UDC 636.085
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BIOENERGY ESTIMATION OF COMPLEX USE OF OILY FLAX PRODUCE

In the zone of dry Steppe of Ukraine the productivity of oily flax seed averages 12.8 cwt/ha and straw – 17.6 cwt/ha. Under irrigation the productivity increases by 32.8 and 58.8 % respectively, and expense of energy – by 27.2%. Bioenergy estimation of complex use of plant mass is done. Extraction of fibre from a straw and use of awn as a fuel material gives 1.9-2.1 times increase of the coefficient of energy efficiency.

Keywords: *oily flax, seed, straw, processing of straw, fibre, awn, energy efficiency.*

Introduction. Producing enormous amount of organic mass from agricultural plants humanity uses considerable part of it irrationally, regarding it to be wastes of production and even spending resources for utilization. Therefore a question of biologizing and harmonization of agroindustrial complex with the laws of nature and biosphere is global problem requiring a solution at modern scientific level. At the same time existing technologies allow successful usage of some types of vegetable mass, generally estimated as side material, getting useful produce additionally.

Analysis of the recent researches. Produce got from flax seed has wide application in chemical, food, mixed fodder industries, medicine, cosmetology; moreover, scientists continuously expose new spheres for application of unique in chemical and fat oil composition lint seed. Taking into account agrotechnical, economic and ecological advantages given by this crop, it is possible to expect the increase of areas under it. It is known from scientific literature that the stems of oily flax have high content of bass, that makes it possible to use it as a raw material for the production of fibre, cellulose, hydrocarbons, composite wares, building materials, fuel etc. Such production is run in Canada, USA, France, Italy, Poland [1]. Scientific substantiations, developments of similar technologies and necessary technological equipment are conducted in Russia [2]. Among home establishments it is expedient to mark the Kherson National Technical University (KNTU), where scientific bases of the primary processing of oily flax fibres are broaden and corresponding technological equipment is designed [3].

Task and methodology of researches. The substantial lack of such works is ignoring influence of agrotechnical factors of crop growing and disregarding variety features' impact on the productivity and technological properties of straw. In 2009-2012 researches on oily flax quality estimation and study of its complex use possibilities were conducted in Askaniyskiy SARS NAAS, having the aim to study the productivity forming processes. The varieties of oily flax of home and foreign plant-breeding establishments were the subject of the study at different levels of moisture provision. The farming enterprise is located in the zone of dry Steppe. The ground cover is presented by darkly-chestnut heavy loamy soils. Humus horizon having capacity of 42-51 cm. Arable layer contains on the average 2.15 % of humus, per 100 g of soil: 5.0 mg of lightly hydrolized nitrogen, 2.4 mg of moving phosphorus and 40 mg. of exchange potassium. A meter-deep layer contains up to 129 mm of accessible moisture, at a general supply of 320 mm. Irrigation is provided from the network of the Kakhovka Irrigation System. Humidity of 0.7 m layer of soil was kept at the level of 65-70% HB with the help of irrigation. Basic till foresaw 20-22 cm deep ploughing with the application of mineral fertilizers N_{45} P_{30} K_{30}. Assessment of straw was executed in accordance with methodologies of seed trial and State standards for long-fibred flax.

The years of researches were characterized by the extreme vibrations of meteorological indices. The year 2011 was more favourable for growth and development of the crop due to the greater supplies of the soil moisture in a spring period and abundant precipitations.

Results of researches. The presented varieties have different ecological origin and were created for different zones. To the varieties of SSC «Institute of agriculture of UAAS» belong Blue-Orange (Blakytno-pomarancheviy), Eurica, «Deutsche Saatfederelung Lippstadt AG» variety Lirina, «SSE ВНІІМК having the name of V.S. Pustovoyt» – Rucheyok and ВНИИМК 620, «SSE Don ДС having the name of A.O. Zhdanov ВНІІМК» variety Nadiyniy. Originators of other varieties are Institute of oil-bearing cultures of NAASU, and of the variety Vera – Askaniyskiy SARS NAAS. Most varieties belong to the drought-resisting ecotypes.

During the research the productivity of varieties fluctuated from 11.6 to 13.8 cwt/ha without irrigation and from 15.8 to 18.2 cwt/ha under irrigation (table. 1). Due to watering the productivity of seed grew on 32.8% on the average.

Table 1

Productivity of oily flax varieties depending on the level of moisture provision, cwt/ha (AV of 2009-2012)

Varieties	Productivity of seed, cwt/ha		Productivity of straw, cwt/ha	
	without irrigation	under irrigation	without irrigation	under irrigation
Pivdenna Nich (St)	13	17.5	16.4	28.7
Iceberg	13.8	18.2	18.8	26
Blue-Orange	11.8	15.8	17.6	27.5
Vera	13	17.3	16	27.1
ВНИИМК 620	13.8	17.7	18.5	25.9
Debut	12.6	16.9	16.3	23.8
Eurica	13.1	16.6	18.4	27.2
Zolotistiy	11.6	16.2	14.5	25.3
Kivikha	12.3	16	15.6	26.5
Lirina	12	16.3	18.5	28
Nadiyniy	13.2	17.5	21.3	38
Orpheus	12.9	17.8	16.7	30.2
Rucheyok	13.5	17.4	19.6	28.1
HCP_{05} for varieties	from 0.3	to 0.38	from 0.56	to 0.85
for moisture provision	from 0.76	to 0.81	from 1.19	to 1.92
for interaction	from 1.08	to 1.14	from 2.1	to 2.71

On a background of natural moistening the greatest productivity was shown by varieties Iceberg, ВНИИМК 620 – 13.8 cwt/ha, Rucheyok – 13.5 cwt/ha, while varieties originated from zone of the sufficient moistening – Lirina, Blue-Orange and Zolotistiy – had the lowest productivity, within the limits of 11.6 - 12 cwt/ha.

Under irrigation the greatest productivity was shown by varieties Iceberg (18.2 cwt/ha), Orpheus (17.8 cwt/ha) and ВНИИМК 620 (17,7 cwt/ha). The least indices of seed productivity had varieties Blue-Orange, Lirina and food-purpose variety Kivikha, the productivity of that changed from 15.8 to 16.3 cwt/ha.

Anatomical and morphological peculiarity of the varieties and their reaction to the conditions of environment are determined by their genotype and influence on forming of straw part of plant. As a rule, taller varieties, objects of northern regions, form greater pedicellate mass, especially under improved conditions of moisture provision. At natural moistening background this group was represented by varieties Nadiyniy 21.3 cwt/ha, Rucheyek 19.6 cwt/ha, Iceberg 18.8 cwt/ha. Under irrigation the group included Nadiyniy 38.0 cwt/ha, Pivdenna Nich 28.7 cwt/ha and also Rucheyek and Lirina 28 cwt/ha.

The calculation of energy efficiency was conducted with a balance method applying normative coefficients after results of calculation of flowsheets [4].

Growing of oily flax seed requires averagely 23.5 GJ/ha of energy charges without application of irrigation and 29.9 GJ/ha under irrigation (table 2). To sum it up, charges of energy for irrigation and related additional measures grow on 27.2%. Depending on the varieties charges increased in accordance with the increase of the crop productivity. According to the results of calculations, due to chemical composition of flax seed, content of gross energy constitutes 22.0 MJ/kg, that is higher than in grain-crops. Receipt of accumulated seed energy on the average GJ/ha without irrigation and 37.4 GJ/ha under irrigation. Drilled on boghara varieties Iceberg and ВНИИМК 620 provided the greatest values of this index – 30.4 GJ/ha. Under the conditions of irrigation this group of varieties was enlarged by Iceberg and Orpheus 40.4 and 39.2 GJ/ha accordingly.

Table 2

Energy efficiency of growing of oily flax seed. (AV 2009-2012)

Varieties	Receipt of energy, GJ/ha.		Charges of total energy, GJ/ha		Energy coefficient (seed)	
	without irrigation	at irrigation	without irrigation	at irrigation	without irrigation	at irrigation
Pivdenna Nich (St)	28.6	38.5	23.5	30.1	1.22	1.28
Iceberg	30.4	40.0	23.6	30.1	1.29	1.33
Blue-Orange	26.0	34.8	23.4	29.7	1.11	1.17
Vera	28.6	38.1	23.5	30.0	1.22	1.27
ВНИИМК 620	30.4	38.9	23.6	30.1	1.29	1.29
Debut	27.7	37.2	23.5	29.8	1.18	1.25
Eurica	28.8	36.5	23.5	29.8	1.22	1.23
Zolotistiy	25.5	35.6	23.4	29.7	1.09	1.20
Kivikha	27.1	35.2	23.5	29.7	1.15	1.19
Lirina	26.4	35.9	23.4	29.7	1.13	1.21
Nadiyniy	29.0	38.5	23.6	30.1	1.23	1.28
Orpheus	28.4	39.2	23.5	30.1	1.21	1.30
Rucheyok	29.7	38.3	23.6	30.0	1.26	1.27

Energy coefficient testifies to positive balance of consumption only of flax seed. It is the highest at varieties that formed the maximal productivity; and under irrigation it grows averagely on 4.3%. Varieties Zolotistiy, Lirina and Orpheus showed the greatest increase of energy due to irrigation.

The analysis of oily flax straw demonstrates content of bass 14.5 % on boghara land and 22 % under irrigation. Although anatomic indices of stem, technological properties of long-stalk flax and oily flax straw and the process of cropping are different, fibre can be withdrawn from the stems of oily flax at applying serial lines of mechanical treatment of unstandard low-grade thrash. Such lines were worked out and improved by the scientists of KNTU and demonstrate possibility of organization of such processing [3].

Table 3

Energy estimation of oily flax growing at the complex use of seed and straw.

Varieties	Energy intensity of fuel material from awn, GJ/ha		General energy coefficient	
	without irrigation	under irrigation	without irrigation	under irrigation
Pivdenna Nich (St)	20.6	33.0	2.24	2.68
Iceberg	23.3	29.6	2.46	2.60
Blue-Orange	22.2	31.9	2.22	2.53
Vera	19.7	32.6	2.22	2.59
ВНИИМК 620	23.8	30.3	2.44	2.56
Debut	20.8	27.2	2.20	2.42
Eurica	23.3	33.2	2.38	2.57
Zolotistiy	18.5	29.9	2.01	2.45
Kivikha	19.6	31.1	2.13	2.50
Lirina	23.1	32.5	2.29	2.59
Nadiyniy	28.4	44.8	2.56	3.14
Orpheus	21.0	33.6	2.25	2.78
Rucheyok	25.8	32.8	2.48	2.65

According to our calculations it is possible to get, depending on a variety and moisture provision, from 2.0 to 8 cwt/ha of short fibre, that, taking into account quality of raw material, can be appraised in 2.8 – 11.1 GJ/ha of total energy. Processing of straw is not accompanied by accumulation of additional energy but allows to use more rationally the present one. Energy charges for growing were taken into account in calculations. Awn is regarded to be wastes of production in the process of flax straw processing, but it can be used for making flags, heat insulation material, building materials or used, after granulation, as a renewable fuel material.

Taking into account the amount of awn and its energy intensity, burning provides the receipt of energy from 18.5 GJ/ha at growing of crop without irrigation to 44.8 GJ/ha at growing under irrigation. Taller varieties Nadiyniy, Eurica, Orpheus provide the highest energy increase. Taking into account general produce output (seed, fibre, awn), the energy coefficient of such technology grows and generalized averagely constitutes for boghara 2.30 and for irrigated lands 2.62.

It is expedient to take Nadiyniy (2.56), Rucheyok (2.48), Iceberg (2.46) and ВНИИМК 620 (2.44) to the group of varieties providing the greatest recoupment of the total energy spent when grown without irrigation. Under artificial moistening such varieties as Nadiyniy (3.14) Orpheus (2.78) and Pivdenna Nich (2.68) are the most efficient.

Conclusions and suggestions. Growing of oily flax according technologies of complex use of vegetable mass allow to get additionally fibre and fuel slugs, that 1.9-2.1 times promotes energy efficiency of growing. These technologies response to ecological approach of renewable resources providing. Further researches for development of technologies of other produce receipt from straw are expedient.

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Анотація

Рудік О.Л.

Біоенергетична оцінка комплексного використання продукції льону олійного

У зоні сухого Степу України урожайність насіння льону олійного в середньому складає 12,8 ц/а а соломи 17,6 ц/га. При зрошенні урожайність зростає відповідно на 32,8 та 58,8 % а витрати енергії на 27,2%. Дана *біоенергетична оцінка комплексному використанню маси рослини. Вилучення волокна із соломи та використання для палива костриці підвищує коефіцієнт енергетичної ефективності в 1,9-2,1 рази.*

Ключові слова*: льон олійний, насіння, солома, переробка соломи, волокно, костриця, енергетична ефективність.*

Аннотация

Рудик А.Л.

Биоэнергетическая оценка комплексного использования продукции льна масличного

В зоне сухой Степи Украины урожайность семян льна масличного в среднем составляет 12,8 ц/а а соломы 17,6 ц/га. При орошении урожайность возрастает на 32,8 и 58,8 % соответственно, а расход энергии на 27,2%.. Сделана биоэнергетическая оценка комплексному использованию массы растения. Извлечение волокна из соломы и использование для топлива тресты повышает коэффициент энергетической эффективности в 1,9-2,1 раза.

Ключевые слова: *лён масличный, семена, солома, переработка соломы, волокно, костра, энергетическая эффективность.*