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1.3. Efficiency of energy crops cultivation for business development in Ukraine

Environmental, economic and social efficiency of energy plants growing can be achieved, if the sustainability criteria developed by the Global Bioenergy Partnership are complied with. This will allow the EU to achieve the goals of 2020 (20 % of renewable energy in final energy consumption, 10 % of renewable energy sources in the transport sector according to the Renewable Energy Directive 2009/28/EU 2009) [1].

Involvement of energy crops in the agriculture of Ukraine has several advantages: environmental, economic and energy. It has been established that perennial energy crops improve the soil structure, increase the content of organic matter in soil. They, due to the powerful phytomass, annually produce high yield that provides high economic indicators of energy-intensive biofuel production [2–5]. All these characteristics encourage scientists to conduct new researches and to find ways to reduce the cost of biomass.

Among the energy crops, representatives of the Poaceae family such as switchgrass, miscanthus giganteus and representatives of the Salicaceae family: willow [6] are the most widespread crops on the territory of Ukraine, according to the studied botanical and biological peculiarities and cultivation technology elements. It has been established that energy crops, taking into account their biological characteristics, differ both in yield and in energy output per unit area while cultivating in different soil and climatic conditions [7].

The energy crops of the Poaceae family differ in their duration of the growing season, the intensity of growth and development, the shape, colour of the edible organs and their structure, the relation to the environment, the technology of cultivation and the peculiarities of harvesting biomass [8, 9].

Switchgrass and Miscanthus are perennial herbs with a C 4 – scheme of photosynthesis. The description of these energy crops is given (Fig. 1–2).

Switchgrass (*Panicum virgatum L.*) is plant from the family of Poaceae.

Fig. 1 – Switchgrass (Panicum virgatum L.)

Plants reach a height of 100 – 150 to 210 – 250 cm. The number of productive shoots per plant is from 12–14 to 30 – 35 pieces. Plants, depending on the shape, are straight and semi-delusional. The number of metamers per stem is from 3 to 7, and in individual forms – up to 9. The diameter of the stem base is 4 – 6 mm on average, but forms with thin and thick stems are found. The sheet plate reaches a length of 50 – 60 cm, in some forms can be much longer; width is 11 – 14 mm on average. Panicle is flat, oval, pyramidical and compressed.

The length of the panicle is 30 – 40 cm, the width – 20 – 30 cm. By weight of 1000 pcs., grains are divided into three groups: with a low weight – up to 1.5 g, with an average weight of 1.5 – 1.8 and a large weight – more than 1.8 g.

Perennial rhizomes can be divided into 8 – 25 (vegetative reproduction) (up to 80) parts depending on the year of life and form of plants. Each landing unit has a length of 5 – 7 cm.

Unlike most perennials, switchgrass has a complete cycle of development (from seed to seed) during the first growing season. Intensive vegetation completes in the III decade of August – late October, depending on the genotype. Intensive plant regeneration begins in early spring (second decade of April) after overwintering. The phase of entering the tube comes from the second decade of July. Flowering is from the third decade of July to the first decade of August. Ripening from the end of September to the mid of October. Vegetation period is about 175 – 185 days.

Yield: aboveground phytomass of plants during the period of panicle appearance is 42 – 64 t/ha, during the flowering period is 42.7 – 70.2 t/ha; dry weight is 10 – 15 t/ha; seed is 500 – 600 (sometimes up to 1000) kg/ha. Energy productivity of plants is 40 – 60 (up to 80) Gcal/ha [10].

Miscanthus giganteus *(M.×giganteus)* is a plant from the family of Poaceae, is a tetraploid hybrid of the Chinese miscanthus *(M. sinensis Anderss.)* and a mucantic mushroom *(M. sacchariflorus (Maxim.) Benth.).*

Fig. 2 – Miscanthus giganteus (M.×giganteus)

Plants reach a height of 220 – 310 (may reach 450 – 500) cm. The number of shoots in the bush is 10 – 15 (up to 70). The stem is straight, rounded. The diameter of the stem is 12 – 25 mm. The number of leaves on the stalk is 11 – 15 pieces, the width is 2.2 – 2.9 cm, and the length is 93 – 102 cm.

The valve has a spindle-shaped, cone-shaped or elliptical shape and reaches a length of 30 – 33 cm. Plants have a rifle-type planting. The number of rhizomes (rhizomes) in one plant is from 18 to 37 pcs., the length is 10 – 15 cm.

Spring branching begins in the second half of April, tillering – the end of June, entering the tube – the end of August. The vegetation is completed in the phase of the appearance of panicle (most often in the phase of entering the tube) in the first half of October. The life cycle of plants lasts 15 – 20 years.

The yield of green phytomass is from 60 to 150 t/ha, dry weight is 10 – 15 (to 32) t/ha. The energy productivity of plants is 67 – 84 (up to 130) Gcal/ha [10].

Energy crops are herbaceous plants, shrubberies, fast-growing trees or other kinds of plants, biomass of which can be used for biofuel production (solid fuel, liquid soil and gas fuel) [11].

The phytomass of energy crops is used not only as a raw material for biofuels production, but also has a wide range of applications. Biomass is processed for various energy sources: solid fuel, biodiesel and bioethanol, as well as biogas. The components for chemical industry (biopolyethylen, bioplastics, and various compositions of household chemicals) and products of deeper chemical synthesis (pharmaceuticals, paints and varnishes, etc.) can be obtained too [12]. In addition, switchgrass has CO_2 neutral balance while growing and processing raw materials [13] and has phytoremediation properties [14].

Location of crop cultivation, soil tillage, seed preparation for sowing, moisture content in the soil at the time of sowing, soil temperature that is determined by the seeding term for the optimal combination of environmental factors are the key elements in the technology of switchgrass growing. Moreover, to improve the conditions of switchgrass growth and development, it is important to protect crops from weeds, including herbicides usage that depends on the soil-climatic zone of cultivation, and the ecotype chosen for cultivation [15–17].

The corresponding analysis of literature sources on this topic allowed us to develop practical effective mechanisms for optimizing the technology of switchgrass growing for the further production of energy-intensive biofuel from the local raw materials in order to reduce energy dependence and increase economic well-being of population of the territorial communities.

Besides, it is important to identify the economic efficiency of the best varieties and hybrids of a particular energy crop which are adapted to the certain conditions. This was the purpose of scientific work.

In view of the above, the authors conducted multi- year research with energy crops in the Central Forest Steppe of Ukraine. The experiment combined the study of energy crops varieties included in the Register of plant varieties suitable for distribution in Ukraine [18].

These are miscanthus varieties: Osinnii Zoretsvit (M1) and Huliver (M2), as well as switchgrass varieties: Morozko (S1) and Zoriane (S2). Energy crops were grown according to the recommendations of scientists [19], research was carried out according to the scientific methods in agronomy [20–22].

The economic efficiency of growing energy crops was carried out by the author's method [23]. Profit from energy crops biomass sale (P_b, Dollar/ha):

$$P_p = S_r - C_t,$$

S_r – revenue from energy crops biomass sale, Dollar/ha; C_t – total cost of energy crops cultivation, Dollar/ha

Profitability of energy crops biomass production (P, %):

$$P = \frac{G_p}{C_t} \cdot 100\%,$$

G_p – gross profit from energy crops biomass sale, Dollar /ha; C_t – total cost of energy crops cultivation, Dollar/ha.

While calculating economic efficiency of energy crops growing, biomass price of 950 UAH/t (At the dollar rate of 1:26) was taken into account.

According to the research results, it has been determined that the varieties of energy crops differed both in terms of yield over three years and in terms of economic efficiency of biomass production. It has been determined that the production costs of energy plantations location and energy crops cultivation will be the highest in the zero and the first year of crop cultivation. Starting from the second year of cultivation, the costs were decreasing and they were minimal starting from the third year that is the period of industrial harvesting of biomass (Fig. 3). This feature is characteristic for all varieties of the studied energy crops.

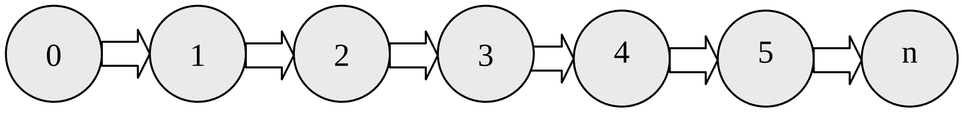
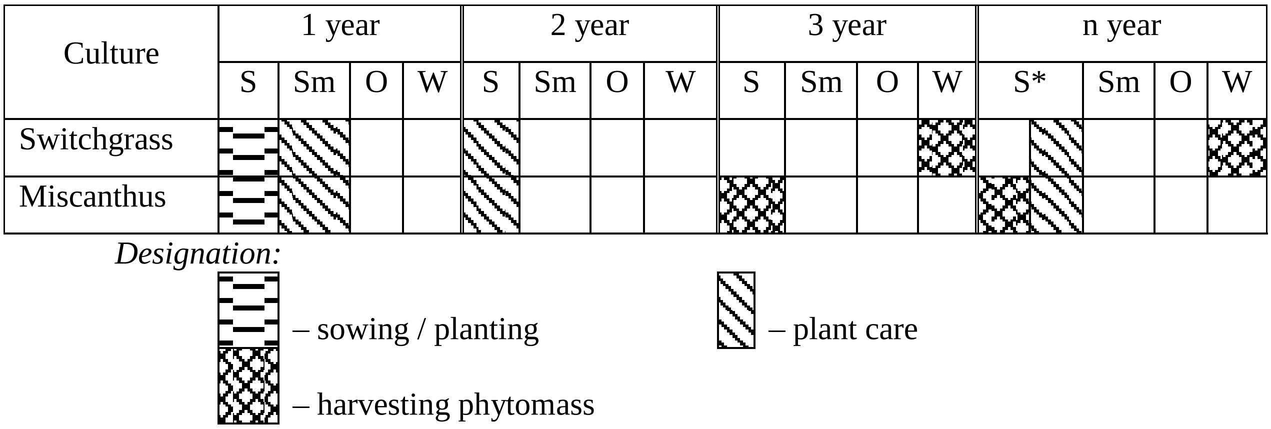


Fig. 3 – Logistic scheme of energy plantation location and cultivation of energy crops

Note: 0 year – plot of land location, basic soil tillage (summer-autumn); 1 year – spring soil tillage, sowing (planting), plant care (spring-summer); 2 year – plant care (spring-summer); 3 year – biomass harvesting (autumn-winter); 4 year – fertilization of crops in spring, biomass harvesting (spring, autumn-winter); 5 and n following years – fertilization of crops in spring, biomass harvesting (spring, autumn-winter).

Based on many years of research, it has been determined that the potential of yields of energy crops along with their specific features, the response to soil-climatic conditions depend on the agrochemical properties of the soil, how it is cultivated, the application of fertilizers, biopreparations, the timing and methods of sowing/planting, care of plants, the specifics of harvesting, and other factors.

For the effective functioning of non-volatile rural territories, an important aspect is the development of a logistic chain for the cultivation of energy crops, the supply of bio-raw materials and the rational use of biofuels (Fig. 4).



* Note: S – spring period; Sm – summer period; O – autumn period; W – winter period.

Fig. 4 – Logistics chain cultivation of biomass energy crops

The comparative characteristics of energy crops in the period of biomass supply make it possible to state that the proper crop management approach, the dry matter yield (raw material for biofuels: solid, liquid and gaseous) is from 15 to 20 t/ha, can be obtained for a long period of time from August-September of the previous year to February-March of the next year.

Miscanthus varieties varied in the range of 16.6 to 17.5 t/ha, switchgrass varieties – from 14.6 to 14.9 t/ha (Fig. 5).

The highest yield was formed by miscanthus varieties Osinnii Zoretsvit, variety Huliver provided lower yields. The Switchgrass variety Zoriane had a yield biomass greater than the variety Morozko.

The use of the energy crops varieties, in comparison allows to increase sales revenue up to 201.7 (Miscanthus varietie Osinnii Zoretsvit) and 212.4 Dollar/ha

(Miscanthus varietie Huliver), and up to 174.5 (Switchgrass varietie Zoriane) and 182.5 Dollar/ha (Switchgrass varietie: Morozko).

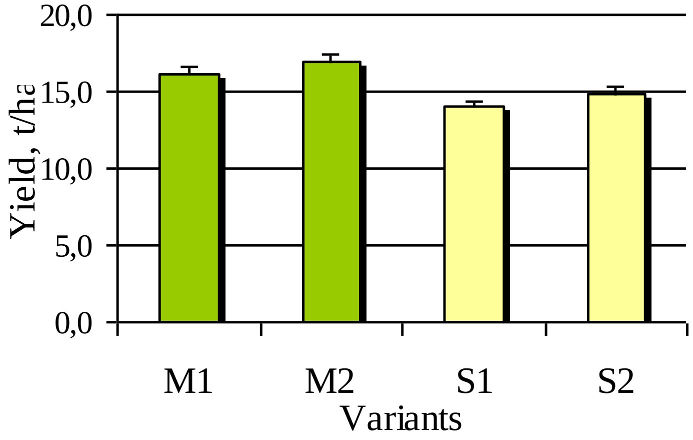


Fig. 5 – Yield of biomass production of energy crops, t/ha
Note: Miscanthus varieties: Osinnii Zoretsvit (M1) and Huliver (M2).
Switchgrass varieties: Morozko (S1) and Zoriane (S2).

Cultivation of Miscanthus variety Osinnii Zoretsvit and Switchgrass variety Zoriane contributes to increase production profitability, accordingly from 123.1 to 102.4 %, on average, throughout three years (Fig. 6–7).

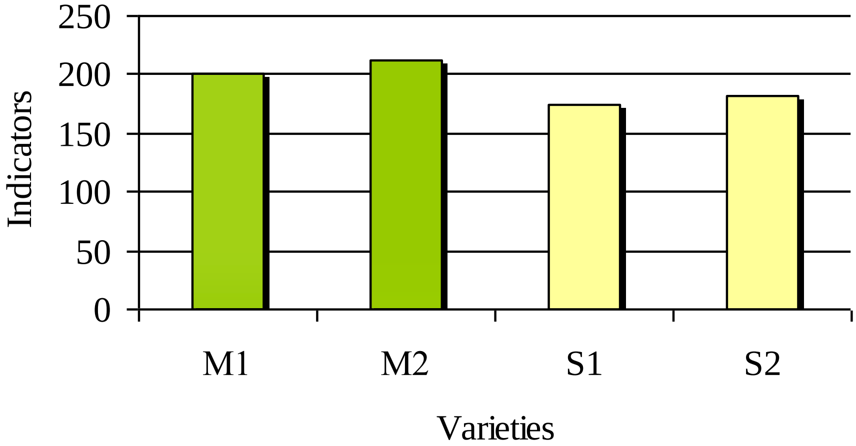


Fig. 6 – Economic efficiency (profit) of biomass production of energy crops, Dollar/ha
Note: Miscanthus varieties: Osinnii Zoretsvit (M1) and Huliver (M2).
Switchgrass varieties: Morozko (S1) and Zoriane (S2).

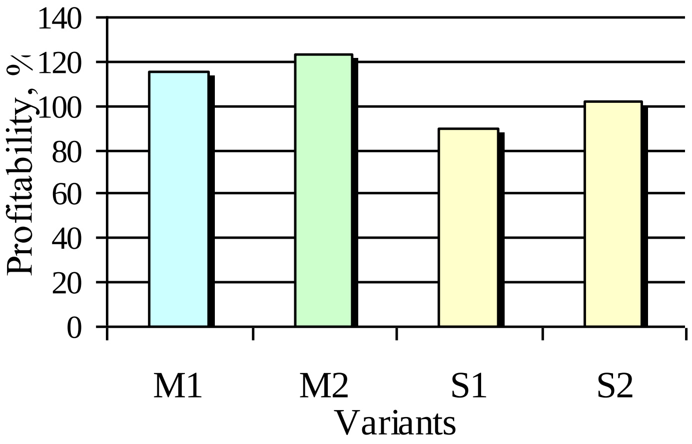


Fig. 7 – Economic efficiency (profitability level) of biomass production of energy crops, %

Note: Miscanthus varieties: Osinnii Zoretsvit (M1) and Huliver (M2).
Switchgrass varieties: Morozko (S1) and Zoriane (S2).

Miscanthus variety Huliver produced dry biomass yields in the range from 16.6 to 17.5 t/ha, throughout three years on average at the level of 16.9 t/ha, which is 0.8 t/ha more than the productivity of variety Osinnii Zoretsvit (16.1 t/ha). The profitability of biomass production by varieties was 123.1 % and 115.4 %, respectively.

The biomass yield of switchgrass variety Morozko varied from 13.1 to 14.4 t/ha (on average over the years by14.0 t/ha), and variety Zoriane – from 14.6 t/ha to 15.1 t/ha, which averaged 14.9 t/ha over the years. A profitability level of the biomass production of switchgrass variety Zoriane was 102.4 %, and the variety Morozko was 89.3 %.

Conclusions

1. In accordance with agro-climatic zoning in Ukraine, there are zonal features of selection and cultivation technology of agricultural and energy crops. In connection with this, an attempt has been made to allocate places of cultivation of cereal energy crops on the territory of Ukraine, taking into account the biological characteristics of plants.

2. Thus, the high economic efficiency of biomass production has been established during the cultivation of miscanthus variety Huliver (with a yield of 16.9

t/ha), variety Osinnii Zoretsvit (16.1 t/ha), as well as variety Zoriane (14.9 t/ha) profitability level is over 100.0 %).

Cultivation and using of biomass energy crops increase the efficiency of service delivery to both business and government agencies and non-profit organizations.

References:

1. Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Electronic resource. Access mode: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0028- 20151005&from=EN.
2. Taranenko A., Kulyk M., Galytska M., Taranenko S. 2019. Effect of cultivation technology on switchgrass (Panicum virgatum L.) productivity on marginal lands in Ukraine. Acta Agrobotanica. Vol. 72 (3) : 1786. Available online: https://doi.org/10.5586/aa.1786.
3. Kalinichenko O. V., Kulyk M. I. 2018. Economic efficiency of rod-shaped millet (switchgrass) cultivation within the forest-steppe of Ukraine. Ekonomika APK, № 11. P. 19. Available online: http://eapk.org.ua/en/contents/2018/11/19.
4. Elbersen W, Kulyk M.: Switchgrass Ukraine: overview of switchgrass research and guidelines, Wageningen, UR Food & Biobased Research. 2016, 26 p. Available online: https://library.wur.nl/WebQuery/wurpubs/444615.
5. Kalinichenko A., Kalinichenko O., Kulyk M. 2017. Assessment of available potential of agro-biomass and energy crops phytomass for biofuel production in Ukraine: Odnawialne źródła energii: teoria i praktyka. Monograph / pod red. I. Pietkun-Greber, P. Ratusznego, Uniwersytet Opolski : Opole, Kijów, (tom II): 163–179. Available online: http://dspace.pdaa.edu.ua:8080/handle/123456789/343.
6. Kulyk M I., Zhornyk I. I., Rozhko I. I. Educational process optimization throughout studying the discipline “Energy crops” by students of the speciality “Agronomy”. Herald of Oleksandr Dovzhenko Hlukhiv National Pedagogical University. Pedagogical sciences. 2018. Issue 1 (36). P. 131–139. URL: https://dspace.pdaa.edu.ua:8080/handle/123456789/1675.
7. Kurylo V. L., Rakhmetov D. B., Kulyk M. I. (2018). Biological features and potential of yield of energy crops of the Thin-skinned family in the condition of Ukraine. Bulletin of Poltava state agrarian Academy: Scientific and production professional journal. Vol. 1 (88), 2018: 11–17. URL: https://doi.org/10.31210/visnyk 2018.01.01.
8. Kulyk Maksym, Shokalo Natalia, Dinets Olha (2019). Morphometric indices of plants, biological peculiarities and productivity of industrial energy crops. Development of modern science: the experience of European countries and prospects for Ukraine: monograph / edited by authors. 3rd ed. Riga, Latvia: «Baltija Publishing», p. 411–431. URL: https://doi.org/10.30525/978-9934-571-78-7
9. Kulyk M. I., Kurylo V. L., Kalinichenko O. V., Galytska M. A. Plant energy resources: agroecological, economic and energy aspects : monograph / Edited by authors. Poltava: Astraya, 2019. 119 p. ISBN 978-617-7669-62-2
10. Kulyk M. Navchalnyi posibnyk: Erhetychni kultury. Poltava, 2016. 154 s.
11. Moroz O. V., Smirnykh V. M., Kurylo V. L., Herasymenko Yu. P., Mostovna N. A., Horobets A. M., & Kulyk M. I. (2011). Switchgrass as a new phytoenergy crop. Tsukr. buriaky [Sugar Beet], Vol. 3 : 12–14.
12. Lesschen J. P., Elbersen H. W, Poppens R., at all. (2012). The financial and GHG cost of avoiding ILUC in biomass sourcing – a comparison between switchgrass produced with and without ILUC in Ukraine. 20 th European Biomass Conference and Exhibition, 18–22 June 2012, 2012-06-18/2012-06-22. URL: https://library.wur.nl/ WebQuery/wurpubs/433099.
13. Kulyk M., Galytska M., Samoylik M., & Zhornyk I. (2019). Phytoremediation aspects of energy crops use in Ukraine. Agrology, 2 (1): 65–73. https://doi.org/10.32819/2617-6106.2018.14020.

14. Bransby D. I., Walker R. H., Miller M. S. (1997). Development of optimal establishment and cultural practices for switchgrass as an energy crop. Five year summary report. Oak Ridge National Laboratory, Oak Ridge, Tennessee.
15. Peters T. J., Moomaw R. S., Martin A. R. (1989). Herbicides for postemergence control of annual grass weeds in seedling forage grasses. Weed Sci. Vol. 37: 375–379.
16. Minelli M., Rapparini L, Venturi G. (2004). Weed management in switchgrass crop. In: Swaaij W. P. M., Fjallstrom T, Helm P, Grassi A (eds) 2 nd world biomass conference, Rome. Vol. 2 : 439–441. Available online. URL: https://pdfs.semanticscholar.org/25fa/0c05a898130a30fb2ac3811562f4eb6703b3.pdf.
17. Реєстр сортів рослин України. Register of plant varieties of Ukraine. Available online: http://service.ukragroexpert.com.ua/index.php.
18. Kulyk M., Elbersen W. Methods of calculation productivity phytomass for switchgrass in Ukraine. Poltava, 2012. 10 p.
19. Kulyk M. I., Rakhmetov D. B,. Kurylo V. L. Methodology of conducting field and laboratory researches with switchgrass (Panicum virgatum L.). Poltava, 2017. 24 p.
20. Rakhmetov D. B., Kalenska S. M., Fedorchuk M. I., et al. Methodical recommendations for optimization of miscanthus cultivation technology in the different soil and climatic zones of Ukraine. “Kolos” Publishing Center: Kherson State Agrarian University, 2017. 22 p.
21. Methodical recommendations for basic and pre-sowing soil tillage and switchgrass sowing / V. L. Kurylo, M. Ya. Humentyk, H. S. Honcharuk, et al. К.: ІВС&SB, 2012. 28 p.
22. Kalinchenko O. V., Kulyk M. I. Naukovyi tvir «Ekspres-analiz ekonomichnoi efektyvnosti vyroshchuvannia enerhetychnykh kultur v umovakh Lisostepu Ukrainy» (Svidotstvo pro reiestratsiiu avtorskoho prava na tvir № 93178 vid 18.10.2019).