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OIL RADISH AS A RAW MATERIAL FOR BIOFUEL PRODUCTION

We have studied the value of oil radish and prospects of its growing in terms of using for biofuel production. The article presents the study results of fatty acid content of its seeds and oil yield technological characteristics of its crops, depending on the technology of sowing and fertilizing.

Key words: *oil radish, biofuel, oil yield, fatty acid content*

Introduction. Currently there is a tendency for fuel price increase, which certainly will affect production volume decline of agricultural products [1]. The use of alternative fuels will allow agrobusiness companies to change the structure of planted areas in favour of oil-bearing crops.

The most common crop used for biofuel production is rape. [1] However, industrial experience has shown that this crop is quite fastidious to abiotic factors of vegetation and growth technology resource component. Such crop as oil radish does not have these disadvantages. Oil radish - is an annual herb of the Cruciferae family, cold-resistant, shade-tolerant and productive, unpretentious to soils. Oil radish seeds contain up to 48 - 50 % of oil. Important positive quality of oil radish is resistance to pod cracking, thanks to what collection can be carried out at full maturity. Oil radish well connects nitrogen and has phytosanitary properties [2].

Besides, there is an intensive emerging tendency to use it for biofuel purposes and biogas production purposes in a number of European countries [3, 4]. As a result, in the last period its area increased almost three times as much in Europe and the United States compared to 1990. In studies of a number of foreign scientists it is observed that oil radish is very promising crop of Nonfood group for Biodiesel market [5, 6] and, D. Shpaar [7] and others [8] point out that technical direction of using its oil is caused by the content of simple unsaturated fatty acids.

It should be noted that in Ukraine at present time industrial processing of oil radish is complicated by the lack of normative-technical documentation [4]. In Russia , by contrast , its oil is widely used in various systems of diesel engines. So A.P. Ukhanov [3] found out that the use of radish - mineral fuel consisting of 50 % oil from oil radish + 50% of diesel fuel improves the environmental specifications of a diesel engine.

The aim of our research was to study the quality indicators of oil radish seeds for fatty acid content and evaluation of oil yield per unit area, depending on the specific technological parameters of seeding and fertilizing.

Materials and methods. Field research was conducted during the 2010 - 2012 on a joint research field of Vinnytsia National Agrarian University and the Institute of Feed and Agriculture of Podillya NAAS on two varieties - Zhuravka and Rainbow.

Soils – are gray forest average loamy with average content: humus 2,9 %, easy hydrolysable nitrogen 8,1, labile phosphorus 18,7, exchange potassium 9,8 mg/100 g soil at pH_{kcl} 5,5.

Conditions in 2010 were the most favorable for oil radish growth and development with precipitation amount during April - September - 449 mm, average temperature is 17,2 ° C and hydrothermal index - 1.49. Conditions in 2012 had evident aridity: precipitation amount during the same period is 272.4 mm, average temperature is 17,7 ° C, hydrothermal index - 0.79.

The research program provided studying two methods of sowing of oil radish - a continuous line (15 cm - row spacing width) at three seeding rates - 3, 2 and 1.5 million pcs./ha of similar seeds and interlaced (30 cm), respectively 1.5, 1, 0, and 0.5 million pcs./ha of similar seeds. Each of options of seeding rates was placed according to three feeding variants: 1st - without fertilizers (control), 2nd - $N_{30}P_{30}K_{30}$ kg s.s.; 3rd - $N_{60}P_{60}K_{60}$ kg s.s.

Number of research replications is four times. The planted area is 30 м^2, accounting area - 25 м^2. Preceding crop is maize to grain. Farming equipment is generally accepted for areas for cultivation. Observations and counts were performed according to conventional methods [9].

Results and discussion. Our research has shown that oil radish seeds has a high fat content (on dry basis) within 34 - 38% depending on the variant, a relatively high content protein 22.4 - 23.8%. 1 kg of dry substance of seeds contains more than 1 k. units, containing 170.3 - 185.3 g of digestible protein in each (Table 1).

Moreover, we found out that oil radish seeds are potentially possible high-energy food, 1 kg of dry substance of which provides 15,9 – 16,6 MJ exchange and 26,1 – 27,3 MJ gross energy.

Table 1

Chemical composition and nutritional value of oil radish seeds in case of various fertilization

Seeding rate, mln. pcs./h of similar seeds	Fertilizers	Content in an absolutely dry substance, %					Dry substance, %	Content in 1 kg of dry substance			
		protein	fat	cellulose	ash	nitrogen-free extract substances		fee units	digestible protein, g	exchange energy, mJ	gross energy, mJ
Zhuravka (average for 2010 – 2012)											
2,0	Without fertilizers	23,6	36,9	17,3	6,2	15,3	93,0	1,02	181,0	15,8	26,5
	$N_{60}P_{60}K_{60}$	23,9	37,8	17,1	6,5	15,6	92,7	1,01	183,7	16,1	26,9
Rainbow (average for 2011 – 2012)											
2,0	Without fertilizers	22,4	37,5	17,0	5,1	16,5	93,3	1,03	170,3	15,9	26,6
	$N_{60}P_{60}K_{60}$	23,6	37,9	18,6	5,2	16,3	94,1	1,02	180,6	16,0	27,3

The results of chromatographic determination of fatty acid content of oil radish seeds in varieties Zhuravka and Rainbow are presented in Table. 2

The received by us results confirm the category of oil for both varieties as semidrying for technical purposes. Besides, we specified a high changeability of fatty acid content of oil radish seeds over the years of research.

Thus, for a variety Zhuravka the content of palmitooleic acid could not be detected in the chromatogram in 2010 and 2012. We have a similar situation with caprylic, eicosatrienoic and elaidic acids. Similar features are observed by some acids for the variety Rainbow. The explanation was found by us in studies of N.A. Nikolaev, T.V. Mazyarkyna and others. [4], who noted that the fatty acid content of cruciferous crop seeds depends on the weather conditions, doses of fertilizers, varietal characteristics of soil nutrition conditions, and the nature of acid accumulation may be changed towards a greater content of certain of them within the family values of their molecular index. Therefore, this question for oil radish requires additional detailed study.

Comparing chemical characteristics of vegetable oils for technical purposes with the results established by us for oil radish, we have proved the possibility of its use for the production of biofuels. We also have determined that oil radish for the period of sowing during the second decade of April (seeding rate of 2 million pcs./ha of similar seeds) provides oil yield within 0,20 – 0,29 t/ha, depending on the type and level of seed yield against the unfertilized background and 0,62 – 0,84 t/ha against the background of introducing $N_{60}P_{60}K_{60}$. Under these conditions the yield of biofuel from oil according to technical standards is 0,37 – 0,40 t/ha against the background of introducing $N_{60}P_{60}K_{60}$ (Table 3).

Table 2

Fatty acid content of oil radish seeds during the first sowing term on the nonfertilized ground, 2010 – 2012

Formula	Fatty acids	Zhuravka			Rainbow	
		2010	2011	2012	2011	2012
$C_{8:0}$	*Caprylic*	–	–	0,48	–	–
$C_{11:0}$	*Undecylic*	0,20	0,54	0,84	–	0,19
$C_{16:0}$	*Palmitic*	5,62	6,04	6,09	–	5,46
$C_{16:1}$	*Palmitoleic*	–	0,15	–	0,13	0,14
$C_{18:0}$	*Elaidic*	30,56	–	–	–	–
$C_{18:0}$	*Stearic*	2,03	2,19	2,38	3,41	2,38
$C_{18:1}$	Oleic	1,72	30,72	31,27	32,21	33,21
$C_{18:2}$	Linoleic	16,34	17,79	17,18	17,82	16,98
$C_{18:2}$	Linolenelaidic	–	1,70	2,30	2,40	–
$C_{18:3}$	Linolenic	9,63	9,26	13,17	13,57	10,28
$C_{20:0}$	Arachic	0,79	0,09	0,79	0,85	0,11
$C_{20:1}$	Eicosenoic	13,60	14,23	0,16	–	13,98
$C_{20:2}$	Eicosadienoic	0,86	0,96	10,79	11,70	0,64
$C_{20:3}$	Eicosatrienoic	–	14,10	–	–	0,11
$C_{22:0}$	Behenic	0,35	0,33	0,32	0,39	0,43
$C_{22:1}$	Erucic	16,28	0,13	12,87	15,40	14,22
$C_{22:2}$	Docosadienoic	0,48	0,40	–	–	0,51
$C_{24:0}$	Lignoceric	1,52	1,21	0,42	0,54	1,37
$C_{24:1}$	Nervonic	–	0,16	1,42	1,58	–

Note: 1. Saturated fatty acids are presented in italic type; 2. IUPAC – International Union of Pure and Applied Chemistry.

Table 3

Oil output of oil radish varieties depending on seeding rate and fertilization for the first sowing term, t/h

Fertilizer	Zhuravka (2010 – 2012)				Rainbow (2011 – 2012)			
	Output, t/ha							
	biological yield of seeds		actual yield of seeds		biological yield of seeds		actual yield of seeds	
	oil	biofuel from oil	oil	biofuel from oil	oil	biofuel from oil	oil	biofuel from oil
2 mln pcs./h of similar seeds								
Without fertilizers	0,28	0,17	0,17	0,12	0,27	0,16	0,20	0,12
$N_{60}P_{60}K_{60}$	0,80	0,50	0,59	0,40	0,73	0,44	0,57	0,37
1,5 mln pcs./h of similar seeds								
Without fertilizers	0,69	0,41	0,39	0,23	0,42	0,25	0,28	0,17
$N_{60}P_{60}K_{60}$	1,02	0,61	0,67	0,42	0,86	0,52	0,61	0,39
The least substantial difference$_{05}$ general, t/ha			*0,31*				*0,26*	

Conclusion. Thus, oil radish is not only a valuable fodder crop, but perspective bioenergetic agricultural crop and by changing parameters of oil radish growing technology we can change the technological parameters of raw material and regulate "biofuel" productivity per hectare of crops.

Pursuant to the Energy Strategy of Ukraine, within the development of non-conventional and alternative energy sources, attention should be paid to the importance of oil radish seeds as a

promising raw material for biofuel production with biofuel oil output up to 0.5 t/ha with seeding rate of 1.5 and 2 million pcs./ha of similar seeds when introducing $N_{60}P_{60}K_{60}$.

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Анотація

Цицюра Я.Г., Цицюра Т.В. Редька олійна як сировина для виробництва бопалива

Розглянуто цінність редьки олійної та перспективи її вирощування з позиції використання для виробництва біопалива. Представлено результати вивчення жирнокислотного складу її насіння та технологічні особливості виходу олії з її посівів залежно від технології сівби та удобрення.

Ключові слова: *редька олійна, біопаливо, вихід олії, жирнокислотний склад*

Аннотация

Цыцюра Я.Г., Цыцюра Т. В. Редька масличная как сырье для производства биотоплива

Рассмотрены ценность редьки масличной и её перспективы выращивания с позиции использования для производства биотоплива. Представлены результаты изучения химического состава её семян и технологические особенности выхода масла с её посевов в зависимости от технологии сева и фонов удобрения.

Ключевые слова: *редька масличная, биотопливо, выход масла, жирнокислотный состав*