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ЕНЕРГЕТИЧНА ЕФЕКТИВНІСТЬ НАСІННИЦЬКИХ ПОСІВІВ *PANICUM MILIACEUM (L.)*

Анотація. *Досліджено енергетичну ефективність технології вирощування проса посівного (Panicum miliaceum L.) на насіннєві цілі в поколіннях. Одержаний рівень коефіцієнта енергетичної ефективності вирощування насіння і зерна різних сортів проса посівного вказує на доцільність в умовах Правобережного Лісостепу рекомендованих до виробництва агроприйомів, а також значну економію енерговитрат.*
Ключові слова: *просо посівне, насіння, зерно, енергетична ефективність.*

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ЭНЕРГЕТИЧЕСКАЯ ЭФФЕКТИВНОСТЬ СЕМЕННЫХ ПОСЕВОВ *PANICUM MILIACEUM (L.)*

Исследована энергетическая эффективность технологии выращивания проса посевного (Panicum miliaceum L.) на семенные цели в поколениях. Полученный уровень коэффициента энергетической эффективности выращивания семян и зерна разных сортов проса посевного указывает на целесообразность в условиях Правобережной Лесостепи рекомендованных к производству агроприемов, а также значительную экономию энергопотребления.
Ключевые слова: *просо посевное, семена, зерно, энергетическая эффективность.*

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ENERGY EFFICIENCY OF SEED SOWINGS *PANICUM MILIACEUM (L.)*

The energy efficiency of the growing technology of millet (Panicum miliaceum L.) for seed production in generations has been investigated. The obtained level of the energy efficiency ratio of cultivating seeds and grain of various varieties of brown-corn millet indicates the expediency of the recommended agricultural techniques in the conditions of the Right-bank Forest-Steppe, as well as the significant energy savings.

Key words: *brown-corn millet, seeds, grain, energy efficiency.*

Target setting. The economic value and environmental feasibility of any plant production technology is characterized by the level of useful and safe use of energy and other non-renewable resources [1].

In the conditions of economic instability and growing inflation, the economic evaluation of agricultural production technologies does not provide a full definition of their expediency and the recoupment of capital investments [2]. Therefore, along with the well-known indicators of economic efficiency, it is expedient to carry out an energy estimation. The energy analysis allows determining the energy costs of performing the separate technological operation and comparing the general level of different technologies, as well as the complexes of machines for their implementation, regardless of the pricing policy. Such a versatility of this method of evaluation the effectiveness of the recommended agronomic techniques is of particular importance under the current economic conditions, when the prices for machinery, energy, fertilizers, seeds, plant protection means and other non-renewable sources of energy are rapidly increasing.

The state of studying the issue. The analysis of the peculiarities of the formation of the cereal crops market in Ukraine demonstrates an ever-increasing interest in the purchase of millet from not only domestic consumers, but also the export-oriented companies. Thus, only in the conditions of 2011/2012 marketing year, the millet export has increased more than twice – to 57.8 thousand tons, and according to analysts' forecasts, in subsequent years it may reach 65 thousand tons [3].

The study of the economic and energy efficiency of cereal crops growing in Ukraine was carried out by such leading sciences as O. S. Alekseieva, V. Ya. Bilonozhko, O. V. Averchev and others. However, due to the gradual change of weather conditions and pricing policies, they have partially lost their relevance. In addition, such studies did not take into account the energy efficiency of cereal crops growing for seed purposes. Therefore, in order to solve this problem, the *objective* of our research was to establish the most suitable and low-energy consuming elements of the technology of high quality seeds growing of various varieties of brown-corn millet.

Statement of basic materials. In order to study the economic and energy efficiency of the elements of the cultivating technology of brown-corn millet varieties for seeds, we have laid a number of field experiments (2003–2016) in the conditions of the Right Bank Forest-Steppe.

The general indicator of the energy evaluation of the efficiency of crop cultivation is the energy efficiency ratio (K_{ee}), which is calculated as the ratio of the energy received with the yield to its total cost per unit production. The total energy expenditure is defined as the sum of direct (fuel, electricity, gas, coal, etc.) and indirect (cars, fertilizera, seeds, etc.) energy consumptions, expended in vehicles constructions, fertilizers, plant protection means, seeds. It is clear that the production of this or that type of product will be effective only when $K_{ee} > 1$ [4].

Analysis of the performed calculations of the total expenditures of non-renewable energy (Ен), its output with the yield of seeds (Ey) and the energy efficiency ratio (Kee) indicate the considerable expediency of the recommended agricultural techniques for the cultivation of millet seeds. In general, according to the results of the conducted calculations, Kee of millet seeds growing was at the level of 3.8-5.6, which is significantly greater than 1 (Table). The high energy value of the cultivated seed (6069 kcal/kg) contributed greatly to such a high level of this indicator.

Despite the fact that the creation and application of mineral fertilizers is a high-energy consumption process, our proposed dosages provided for the effective product in terms of energy. Thus, in comparison with the non-fertilized control, the expense amount of non-renewable energy consumption on the plots with total fertilizer application $N_{60}P_{60}K_{60}$ (experiments 1–3) increased from 15.83–16.15 GJ/ha to 22.29–22.60 GJ/ha, or 40–41% more. However, a substantial increase in seed yield obtained at the experimental plots provided a significant additional accumulated energy output – at the level of 18.20–40.88 GJ/ha, which is 24–51% more compared to no treatment.

A similar positive energy effect was also obtained using the optimal sowing parameters of the seed cenosis (Experiments 4 and 5). Thus, the sowing of millet with the usual row method with a seed rate of 3.5 million pcs. of similar seeds/ha in the first and second decades of May provided the energy output with a seed yield of 96.92–118.25 GJ/ha, when K_{ee}=4.3–5.2. By the wide-row sowing methods at 30 and 45 cm and the transfer of sowing to the third decade of May, the level of these indicators on the recommended variants of seed rates (2.5 and 2.0 million pcs/ha) was somewhat lower and was within the range of 93.78–106.59 GJ/ha respectively, at K_{ee}=3.8–4.4.

The mowing of seed sowings at 65–70% of the degree of head maturity with the subsequent swath threshing in three and six days (experiment 6) was almost equivalent to the energy input in the seed yield (100.22 and 100.56 GJ/ha), and the threshing delay to 85–90% of maturity and the direct threshing use somewhat reduced the level of this indicator (by 2%).

The variants of the first seed progeny sowings had the significantly lower level of these energy efficiency indices. So, if the total expenses of non-renewable energy remained unchanged (22,60 GJ/ha), the much lower energy value of the obtained grain yield (4046 kcal/ha) significantly reduced the amount of energy accumulated in it – according to the level only 39.82 – 70, 98 GJ/ha. However, taking into account that the energy efficiency ratio was greater than 1 (K_{ee}=1,8–3,4), the recommended agricultural techniques of the seed material cultivation remained more energy-efficient.

Conclusion. The obtained level of the energy efficiency ratio of seeds (3,8–5,6) and grain (1,8–3,4) growing of various varieties of brown-corn millet shows the expediency of the recommended agricultural techbiques in the conditions of the Right-bank Forest-Steppe and a significant saving of

Таблиця 1

Energy efficiency of millet seeds growing depending on the recommended agricultural techniques

Variant of the experiment (variety, millet forecrop, mineral nutrition system, time and method of sowing, seeding rate, harvesting)		Seed sowing			The first seed offspring		
		Ен, *GJ/ha*	Еу, *GJ/ha*	K_{ee}	$E_н$, *GJ/ha*	Еу, *GJ/ha*	K_{ee}
1		*2*	*3*	*4*	*5*	*6*	*7*
–		Experiment 1 *(2003 – 2006 pp.)*			Experiment 7 *(2004 – 2007 pp.)*		
Veselopodilske 16 variety	No fertilizers*	16,14	75,16	4,7	22,60	34,53	1,5
	Ground + N_{60}	22,60	100,83	4,5	22,60	48,32	2,1
Golden variety	No fertilizers*	16,15	80,24	5,0	22,60	37,89	1,7
	Ground + N_{60}	22,60	121,12	5,4	22,60	52,14	2,3
Golden variety		Experiment 2 *(2005 – 2007 pp.)*			Experiment 8 *(2006 – 2008 pp.)*		
Forecrop: peas	No fertilizers*	16,15	89,92	5,6	22,60	56,39	2,5
	$N_{60}P_{60}K_{60}$	22,60	115,28	5,1	22,60	67,71	3,0
Forecrop: winter wheat*	No fertilizers*	16,15	84,00	5,2	22,60	53,42	2,4
	$N_{60}P_{60}K_{60}$	22,60	112,87	5,0	22,60	63,73	2,8
Poltavske Zolotyste variety		Experiment 3 *(2006 – 2009 pp.)*			Experiment 9 *(2007 – 2010 pp.)*		
Common row sowing method (15 cm)	No fertilizers*	16,13	76,01	4,7	22,59	45,15	2,0
	P_{60}	16,88	76,35	4,5	22,59	59,26	2,6
	$N_{60}K_{60}$	21,83	89,13	4,1	22,59	57,37	2,5
	$N_{60}P_{60}K_{60}$	22,60	94,21	4,2	22,59	51,38	2,3
Wide-row sowing (45 cm)	No fertilizers*	15,83	70,76	4,5	22,59	43,20	1,9
	P_{60}	16,59	79,39	4,8	22,59	57,44	2,5
	$N_{60}K_{60}$	21,53	80,94	3,8	22,59	52,19	2,3
	$N_{60}P_{60}K_{60}$	22,29	92,20	4,1	22,59	61,13	2,7
–		Experiment 4 *(2009 – 2012 pp.)*			Experiment 10 *(2010 – 2013 pp.)*		
Slobozhanske variety, Common row sowing method	first term	22,62	96,92	4,3	22,62	61,54	2,7
	second term*	22,62	106,82	4,7	22,62	55,07	2,4
Wide-row sowing	third term	22,31	97,26	4,4	22,62	57,01	2,5
Lana variety, Common row sowing method	first term	22,62	102,84	4,5	22,62	70,98	3,1
	second term*	22,62	112,66	5,0	22,62	56,71	2,5
Wide-row sowing	third term	22,31	98,78	4,4	22,62	61,68	2,7
Omriiane variety		Experiment 5 *(2008 – 2011 pp.)*			Experiment 11 *(2009 – 2012 pp.)*		
Звичайний рядковий спосіб (15 см)	3.5 million pcs./ha	22,62	118,25	5,2	22,62	72,55	3,2
	4.0 million pcs./ha*	22,73	124,25	5,5	22,62	50,65	2,2
Широко-рядний спосіб (30 см)	2.5 million pcs./ha	22,41	98,02	4,4	22,62	73,99	3,3
	3.0 million pcs./ha*	22,52	106,59	4,7	22,62	56,31	2,5
Широко-рядний спосіб (45 см)	2.0 million pcs./ha	22,31	84,05	3,8	22,62	76,12	3,4
	2.5 million pcs./ha*	22,41	93,78	4,2	22,62	67,48	3,0
Golden variety		Experiment 6 *(2012 – 2015 pp.)*			Experiment 12 *(2013 – 2016 pp.)*		
Degree of seed maturity 65–70%*	*3 days of swath storing*	22,60	100,22	4,4	22,60	61,62	2,7
	*6 of swath storing **	22,60	100,56	4,4	22,60	60,73	2,7
	direct threshing	19,51	98,35	5,0	22,60	39,82	1,8

Note. * – control

energy costs.

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