable resources in Ukraine

Kind of energy	Reserves, billion kWt*h per year	
	Potential	In fact
Solar energy	$720 \cdot 10^{3}$	$130 \cdot 10^{3}$
Wind energy	$965 \cdot 10^{3}$	$360 \cdot 10^{3}$
Hydro energy	17,4	6,4
Geothermal energy	$5{,}1 \cdot 10^{6}$	$14 \cdot 10^{3}$
Biomass energy	12,5	6,1

Crop production efficiency depends on variety of social, economical and technological factors which determine ecological compatibility of this industry Agricultural lands in Ukraine make up 42,893 million hectares with share of arable lands equal to 32,446 million hectares, which is 78 % [7]. One of the threats for food safety in Ukraine is irrational land use in general and arable lands in particular. Structure of sowing areas in Ukraine demands have to be diversified according to demands on food and state safety and laws on agriculture (fig.1).

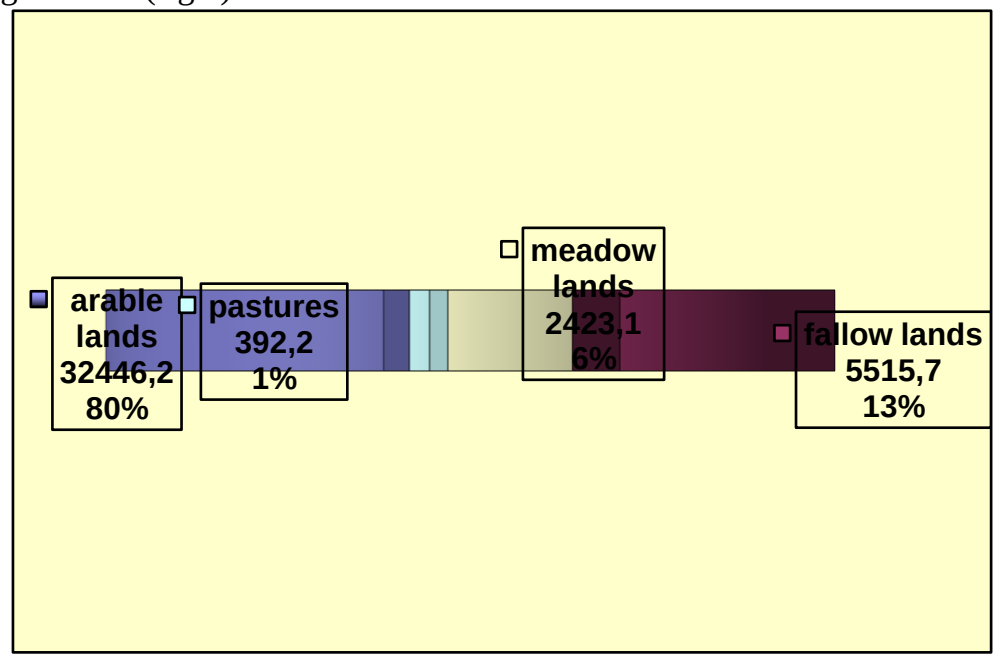


Figure 1. Agricultural lands share in Ukraine, th.ha

Bioclimatic potential of state allows cultivating all basic crops

Main criteria of food safety according to FAO data are volumes of transitional grain supply and its per capita production. During recent years situation on world food market dramatically changed (table 2). Increase of grain consumption for food purposes in developing countries and reorientation of production from food to bioenergy purposes in developed countries resulted in excessive demand on this strategic agricultural resource [fig. 5]. Grain consumption rose up from 1 billion 250 millions tones in 1976 to 2 billion 50 millions in 2007 and will increase in nearest decades.

2. World grain consumption, million tons

Grain	Years			
	1984–1986	1997–1999	2015	2030
Wheat	504	582	730	851
Rice	308	386	472	533
Fodder	796	896	1177	1446

In last seven years (except for 2005) consumption demand exceeds production volumes and during this period world population consumes grain products on 310 million tons more than produced. Transitional grain supply in last 20 years decreased from 34 to 13 % (% of consumption) and this trend is ongoing.

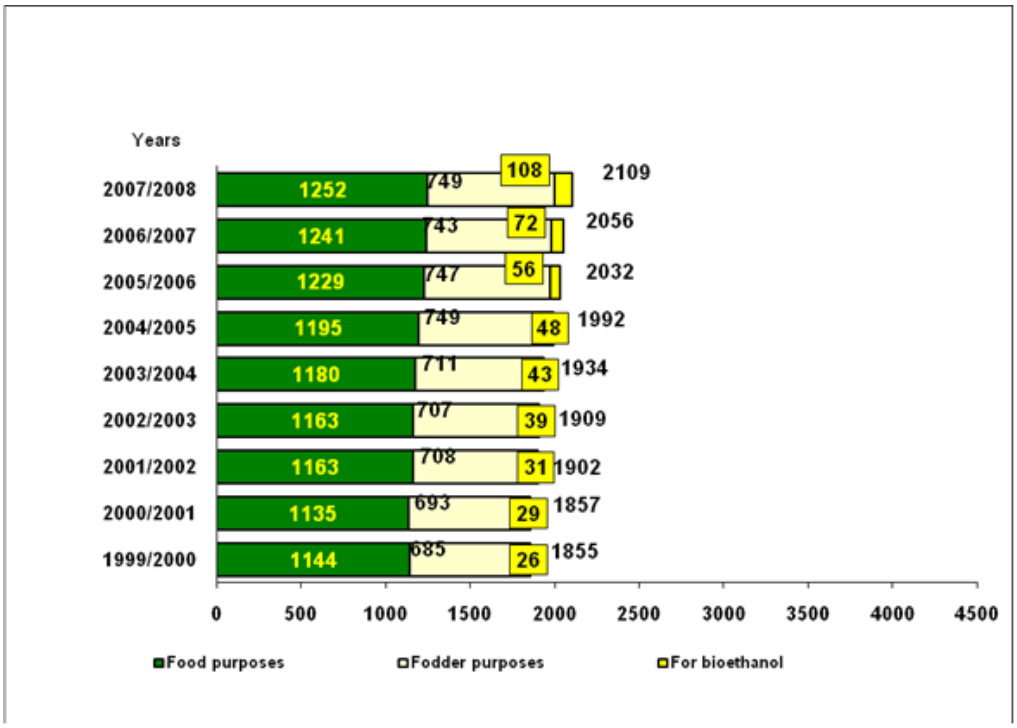


Figure. 2 World production and use of grain, million tons [8]

People eat away food accumulated in XX century and primary goal of food market stabilization is increase of transitional grain supply from 1.5 month supply in 2008 to at least 2 month supply aiming at 3 month supply. Grain production is one of the major branches of agro industry in Ukraine, providing functioning of processing industries, including food, mixed fodder and other industries and also food safety and independence of Ukraine. One of the main tasks under modern social and economic conditions is increase and stabilization in food, fodder and raw grain production, primarily basic cereals grain. Most effective ways of this task implementation is creation of new high productive varieties of cereals, rational land use and development of economically efficient and ecologically friendly technologies of production, adapted to ecological conditions of different zones. Threat to Ukrainian food safety is caused by strong dependence of National economy from foreign markets and external factors. To provide desirable gross production, we should adequately position Ukraine among Countries – grain producers, try to reach European level of cereal crops yield. Currently yield of cereals in Ukraine is 2 times less than in the EU, and 3 times less than in the USA.

But a not only volume of production is important. We also should aim at quality of products. Majority of Earth population is suffering from hunger and irrational nutrition. Lack of protein for children is one of essential problems of developing countries. To solve this problem we should pay more attention to selection of new cereal varieties with high content of protein with improved food quality, because these crops are cheap and easy available as source of protein. Protein content is a distinguishing feature of different species and varieties but genetic reaction under influence of ecological factors can be significantly changed. According to the use of grain different quality parameters applied and affecting exercise price – grain quality is a matter of trade.

Agroindustrial sector of Ukraine has great potential in grain production. Genetic potential of modern cereal varieties of Ukrainian selection is: winter wheat –12–13, barley – 10–11 and maize – 12–13 tons per hectare. But regular violations of technological requirements, current assets deficit, lack of investments in renovation of means of production, low professional level of producers result in realization of this potential just on 10–25%.

Implementing modern technologies of cereals cultivation we can produce 75–80 million tons annually and up to 100 million tons annually in a long–term perspective, that allows to export up to 40–45 million tones [2]. Average internal grain consumption in Ukraine is 26–28 and export is about 10 million tons of grain. Gross grain production in Ukraine is heterogeneous [fig. 6] due to dependence of production on weather conditions of vegetation year and low level of production process. Nevertheless Ukraine has great production potential: 20,2 (2003) – 51,2 (1989) million tons, including winter wheat 9,78 (2003) –30,4 (1990), maize – 1,54 (1994) – 8,64 (1988). It shows irrationality of sowing areas.

According to demand of species and varieties to different ecological factors there are so called durability limits. Cultivation of winter crops in regions with high weather risks caused significant yield losses. In Ukraine approximately every three years in decade about 20% of sowing areas under winter crops is being destroyed by frosts. Annually from 7 to 13% of winter wheat is being damaged by frost, it makes up 0.5–0.8 million hectares.

Thus, significant areas of damaged winter crops need to be resowed in spring time which requires additional financial and energy resources. Another possible reason of grain production low efficiency is a high cost and significant losses of grain production, processing and storage. Grain losses during harvesting and storage exceed average German data (3 %) and reach about 13 %.

Analyses of production, consumption and placement of cereals prove expediency of enriching assortment of cereal crops with new crops, able to provide high grain yields with appropriate quality, suitable for multipurpose use (table 3).

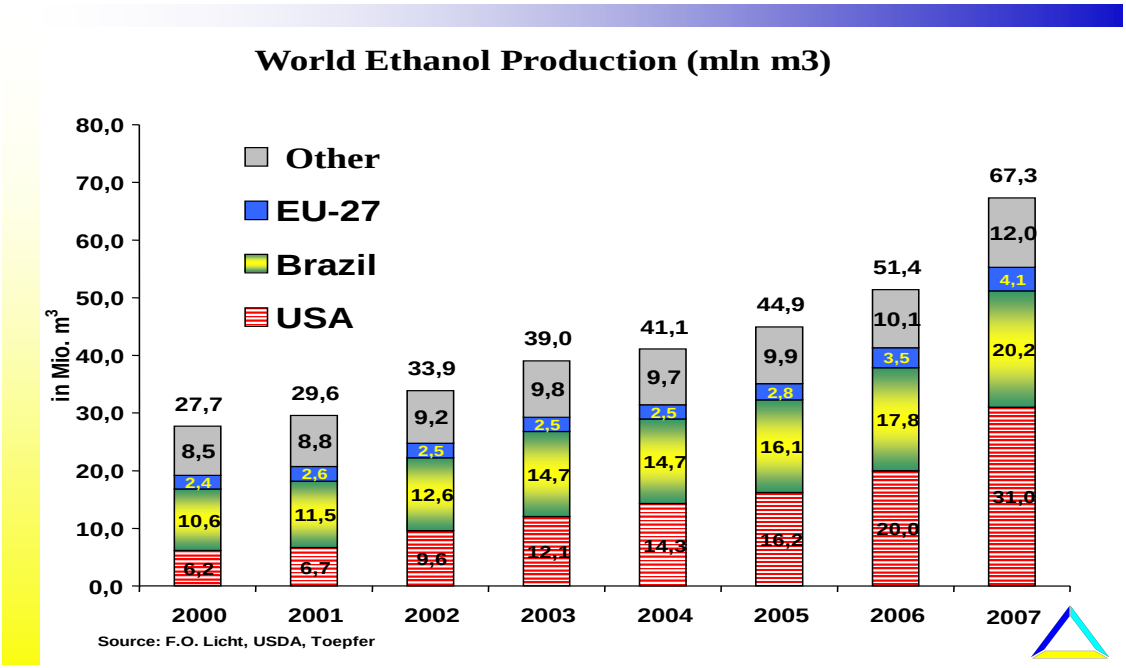
Generalized data of researchers and State commission on varieties testing and protection indicate that in Forest–Steppe of Ukraine main factor which determine level of genotype potential realization is weather. But sensibility to this factor unequal for different crops. More sensible are winter wheat varieties – 83 %, less sensible are winter rye varieties – 50 %, varieties of triticale have medium sensibility – 70 % [8].

Technological supply of crop agrcenosis and winter crops in particular according to their biological properties help to decrease unregulated factors influence on productivity formation and enhance role of variety and fertilization system. Factors share in productivity formation for different varieties of winter crops in combination “condition of the year”, “technology”, “variety” make up respectively 3.6, 82,3 and 4,0 %. Share of “variety” factor increases on high backgrounds of mineral nutrients. From 22,5% on control to 35,4, 39,9

and 43,8 % respectively to application of $P_{45}K_{60}N_{20II+40IY}$, $P_{90}K_{120}N_{30II+60IY+30YII}$ і $P_{135}K_{180}N_{30II+90IY+60YII}$ [8].

3. Productivity potential of energy crops – sources of bioethanol [9,10]

Raw	Yield, t/ha	Bioethanol output, l/ha	Amount of biomass per 1 liter of bioethanol, kg/l
Grain Maize	9,2	3520	2,6
Wheat	7,2	2760	2,6
Rye	4,9	2030	2,4
Triticale	5,6	2230	2,5
Jerusalem artichoke	30,0	2610	11,5
Chicory	3,5	3248	1,1
Sugar beet	61,7	6620	9,3
Potato	44,0	3550	12,4
Sorghum (sugar), green masse	65,0	8000	8,13
Sorghum (sugar), grain	8,0	6400	1,25



Concept of sugar beet production in Ukraine needs to be reconstructed. In 2008 in Ukraine the lowest yield of beetroots at range of 7,68 million tones with sugar output 0,95 million tones was admitted. In 2009 sugar yield was at range 1,2 million tons. Taking into account that Ukraine needs 2,0–2,2 million tons of sugar to cover own needs we become sugar importer. At the same time resource potential of the country can provide much greater production volumes of this strategic raw, but reconstruction of this branch requires strong investment.

In recent years in Ukraine areas under sugar beet dramatically decreased, at the same time areas under oilseeds such as sunflower, spring and winter rape, soybean tended to increase.

In the world annually about 90 million tons of oils and fats are being produced, 80% of which are vegetable oils and 20 % – fats of animal origin. Around 86% of their production is used for food and feed purposes, 14 % – for technical purposes. There is a

significant range of oilseed crops that are grown for food purposes and as renewable industrial raw materials in Ukraine (Table 4, 5).

Among renewable energy developments sources of biological origin such as biodiesel, bioethanol, biofuels biogas are becoming increasingly important. Majority of countries actively perform bioenergy program. Thus, this year, European countries will develop more than 4 million tons of biodiesel only. Last year the United States, for example, processed 70 million tons of corn for ethanol, and this year plan to bring that number to 100 million tons. This trend is observed in other countries (Fig. 8).

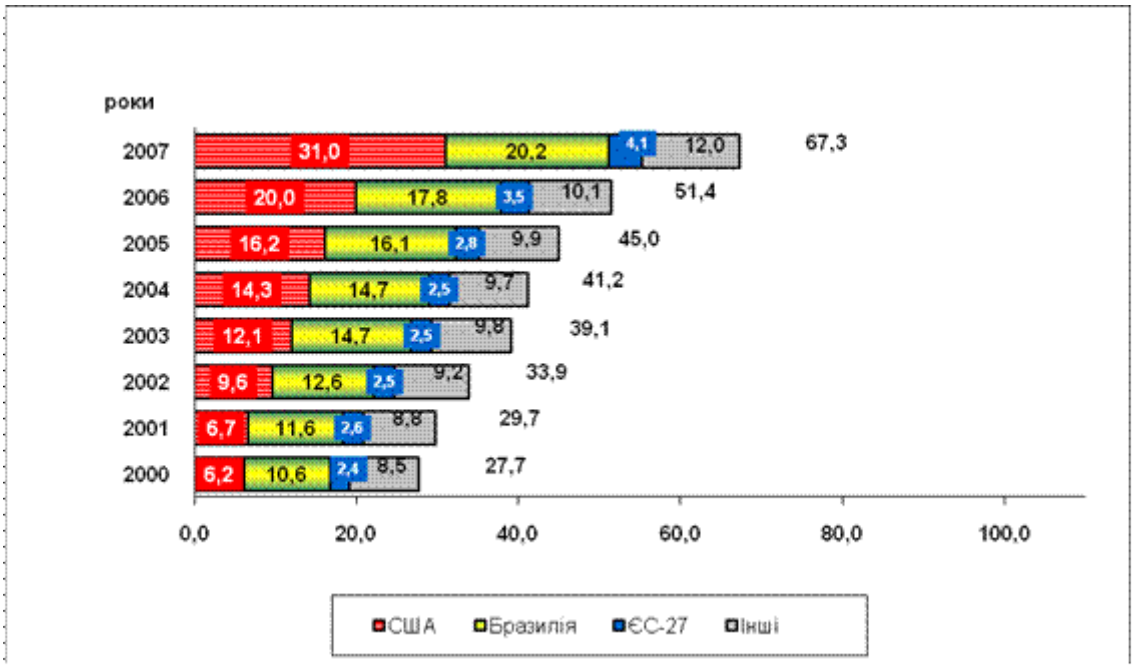


Figure 3. World ethanol production

However, if the deficit of grain on world markets exists, bioenergy program developed by countries is further compounded and complicated to the world food situation. That is why the United Nations appealed in 2007 to such countries with a proposal to suspend the application of biofuel production to avoid hunger in poor African and Asian countries. But, according to experts, there is no alternative to bioenergy.

4. Potential productivity of brassicaceae family oilseed crops–raw for phytodiesel production [9, 10]

Species	Seed yield, t/ha	Oil content, %
Winter rape	1,5–4,5	45–50
Spring rape	1,3–3,5	41–49
Oil raddish	1,2–2,1	31–50
Winter cress	1,5–2,5	43–47
Spring cress	1,0–2,0	38–48
White mustard	1,0–2,2	35–47
Brown mustard	1,2–2,1	32–49
Camelina	0,6–2,9	33–41

Biofuel created for crop production another value equivalent – energy. Where once price was determined solely by balance of supply and demand in the food market, then now

a unit of biofuel (biodiesel, ethanol or biogas) is compared with that which is produced from fossil hydrocarbons. For this reason rising prices on oil and gas will automatically lead to higher prices on agricultural production.

In settling of energy issues new will play a crucial role, energy efficiency ratio of which can be increased by 75–90 %. Those technologies which are used in industry, agriculture and transport are too wasteful.

5. Potential productivity of oilseed crops–raw for phytodiesel production [9,10]

Species	Seed yield, t/ha	Oil content, %
Chufa	4,5–12,0	23–40
Soya	1,0–2,6	17–27
Peanut	1,5–4,0	52–60
Sesamum indicum	0,8–1,0	47–65
Safflower	1,0–3,5	25–50
Sunflofer	1,3–3,9	41–52
Lallemantia iberica	1,0–1,2	23–38
Oil flax	1,2–3,0	30–47

Mankind with its energy and industrial potential only accelerates the processes of destruction of the biosphere, reduces the degree of its organization and increases the entropy. One of the main tasks of the future of science is to learn how to ensure proper quality of power, forcing our civilization through the reduction of entropy. Security of energy quality is our obligation on the way to posterity.

And if other countries find the mechanisms of resource containment of inflation, Ukraine reserves are insignificant, especially food and energy reserves are about 1 / 3 of annual needs. It should be recognized that food and energy security of Ukraine last year has decreased dramatically.

In terms of energy and power consumption per unit of manufactured products Ukraine is 2–3 times ahead countries of Eastern Europe and 5–7 times of developed countries. In terms of energy balance of primary energy consumption Ukraine has the largest share of natural gas – 41 %, 19 % – oil, 19 % – coal, 17 % – uranium. While the U.S. consumes 24 % of natural gas, 38 % – oil, 23 % – coal, 8 % – of uranium, the EU's energy balance is slightly different: gas – 22 %, oil – 41 %, coal – 16 % of uranium – 15 %.

Taking into consideration dependence on gas import, prices on which tripled during last three years, Ukraine has to seek alternative sources and implement a strong policy of energy efficiency and energy saving. A series of programs and Resolutions were developed and adopted in our country due to the search for alternative energy sources and energy–consuming technologies that are envisioned in the Energy Strategy of Ukraine till 2030. Currently, Ukraine imports about 60 % of energy, and by 2030 this dependence should decrease to 11 %. Synthetic gas is a great alternative to natural gas. Thus, the cost of the alternative fuel is much lower than of natural gas. Tests in Ukraine of a number of alternative forage crops have shown their high potential for biomass production. Testing and introduction of alternative crops to produce biomass for biogas plants has great importance because through the diversity of crops not only more sustainable cropping system provided but also take place enriching agrosystems, new possibilities of developing of

economically and ecologically grounded crop rotations for biomass production, which adapted to local conditions and regulate monocrop around biogas plants (tabl.6).

6. Energy efficiency of phytoenergy crops as a source of solid fuels and gas [10]

Parameters	Mesuaring units	Cotton tree (populus)	Willow	Miscanthus	Schavnat	Sakhalin Knotweed
Dry matter yield Period	t/ha	10–20 In 3–4 years	10–15 In 3–4 years	15–20 In 2 years	10–20 In 1 year	13–20 In 1 year
Thermal capacity	mJ/kg cm	18	20	18	18	18
Production energy consumption	gJ/ha	28	27	12–18	12–16	10–15
Energy output	gJ/ha	220	160	160–170	150–160	150–160

Conclusions

Arable lands productivity in Ukraine along with production and consumption of essential food products show significant prospects of biomass production as raw material for industry and biofuel without cuts in food stock and provision of food and energy safety of Ukraine. Estimation of ecological and ecotoxicological aspects of phytomass production allows to determine certain differences in production of raw material for energy, industrial and also food and fodder purposes. They depend on crop, technology and other growth factors, and typically are not specific for the production of renewable energy and raw materials for technical purposes compared to crop production in general.

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Приведений аналіз стану виробництва й потреби споживання основних продуктів харчування в світі та в Україні. Показані значні перспективи вирощування біомаси як сировини для промисловості й біопалива без скорочення обсягів виробництва продукції продуктів харчування та забезпечення продовольчої та енергетичної безпеки України, за рахунок розширення різноманіття культур та інших факторів.

Представлен анализ состояния производства и необходимости потребления основных продуктов питания в мире и в Украине. Показаны значительные перспективы выращивания биомассы как сырья для промышленности и биотоплива без сокращения объёмов производства продуктов питания и обеспечения продовольственной и энергетической безопасности Украины, за счёт расширения разнообразия культур и других факторов.