UDC 633.63: 620.952

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ENERGY EFFICIENCY OF SUGAR BEET, DEPENDING FROM PLANTS POPULATION.

There are results of research effect of density of plants of sugar beet sort "Belotserkovskyy 45" and hybrid "Alexandria" on output bioethanol, biogas and the total energy.

Key words: *sugar beet, plant population, bioethanol, biogas, energy output.*

Introduction. Ukraine only partially self-sufficient in their own energy and have to cover energy deficit by imports. According to the Ministry of revenues and charges for 2012 at the territory of Ukraine imported 6.97 million tons petroleum and petroleum products ($8.84 billion), which more than 10% of total imports. [1] So, reducing use of petroleum products due to the widespread introduction of fuels with biological components will reduce the energy dependence of the Ukraine and will improve the ecological environment.

The legislation of Ukraine provides for a gradual increase of production and use of biofuels. Specifically, in the gasoline in 2013 recommended add at least 5% bioethanol. Since 2014 the share of five percent ethanol is mandatory and will increase to 7% in 2016 [2]. To implement the provisions of this statute, for domestic consumption of gasoline about 4.2 million tons, annually have make about 300 tons ethanol [3]. An important impetus for development of bioenergy in Ukraine is implementing "green" tariff for electricity generated from biogas [4]. So, from April

2013 until 2015 factor "green" tariff will be 2.3. Electricity produced from biogas will be buying for price 2.3 times higher than the retail price for the second class. Thus, Ukraine has created a favorable legal framework to increase production of bioethanol and biogas.

Valuable source of raw material for bioethanol production is sugar-crops (sugar and fodder beet, sugar sorghum, etc.). The most effective traditional for Ukraine sugar-crop for ethanol production is sugar beets. One hectare of sugar beet (crop capacity of 60 t/ha and 16% sugar) can get more than 4.3 t/ha ethanol. This amount ethanol is enough for 68.4 thousand km.

However, there is not technology for growing sugar beet as a feedstock for biofuel production adapted to soil and climatic conditions of Ukraine. No information about impact of density of plants of sugar beet on the their energy performance.

Materials and methods research. Experimental researches were carried out during the years 2010-2012 in the fields Belotserkovskoy experimental breeding station (forest-steppe zone of Ukraine). We studied sailed density of plants of sugar beet beet sort "Belotserkovskyy 45" and hybrid "Alexandria" to the theoretical output of biofuels and energy.

Research carried out on typical chernozem, deep, low humus, medium loam. The humus content in the plow (0-30 cm) layer of soil - 3.75%, nitrogen easily accessible - 11.7, mobile phosphorus (by Chirikov) - 26.4, exchangeable potassium - 15.4 mg/100 g of soil hydrolytic acidity - 2, 74 mh-ekv/100 g soil.

Temperature readings during the growing season for all years of study were higher than average long-term (Table 1). This is especially felt in the summer months when the average temperature was at 3-5 ° C higher than the average long-term. Years of research were variegated by the number of water.

So, the weather conditions during the researches were typical for forest-steppe zone of Ukraine as the average long-term indices as the degree of deviation from them on some years and in general were favorable for the cultivation of sugar beet as energy crops.

Table 1

Weather conditions during the growing season of sugar beet cultivation

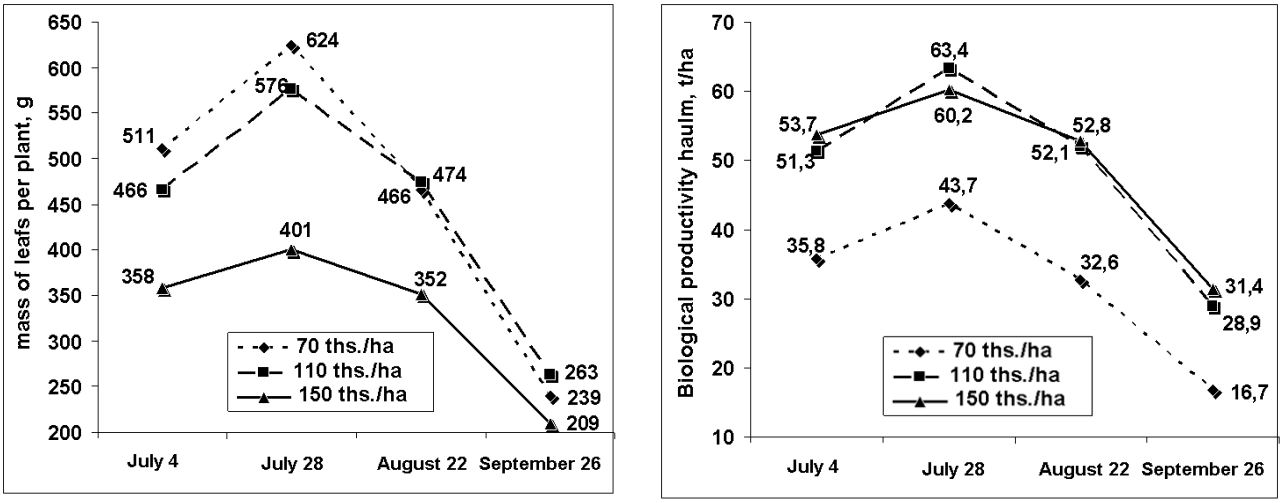
Month	Monthly average values			
	2010 p.	2011 p.	2012 p.	average long-term
April	9,9/34,0	9,6/20	11,8/71,7	8,4/47
May	16,9/50,1	15,8/52	18,2/6,8	14,9/46
June	21,2/59,6	20,1/135	20,1/39,8	17,8/73
July	23,1/102,0	21,4/115	22,4/58,9	19,0/85
August	23,7/17,8	19,0/59	19,8/91,8	18,4/60
September	14,5/29,6	14,6/19	16,4/20,4	13,8/35
October	6,0/33,1	7,0/63	10,3/42,9	7,8/33

Note: the numerator - Temperature, ° C, the denominator - the amount of precipitation, mm

The results of research. The research showed that growth and development plant of sugar beet sort "Bilotserkivskiy 45" during the growing season was not uniform. The most active increase in leaf area was from in the spring until on July, when the leaf mass exceeds twice the mass of roots. So at the end of July the mass of leaves of one plant when the density of plants 70 ths. /ga was largest - 624 g (Fig. 1). A little fewer was a mass leaves of plant for density 110 ths./ga and it was 576 g. Minimum of leaves at one plant (401 g) when was maximum density of plants of sugar beet - 150 ths./ha. But at time of harvest (end of September), the difference in mass of leaves at one plant of sugar beet sort "Bilotserkivskiy 45" for varying density of plants was not significant and ranged from 209 to 263 g.

The highest productivity of haulm (63.4 t/ha) from sort "Bilotserkivskiy 45" was in late July when the density of plants was 110 ths./ha (Fig. 1 B). Harvest of haulms was slightly lower (60.2 t/ha) when plant density was 150 ths./ha. Despite the fact that the mass of leaves on 1 plant was greatest when plant density was 70 ths./ha harvest of haulms was the lowest (43.7 t/ha) in the end of July on this variant. This trend continued till time of harvest too. Harvest of haulms was 31.4 t/ha when plant

density was 150 ths./ha, 21.9 t/ha when plant density was 110 ths./ha and 16.7 t/ha when plant density was 70 ths./ha.



a) *b)*

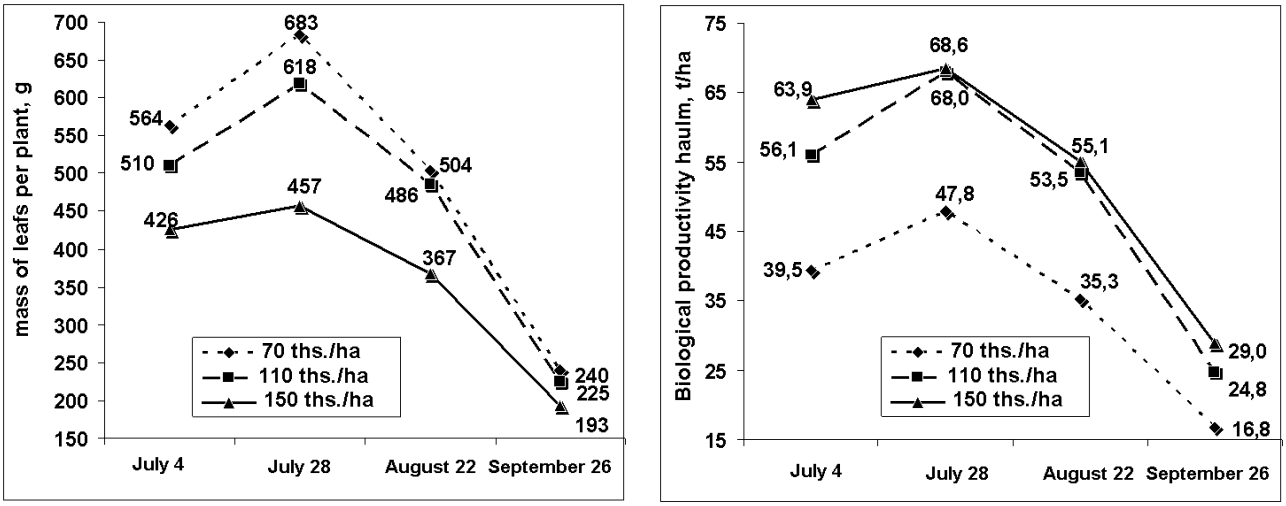
Figure 1. Dynamics mass of leaf of sugar beet of sort Bilotserkivskiy 45: a) - per plant, b) - per hectare.

Growth and development of leaves of sugar beet hybrid "Alexandria" there was more intense than the sort. At the end of July the mass of leaves was largest 683 g per plant when plant density was 70 thousand units./ha, which is 59 g more than sort "Belotserkovskyy 45". The minimum mass of leaves per plant was at hybrid "Alexandria" (457 g) when plant density was 150 ths./ha (Fig. 2 a). However, during the harvest (late September), the difference in mass of leaves per plant of hybrid "Alexandria" at different plant density was not significant and ranged from 193 to 240 g.

The maximum productivity of haulms (68.6 t/ha) hybrid "Alexandria" was observed in late July when plant density was 150 ths./ha (Fig. 2b). Slightly lower productivity of haulm (68.0 t/ha) was when the density of plants was 110 ths./ha. Despite the fact that the mass of leaves per plant was highest when the density plant was 70 ths./ha productivity of haulms was minimal and amounted 47.8 t/ha in this variant of the experiment. This trend continued till time of harvest too. When plant density was 150 ths./ha, then productivity of haulms was 29.0 t/ha, when the density

was 150 ths./ha - it was 24.8 t/ha and when the density was 70 ths./ha - it was 16.8 t/ha.

The intensity of leaf growth of sort and hybrid was maximal when phase of closing leaves in rows finished and early intensive growth of roots but assimilation surface area was highest during the period of intensive growth of roots, and then decreased in connection with demise leafs on the lower tiers.

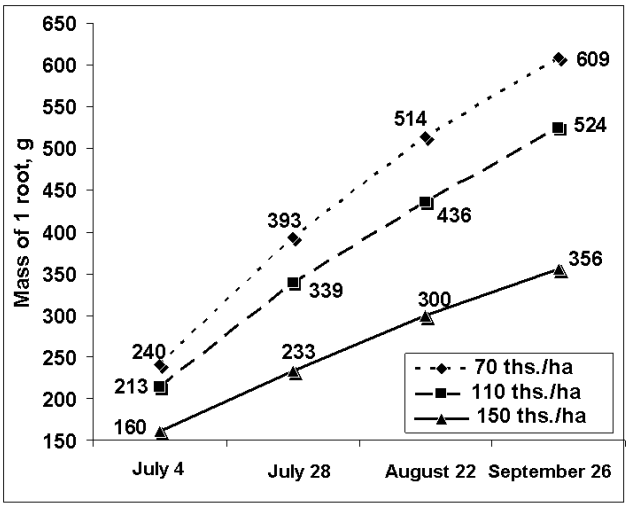


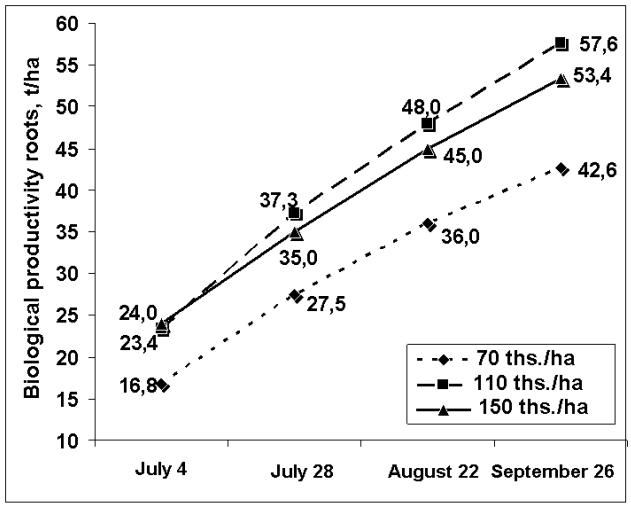
a) *b)*

Figure 2. Dynamics mass of leaf of sugar beet of hybrid "Alexandria": a) - per plant, b) - per hectare.

The most active root mass increase was in the second half of the growing season (late July - early August), when the mass of leafs is beginning to decrease. So, at the time of harvesting roots the average mass of one root of sort "Bilotserkivskiy 45" was the largest (609 g) when plant density was 70 ths./ha (Fig. 3 a). Averaged mass of root was lower (524 g) when plant density was 110 ths./ha. Averaged mass of root was minimal (356 g) when plant density was maximum (150 ths./ha).

The maximum biological harvest of roots (57.6 t/ha) sort "Bilotserkivskiy 45" was when plant density was 110 ths./ha (Fig. 3b). Slightly less (53.4 t/ha) was productivity of roots when the density of plants was 150 ths./ha. Despite the fact that the average mass of a sugar beet roots, when plant density was 70 ths./ha, was maximum (609 g), harvest of roots in this variant of the experiment was minimal - 42.6 t/ha.

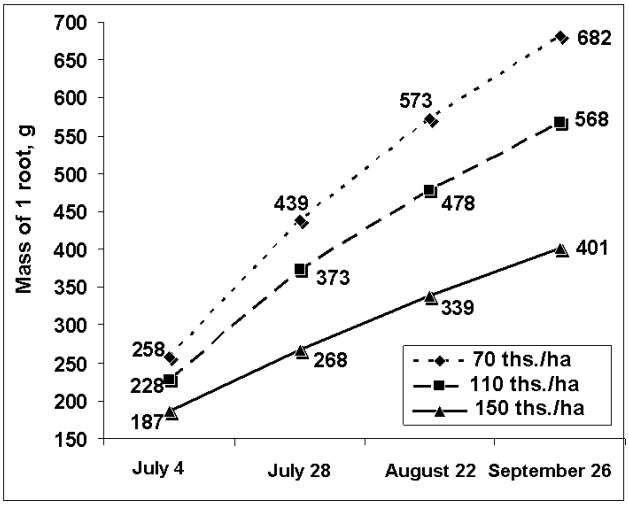


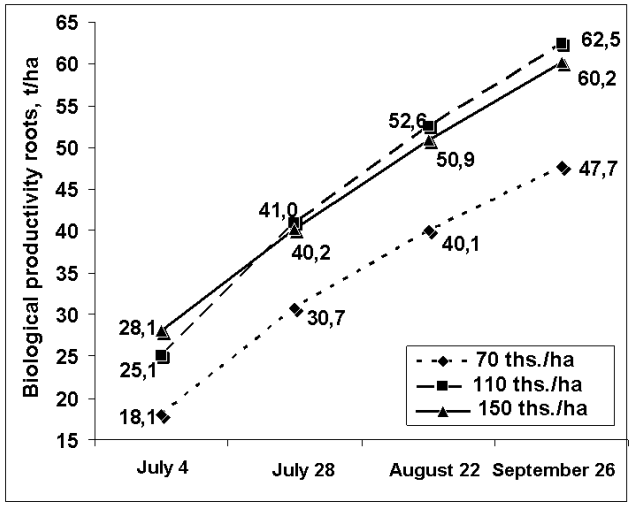


a) *b)*

Figure 3. Dynamics of mass of roots, depending from density of plants of sugar beet sort "Bilotserkivskiy 45": a) - per plant, b) - per hectare.

Growth and development of plants of sugar beet of hybrid "Alexandria" was more intense than the sort. For example, in the time of harvest average mass of root (plant density was 70 ths./ha) was maximum 682 g, it's on 73 grams more than the average mass of root sort "Bilotserkivskiy 45" (Fig. 4 a). When plant density was 110 ths./ha average mass of root was less (568 g), it's on 44 g less than the mass of the root sort "Bilotserkivskiy 45". Minimum (401 g) average mass of root of hybrid "Alexandria" was when the density of plants was 150 ths./ha.





a) *b)*

Figure 4. Dynamics of mass of roots, depending from density of plants of sugar beet hybrid "Alexandria": a) - per plant, b) - per hectare.

When plant density was 110 ths./ha, then biological productivity of roots of hybrid "Alexandria" was maximum (62.5 t/ha) (Fig. 4 B). Slightly less (60.2 t/ha) was productivity of root when the density of plants was 150 ths./ha. The average mass of a sugar beet (density of plants 70 ths./ha) was maximum (682 g), but the biological productivity of roots in this variant of the experiment was minimal - 39.6 t/ha.

The actual harvest of sugar beet of sort (49.0 t/ha) and hybrid (53.1 t/ha) was maximum when plant density was 110 ths./ha (Table 2). Productivity of haulm for hybrid "Alexandria" was also higher. The maximum sugar content of beets was in sort "Bilotserkivskiy 45" (17.9%) and hybrid "Alexandria" (17.2%) when plant density was 150 ths./ha.

Table 2.

Productivity of sugar beet and output of biofuels and energy depending on the density of plants (ESS Bilotserkivska 2010-2012).

Indexes	Sort "Bilotserkivskiy 45"			Hybrid "Alexandria"		
	Density of plants (at the time of harvest), ths./ha					
	70	110	150	70	110	150
Harvest of roots, t/ha	38,4	49,0	42,7	43,0	53,1	48,1
Harvest of haulms, t/ha	13,4	23,1	25,1	13,4	19,8	23,2
Sugar content of roots,%	15,7	17,4	17,9	15,2	16,3	17,2
Output of ethanol from roots, kg/ha	2765	3913	3510	2998	3973	3799
Output of biogas from haulms, m3/ha	1405	2430	2633	1411	2079	2432
Output of energy from roots, GJ/ha	69,12	97,82	87,75	74,94	99,33	94,97
Output of energy from haulms, GJ/ha	30,64	52,98	57,41	30,76	45,32	53,01
Total energy output, GJ/ha	99,76	150,80	145,16	105,71	144,66	147,99

The maximum amount of ethanol can be obtained when plant density was 110 ths /ha, while the difference between the sort and hybrid was not significant. This is

because despite greater productivity of roots of hybrid "Alexandria", sort "Bilotserkivskiy 45" had higher sugar content.

The maximum calculated output of biogas from haulms of sugar beet obtained when plant density was 150 ths./ha. This is due to increase productivity of haulm with increasing plants density. When the plant density is 150 ths./ha from haulms of sort "Bilotserkivskiy 45" can be obtained more than 2.6 ths.m^3/ha biogas but from haulms of hybrid "Alexandria" - over 2.4 ths.m^3/ha.

Maximum total output energy (150.8 GJ/ha) from roots and haulms of sugar beet sort "Bilotserkivskiy 45" when plant density was 110 ths./ha. For hybrid "Alexandria" increase plant density from 110 to 150 ths./ha resulted in a slight increase in the output of energy from 144.7 to 148.0 GJ/ha.

Conclusions. The maximum productivity sugar beet sort "Bilotserkivskiy 45" (49.0 t/ha) and hybrid "Alexandria" (53.1 t/ha) was when plant density was 110 ths./ha. Despite the fact that the harvest of roots of sugar beet of hybrid "Alexandria" was higher than the sort "Bilotserkivskiy 45" calculated output of ethanol was almost the same because the sugar content of roots of sort was higher.

Maximum calculated output of biogas from haulms during sugar beet harvesting can be obtained when density of plants is 150 ths./ha. In compacted crops of sugar beet from haulms of sort "Bilotserkivskiy 45" can be obtained over 2.6 ths.m^3/ha of biogas and from hybrid "Alexandria" - over 2.4 ths.m^3/ha.

Maximum total energy output (150.8 GJ/ha) can be obtained from sugar beet sort "Bilotserkivskiy 45" when plant density is 110 ths./ha. Slightly lower was output of total energy from roots and haulms of hybrid "Alexandria" (148 GJ/ha) when plant density was 150 ths./ha. Reduced density plants of hybrid to 110 ths./ha resulting in decrease in energy is 3.3 GJ/ha.

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Анотація

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Енергетична ефективність цукрових буряків залежно від густоти стояння рослин

Представлено результати досліджень з впливу густоти стояння рослин цукрових буряків сорту Білоцерківський 45 та гібрида Олександрія на вихід біоетанолу та біогазу, а також на загальний вихід енергії.

Ключові слова: *цукрові буряки, густота стояння рослин, біоетанол, біогаз, вихід енергії.*

Аннотация

Курило В.Л., Ганженко А.Н., Дубовый Ю.П., Макаренко А.С.

Энергетическая эффективность сахарной свеклы в зависимости от густоты стояния растений

Приведены результаты исследований влияния густоты стояния растений сахарной свеклы сорта Белоцерковский 45 и гибрида Александрия на выход биоэтанола и биогаза, а также на общий выход энергии.

Ключевые слова: *сахарная свекла, густота стояния растений, биоэтанол, биогаз, выход энергии.*