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Seed germination of *Lunaria* genus depending on the year of collection and level of pod maturity

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Abstract

The percentage of seed germination of the *Lunaria* genus in dependence of the year of harvesting and the level of maturation of the pod was studied. The high level of seed germination was revealed. The term of storage without losing germination ability for these plants is relatively long and even after 8 years of storage the seed germination was more than 60%. The germination of the seeds derived from non-completely mature pods was more than 80%.

Key words: *Lunaria*, seed, germination, pod, maturity, harvesting

Introduction

Cruciferae (*Brassicaceae*) is one of the most common and widespread family in northern semisphere of the Earth. Many plants of this family are used by people. These plants are used for eating, feeding domestic animals, making lubricants, drags, in gardening and landscape design end etc. A lot of these plants are horticultural and are growing in many countries of the world. But not all valuable species of this family in our time are widely using. One of these plants is *Lunaria* L.

Common name of this plant is honesty. It's name arose in the 16^{th} century, and it may be due to the translucent seed-pods which are like flattened pea-pods and borne on the through winter. In South-East Asia and elsewhere, it is called the Money Plant, because its seed pods have the appearance of silver coins. In the United States it may also be known as "Silver Dollars", also because of the silver pods. In Denmark it is known as *Juda spenge* and in The Netherlands as *Juda spenning* (coins of Judas) because of its resemblance to silver coins, a reference to Juda Iscariot (Coombes, 2012).

Lunaria genus consists of two species: *Lunaria annua* (=*biennis*) L. and *Lunaria rediviva* L. They both successfully grow in Europe. These species are very morphologically similar. The main difference between these species is their type of plant development. *L. rediviva* is a perennial plant whether *L. annua* – annual sample (Boika, 2014).

Seed-cooked. A pungent flavour, they are used as a mustard substitute. *Lunaria* plants are ornamental plants for shadow and semi-shadow places. But recently interest to this plant is rising due to presence of a high level of nervonic acid in its oil. This acid is used for the production of drags against diseases of human nervous system (Cook, 1998). And now question concerning the growing this crop in industrial scale is very actual.

For industrial goals the term of storage of the seeds is very important. And also the level of maturity of these seeds is very important too. *Lunaria* plant has a relatively long term of blooming, so its pods on the one plant have different stages of maturation when starts the time to harvest them. The aim of our work was to estimate a percentage of seeds germination in dependence of the year of harvesting and the level of the pod maturity.

Material and methods

To estimate the seed germination in depending on the year of seed collection the seeds of *Lunaria annua* plants harvested from 2008 to 2016 years were used as a material. The seeds were germinated in the dark in Petri dishes on a filter paper moistened with distilled water in three replications of 100 pieces in each. For estimation of the seed germination in depending on pod maturity the seeds isolated from the pods of the upper, middle and lower parts of the plant were used. 50 seeds in three replications were placed in Petri dishes on wet filter paper and germinated for two weeks. Germination of the seeds in both experiments was carried out in room conditions. All data were statistically processed.

Results and Discussion

Seeds of all plants during storage lose ability to germinate. One species loses this ability earlier, another one – later. The term of seed storage without losing germination ability is very important trait that characterizes agricultural crops.

The percentage of seed germination of *Lunaria* genus plants depending on the year of harvesting was estimated. Seeds were harvested during 8 years from 2008 to 2016. The results are shown in Figure 1. It can be seen from the bar chart that the seeds of the *Lunaria* possess a high percentage of germination. In the first three years after harvesting (2014-2016) the percentage of germination was almost equal to 100%. After that we can see decreasing the percentage of germination, but it is still high. The lowest level of the seed germination was found after 8 years of storage – just up 60%. So, we can say that the seeds of *Lunaria* genus have a very good potential to save ability to germinate during storage without any special conditions. It can be very useful for the industrial growing this crop.

Due to long time of blooming on one plant at the end of vegetation we can see the pods with four levels of maturation. The first one is when pods are completely mature and start cracking themselves. The second stage of maturation is when pod is mature; all seeds are inside the pod. The next stage is when pods are not-completely mature and for ejecting seeds we must apply the force. And the last stage is when pods are not mature and seed formation is incomplete.

The term of the harvesting is very important to grow this crop in industrial scale. It must be at the most appropriate time when majority of the seeds is mature, but they don't start to fall out. So, it’s very important to know how the level of pods maturity correlates with the seed ability to germinate. For this purpose the percentage of germination of the seeds derived from pods with different levels of maturity was estimated. Results are presented in the Table 1.

How we can see from Table 1 the percentage of seed germination when pods are completely mature reaches almost 100%. In the case with not completely mature seeds (not easily cracked pods) the level of seed germination was 88%, that still was very high. Not fully ripened seeds derived from the immature pods (data not shown in the table) did not germinate at all. So, we can say that the most approriate time to harvest the seeds of honesty is when the majority of the pods on the plant only starts crack themselves. It will help to avoid losing the seeds and contamination of the field.

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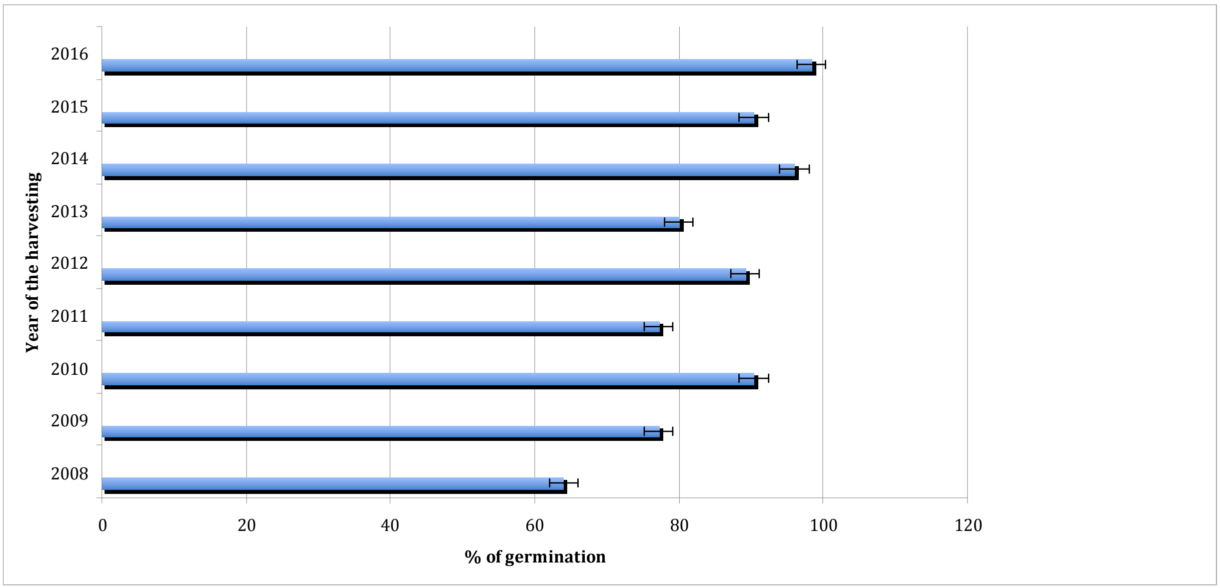

Figure 1. Percentage of seed germination in dependence of the year of harvesting

Table 1. Percentage of seed germination derived from the *Lunaria* pods with different levels of the maturity

The level of the pod's maturity	Percentage of germination, %
Completely mature, crack themselves  1	98,6 ± 2,4
Mature, easily crack  1	97,0 ± 2,2
Non-completely mature, not easily crack  1	88,0 ± 2,4

Genetic variability induced with ethyl methanesulfonate in M_2 and M_3 of white mustard (*Sinapis alba* L.)

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Abstract

The spectrum and frequency of mutations after seed treatment with ethyl methanesulfonate at 0,01-0,5% concentrations was studied in M_2 and M_3 of two genotypes of *Sinapis alba* L. 18 types of heritable changes were revealed in M_2 generation. In this generation, the overall frequency of morphological and physiological mutations ranged from 13,8 % to 36,0 %, depending on the concentration of mutagen. In M_2 generation frequency of complex and multiple mutations in some treatments reached 4,8 %. However, they were not found at the lowest concentration of mutagen. The maximum frequency of economically valuable mutations was 24,0 %. In M_3 generation a significant narrowing of the spectrum and frequency of mutations was showed. Characteristically, the mutations appeared mostly at low concentrations of the mutagen with a maximum rate up to 13,0 %, and the complex and multiple mutations were not found almost at all.

Key words: *Sinapis alba,* ethyl methanesulfonate, M_2 and M_3 generation, mutation, frequency and spectrum

Introduction

White mustard comes from the Mediterranean. From there it spread almost all over the northern hemisphere, including India, Japan, and America. In India, white mustard is grown as a vegetable, the young leaves of which are used in the winter. In Russia, this mustard appeared only in the XVII century in the Lower Volga.

White mustard (*Sinapis alba* L.) is a cross-pollinated crop of spring type. The inflorescence is a raceme consisting of 25-100 flowers with a strong honey scent. Each pod contains 4-6 cylindrically shaped seeds of pale yellow or cream with a bitter taste. Weight of 1000 seeds is 4-7 g.

There are such ecotypes of white mustard: north, with long growing season, large size of vegetative organs and high productivity; south, adapted to the steppe zone of the former Soviet Union and with smaller plant dimensions; Mediterranean, belongs to Egypt and Italy, precocious, but the small size and low yield. White mustard was one of the first crops, which was used to obtain the experimental mutations.

The first information about the research in the field of experimental mutagenesis in white mustard dated 1947. They reported the obtaining mutants of that crop under the action of X-rays or chemical mutagen ethyleneimine at Svalof Plant Breeding Station (Sweden). Extensive research on the use of induced mutagenesis allowed the

Swedish breeders to receive in 1950 the first mutant variety of white mustard "Svalof's Primex" which was characterized by high yield and oil content (Andersson and Olsson, 1954).

Since then, a great possibility of an experimental mutagenesis to create valuable breeding material in oilseed crucifers, including white mustard, are shown (Brown et al., 2014). This work is being done at the Institute of Oilseed Crops of NAAS (Zhuravel, 2008). So, as a result of studies on the induced mutagenesis by direct selection of the mutants the large-seeded variety called Zaporizhanka was created (Lyakh et al., 2009), which in 2010 was included in the Register of Plant Varieties of Ukraine.

However, despite significant advances to increase genetic variability using induced mutagenesis, the possibility of expanding the spectrum of mutations is still far from being exhausted in this crop. This is especially true for morphological traits, variability of which is limited. At the same time, the introduction into new variety of a clear, visually easy recognizable trait, would not only protect the copyright of breeders, but also simplify the management of seed growing.

Material and methods

Sinapis alba mature seeds of № 581889 and № 581890 samples from the collection of the Institute of Oilseed Crops of the National Academy of Agricultural Science were treated with 0,01, 0,05, 0,1 and 0,5 % of ethyl methanesulfonate for 18 hours. 200 seeds were used for every treatment. After treatment the seeds were washed to remove the mutagen. Seeds of every M_1 plant were sown separately in individual plant-to-progeny rows. In the M_2 and M_3 generations the visually selected mutants were self-pollinated and advanced from M_2 to M_3 and M_3 to M_4 respectively. Every mutant line was raised along with its parent. Mutation frequency was calculated as a percent of families with mutant plants selected in M_2 and M_3 to the total number of analyzed families. In calculating the frequency and spectrum of mutations in M_3, mutations identified in M_2 repeatedly disregarded.

Results and Discussion

18 types of inherited changes were revealed in the M_2 generation. Mutations associated with the violation of chlorophyll synthesis accounted for half of them. They were identified as for seedlings and adult plants of both genotypes. With increasing the doses of mutagen the total frequency of chlorophyll mutations increased. The highest frequency of mutations was found at a concentration of 0,1% ethyl methanesulfonate (Table 1).

In addition to a fairly broad spectrum of mutations associated with chlorophyll deficiency, we found changes causing an excess of various pigments. The dark green plants have been revealed with a sufficiently high rate. Except coloring, they differed from the control by thickened stem, late ripening and had a high productivity. We often found the mutants with anthocyanin coloration of leaves, which was clearly visible especially in cold weather. Brown spots on the upper leaves were phenotypic expression of some mutants. These plants did not reduce their productivity.

The mutation of three cotyledons was found in both genotypes of white mustard. Usually cotyledonary leaves grew apart, but sometimes two of them were fused.

Tall and low mutants with a frequency of 1.0-2.4% were observed at different mutagenic treatments in two genotypes of white mustard. At the same time, tall-mutant plant not only exceeded the height of the control plant of 40-60 cm, but also had a rich green color, thick stems, and was a late-maturing.

Mutation of a pale yellow (lemon) flower color was selected in one of the sample and was characterized by a lighter color of flower petals than in the control. Any variations of the seed coat color failed to reveal. Luck can be considered as identifying the mutations of seed size with a rate of 2,0-3,6%. Mutants of both genotypes exceeded the weight of 1000 seeds for control of 3-4 g.

Early maturing plant is characterized by changes in the maturation period of 5-8 days compared to the control and is useful mutation. It was isolated with a frequency of 0.9-2.0 %. Approximately the same frequency was found for mutation causing elongated plant growing period. Mutants of this type are characterized by thickening the stem, tall, and lengthening the period of maturation by 8-10 days.

In M_2 generation with sufficiently high frequency the families with several types of changes (multiple mutations), as well as a families in which one mutant plant had some modified characteristics (complex mutations), were revealed. However, these changes are not found at a minimum (0.01%) concentration of the mutagen (Tab. 2).

The data presented in Table 1 and 3 indicate a significant narrowing the spectrum of mutations in the M_3 generation (11 types) compared with the M_2 (18 types of variations). The frequency of mutations in the M_3 generation was also lower than in M_2 (Table 3 and 4). Characteristic that changes in M_3 appeared mainly with a low concentration of mutagen and there were almost entirely absent when the concentration of ethyl methanesulfonate was 0.1% and higher. Multiple mutations (with low frequency) were revealed only in genotype number 581889, and complex mutations were not found at all in two samples (Table 2).

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Table 1. Spectrum and frequency of mutations induced with EMS in M_2 of *Sinapis alba*, %

Type of mutation	№ 581889				№ 581890		
	0,01	0,05	0,1	0,5	0,01	0,05	0,1
Albina	0	0	0	9,2	3,6	0	0
Viridis-albina	3,6	0	6,0	0	3,6	0	4,8
Striata	0	0	0	0	3,6	0	0
Xantha	0	4,0	0	0	0	0	0
Viridis	3,6	4,0	4,0	4,6	0	0	4,8
Xanthoviridis	0	0	0	0	0	5,9	0
Dark green plant	0	0	6,0	0	0	2,0	0
Brown spots on leaves	0	0	6,0	0	0	5,9	0
Anthocyanin leaf coloration	7,3	0	6,0	0	0	0	9,5
Three cotyledons	7,3	10,0	4,0	0	0	4,0	0
Fasciation	0	0	0	0	1,2	0	0
Opposite branch arrangement	0	0	0	0	1,2	0	0
High stem	0	1,0	0	0	2,4	0	0
Lower stem	0	1,0	2,0	0	1,2	0	0
Lemon flower color	1,8	2,0	0	0	0	0	0
Large seeds	0	2,0	2,0	0	3,6	0	0
Earliness	0,9	0	0	0	0	2,0	0
Late-plant	1,8	0	0	0	1,2	0	0
Number of families	110	100	50	22	84	51	21
Total mutations, %	26,3 ± 4,20	24,0 ± 4,27	36,0 ± 6,79	13,8 ± 7,35	21,6 ± 4,49	19,8 ± 5,58	19,1 ± 8,57

Table 2. Total frequency of mutant families with multiple, complex and economically valuable mutations in M_2 and M_3 of *Sinapis alba*, %

EMS, %	Multiple mutations		Complex mutations		Economically valuable mutations	
	M_2	M_3	M_2	M_3	M_2	M_3
№ 581889						
0,01	0	0	0	0	13,6	0
0,05	0	1,0	2,0	0	10,0	1,0
0,1	2,0	0	0	0	24,0	2,0
0,5	0	0	0	0	4,5	0
№ 581890						
0,01	0	0	0	0	7,1	7,3
0,05	2,0	0	0	0	2,0	2,0
0,1	4,8	0	4,8	0	14,0	0

Table 3. Spectrum and frequency of mutations induced with EMS in M_3 of *Sinapis alba*, %

Type of mutation	№ 581889				№ 581890		
	0,01	0,05	0,1	0,5	0,01	0,05	0,1
Albina	0	2,0	0	0	2,4	0	0
Viridis	2,7	0	0	0	4,9	0	0
Xanthoviridis	2,7	0	0	0	0	0	0
Dark green plant	3,6	0	2,0	0	0	0	0
Anthocyanin leaf coloration	1,8	0	0	0	0	0	0
Three cotyledons	0	4,0	0	0	0	2,0	0
Opposite branch arrangement	0	2,0	0	0	0	0	0
High stem	0	0	0	0	0	2,0	0
Lemon flower color	0	4,0	0	0	2,4	0	0
Earliness	0	1,0	0	0	0	0	0
Late-plant	0	0	0	0	0	2,0	0
Number of families	110	99	50	21	82	50	19
Total mutations, %	10,8 ± 2,96	13,0 ± 3,38	2,0 ± 1,98	0	9,7 ± 3,27	6,0 ± 3,36	0

Table 4. Total frequency of mutant families in M_2 and M_3 of different genotypes of *Sinapis alba*, %

Mutation	№ 581889		№ 581890	
	M_2	M_3	M_2	M_3
Chlorophyll synthesis violation	14,5	5,4	12,8	4,0
Cotyledonary and true leaves	7,1	1,4	1,3	0,7
Stem and branches	1,1	0,7	3,2	0,7
Flowers	1,4	1,4	0	1,3
Seeds	1,1	0	1,9	0
Physiological traits	1,1	0,4	1,3	0,4
Number of families	282	280	156	151
Total mutant families, %	26,3 ± 2,62	9,3 ± 1,74	20,5 ± 3,23	7,4 ± 2,13

Comparative analysis of oil fatty acid composition of Ukrainian spring *Camelina sativa* breeding forms and varieties as a perspective biodiesel source

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Abstract

Biodiesel is produced in Europe mainly from rapeseed oil, but recently such plant as *Camelina sativa* obtained renewed interest. According to comparison of spring camelina forms (breeding lines) and cultivars breeded in the National Botanical Garden of Natl. Academy of Sciences of Ukraine with reference varieties of Ukrainian, European and North American origin it was established that the most suitable source for biodiesel production is form FEORZhYaFD due to its fatty acids composition and several agronomical traits, especially oil productivity (42.6 %). Oil from this form is characterised by a high content of unsaturated (86.42 %) and polyunsaturated (61.21 %) fatty acids, the highest value of polyunsaturated/monounsaturated fatty acid ratio (PU/MU) – 2.43, low elongation ratio (ER) – 0.13, high desaturation ratio (DR) –0.7, oleic desaturation ratio (ODR) –0.8, linoleic desaturation ratio (LDR) – 0.65.

Key words: *Camelina sativa*, false flax, Ukrainian varieties, oil, fatty acids, biodiesel

Introduction

With the increasing needs in the alternative fuels [12], new sources of energy are offered, in particular obtainment of biodiesel and bioethanol from plant raw materials [1, 13]. Today, biodiesel is produced mainly from rapeseed oil, but lately energy potential of the less common species of *Brassicaceae* family, such as winter and spring false flax (camelina), white mustard, oilseed radish and others was evaluated [8, 9, 17, 21]. Camelina, or false flax, is insufficiently used representative of the family *Brassicaeae,* which obtained recently renewed interest. Earlier the results of archaeological studies have shown that this plant was cultivated in Europe during the Bronze age [5, 22], where it was used as an important oil crop. Now camelina is considering as one of the potential alternative plant species for oil production [3, 11, 18, 19]. Therefore, the main goal of this research was to study fatty acid composition of main Ukrainian false flax breeding lines and conduct out a comparative analysis of their fatty acid profiles.

Material and methods

Seed oil of high productive spring false flax forms (breeding lines) and cultivars (*Camelina sativa* (L.) Crantz) of Ukrainian breeding was used for investigation. Forms FEORZhYaF-1, FEORZhYaF-2, FEORZhYaF-3, FEORZhYaF-4, FEORZhYaF-5, FEORZhYaFD, FEORZhYaFCh as well as varieties Peremoha and Evro-12 were obtained from the National Botanical Garden named M.M. Hryshko of Natl. Academy of Sciences of Ukraine (Kyiv) [2, 16] and two varieties Mirazh and Klondaik (as reference samples) were breeded in the Institutes of Natl. Academy of Agrarian Sciences of Ukraine.

Oil extraction from respective seed samples was done using the manual press Prom-1 (Olis, Ukraine). Determination of the fatty acid composition of the seed oils of mentioned above forms and varieties was conducted out by the method of gas-liquid chromatography using chromatograph GC 2014 (Shimadzu, Japan). Identification of fatty acids was carried out by comparing the received chromatograms with chromatograms of such standard solutions as methyl esters of fatty acids C_6-C_{24}.

Formulas to calculate the basic ratios, which were used for the fatty acid composition analysis are presented in Fig. 1 and Fig. 2. Coefficients of ER (elongation ratio), DR (desaturation ratio), ODR (oleic desaturation ratio), LDR (linoleic desaturation ratio) were estimated by methods described by Velasco et al. [20] and Pleines and Friedt [14]. Fatty acid ratios were estimated according to Budin et al. [3].

$$\mathrm{ER} = \frac{\%\mathrm{C}20:1 + \%\mathrm{C}22:1}{\%\mathrm{C}20:1 + \%\mathrm{C}22:1 + \%\mathrm{C}18:1 + \%\mathrm{C}18:2 + \%\mathrm{C}18:3}$$

$$\mathrm{DR} = \frac{\%\mathrm{C}18:2 + \%\mathrm{C}18:3}{\%\mathrm{C}20:1 + \%\mathrm{C}22:1 + \%\mathrm{C}18:1 + \%\mathrm{C}18:2 + \%\mathrm{C}18:3}$$

$$\mathrm{ODR} = \frac{\%\mathrm{C}18:2 + \%\mathrm{C}18:3}{\%\mathrm{C}18:1 + \%\mathrm{C}18:2 + \%\mathrm{C}18:3}$$

$$\mathrm{LDR} = \frac{\%\mathrm{C}18:3}{\%\mathrm{C}18:2 + \%\mathrm{C}18:3}$$

Figure 1. Main coefficients using for analysis of fatty acid composition in different plant oil samples: ER - elongation ratio, DR - desaturation ratio, ODR - oleic desaturation ratio, LDR - linoleic desaturation ratio.

$$S/U = \frac{Saturated\ fatty\ acids}{Unsaturated\ fatty\ acids} \qquad PU/MU = \frac{Polyunsaturated\ fatty\ acids}{Monounsaturated\ fatty\ acids}$$

Figure 2. Main coefficients using for analysis of saturated and unsaturated fatty acid ratio in different plant oil samples.

Results and Discussion

The results of the chromatographic analysis (Table 1) show that seed of all forms and varieties of false flax possess a high content of linolenic, linoleic, oleic, gondoic and palmitic fatty acids. Polyunsaturated linolenic acid has been found in quantity from 31.35 to 35.56 % in the studied forms and varieties. The highest quantity of linoleic acid has been found in the oil of variety Klondaik (24.65 %). The majority of fatty acids (>85 %) is presented by unsaturated fatty acids, among which a significant percentage of linolenic (31.2–38.27 %), oleic (12–18.47 %), linoleic (19.76–24.65 %) acids was found. Content of erucic acid is also very low and does not exceed 2 %.

Table 1. Oil fatty acid composition of different Ukrainian false flax (*C. sativa*) forms and varieties (%)

Variety name/CN:DB	18:1	18:2	18:3	20:1	22:1	Other
Mirazh	17.48	20.76	32.73	9.95	1.72	17.36
Klondaik	13.52	24.65	31.61	10.77	1.7	17.76
Peremoha	17.32	21.19	32.27	12.05	1.38	15.8
Evro-12	13.05	19.76	35.56	11.65	1.86	18.12

FEORZhYaF-1	16.72	20.09	34.07	10.78	1.47	16.88
FEORZhYaF-2	18.47	20.03	32.5	12.5	1.55	14.96
FEORZhYaF-3	13.8	20.58	32.45	12.84	1.74	18.6
FEORZhYaF-4	13.19	21.86	31.35	12.91	1.85	18.85
FEORZhYaF-5	12.0	20.96	34.97	12.46	2.02	17.61
FEORZhYaFD	14.14	20.45	38.27	9.53	1.28	16.33
FEORZhYaFCh	13.22	21.62	33.11	11.74	1.77	18.54

The content of different monounsaturated and polyunsaturated fatty acids esters in fuels can provide its higher resistance to low temperatures. Such fuels will have a lower cloud point [4]. The content of fatty acids esters, such as palmitoleic (16:1), oleic (18:1), linoleic (18:2), linolenic (18:3), eicosenoic (gondoic) (20:1), eicosadienoic (20:2), eicosatrienoic (20:3), erucic (22:1), docosadienoic (22:2), docosatrienoic (22:3), and nervonic (24:1), determines the quality of fuel that is needed to obtain. The most common among listed fatty acids in the composition seed oil of *Brassicaceae* plants are oleic (18:1), linoleic (18:2), linolenic (18:3), gondoic (20:1) and erucic (22:1) [10, 20].

Table 2. Fatty acid composition of different false flax (*C. sativa*) varieties cultivated worldwide for biodiesel production (%) [6-8]

Variety name/CN:DB	18:1	18:2	18:3	20:1	22:1	Other
SO-30	15.53	21.96	34.85	13.06	0.17	14.43
SO-40	16.32	20.03	36.32	12.87	0.15	14.31
SO-50	16.5	19.57	35.94	13.74	0.17	14.08
SO-60	17.65	18.95	35.69	13.78	0.16	13.77
Blaine Creek	17.45	19.03	35.54	14.01	0.13	13.84
Calena	15.66	19.11	36.91	13.72	0.14	14.46

Assessment of fatty acid composition of the oils is a difficult task because of large number of various fatty acids, each of which has specific properties. Obtained fuel from certain types of oil should be enough light (have small carbon number, not more than 18), therefore important is the contents of the mono- and polyunsaturated fatty acids with short chain (such as C18:2, C18:3), but oil presents a mixture of a large number of different fatty acids, that complicates the quality assessment of new sources for obtaining biodiesel. For this reason, some coefficients are using for more accurate assessment of the qualitative composition of different oil types: ER (elongation ratio), DR (desaturation ratio), ODR (oleic desaturation ratio), LDR (linoleic desaturation ratio) [14, 20]. ER shows ratio of unsaturated fatty acids with long chain to total number of major unsaturated fatty acids. Since fuel must contain short-chain esters, increased ER means the deterioration of final product quality. DR shows the ratio of major polyunsaturated fatty acids and total number of major unsaturated fatty acids. The increase in DR number displays higher quantity of polyunsaturated fatty acids, which means improving quality of biodiesel (higher volatility, lower cloud and pour point, lower viscosity). ODR reflects the ratio of polyunsaturated fatty acids with short chain and all unsaturated fatty acids with short chain, LDR – linolenic acid to polyunsaturated fatty acids with short chain. Increase of ODR and LDR values can testify about the improvement of biodiesel quality as well as increase of DR levels.

Also to assess the results of the chromatographic analysis we used as indicators S/U (saturated fatty acids/unsaturated fatty acids) and PU/MU (polyunsaturated fatty acids/monounsaturated fatty acids) proportions [3]. An increasing S/U value means increasing of saturated fatty acids amount that reflects negatively on the above mentioned characteristics of biodiesel. While the increase of PU/MU value means increasing of polyunsaturated fatty acids amount, compared to the monounsaturated fatty acids amount that represents positive factor.

We have calculated these values for studied plant genotypes, and also for the most prevalent false flax varieties used for biodiesel production (Table 3). The results of our analysis show that the content of unsaturated fatty acids in false flax seed oil reaches 87.14 % (cultivar Peremoha), while the total content of unsaturated fatty acids in foreign analogues of *C. sativa* varieties reached to 86.23 %. The highest PU/MU values were noted for FEORZhYaFD form – 2.43, less for FEORZhYaF-5 form – 2.21 and for variety Klondaik – 2.23. This values for foreign varieties were only 1.98 for SO-30 and 1.92 for SO-40.

Table 3. Main coefficients using for analysis of fatty acid composition of seed oil calculated for different form or varieties of false flax

Variety name	Total sat. (%)	Total unsat. (%)	Total polyunsat. (%)	Total monounsat. (%)	ER	DR	ODR	LDR	S/U	PU/MU
Mirazh	14.3	85.7	56.12	29.59	0.14	0.65	0.75	0.61	0.17	1.9
Klondaik	14.73	85.27	58.84	26.44	0.15	0.68	0.81	0.56	0.17	2.23
Peremoha	12.86	87.14	56.08	31.06	0.16	0.64	0.76	0.61	0.15	1.81
Evro-12	14.36	85.64	58.7	26.94	0.17	0.68	0.81	0.64	0.17	2.18
FEORZhYaF-1	13.75	86.25	56.99	29.26	0.15	0.65	0.76	0.63	0.16	1.95
FEORZhYaF-2	12.12	87.88	54.99	32.89	0.17	0.62	0.74	0.62	0.14	1.67
FEORZhYaF-3	15.28	84.72	55.91	28.81	0.18	0.65	0.79	0.61	0.18	1.94
FEORZhYaF-4	15.51	84.49	56.14	28.35	0.18	0.66	0.8	0.59	0.19	1.98
FEORZhYaF-5	13.89	86.11	59.26	26.85	0.18	0.68	0.82	0.63	0.16	2.21
FEORZhYaFD	13.58	86.42	61.21	25.21	0.13	0.7	0.81	0.65	0.16	2.43
FEORZhYaFCh	15.11	84.89	57.74	27.15	0.17	0.67	0.81	0.61	0.18	2.13
SO-30	14.43	85.57	56.81	28.76	0.16	0.66	0.79	0.61	0.17	1.98
SO-40	14.31	85.69	56.35	29.34	0.15	0.66	0.78	0.65	0.17	1.92
SO-50	14.08	85.92	55.51	30.41	0.16	0.65	0.77	0.65	0.16	1.83
SO-60	13.77	86.23	54.64	31.59	0.16	0.63	0.76	0.65	0.16	1.73
Blaine Creek	13.84	86.16	54.57	31.59	0.16	0.63	0.76	0.65	0.16	1.73

It is necessary to note that false flax is characterised by quite low ER value because of the small quantity of long-chained acids in oil. This value varies in the range from 0.13 (FEORZhYaFD) to 0.18 (FEORZhYaF-4) in false flax, while in its foreign analogues ER value reaches 0.15–0.16. The highest DR value was found in false flax (up to 0.7 in FEORZhYaFD). In the most prevalent North American and European varieties this value reaches only to 0.66 (SO-40), 0.66 (SO-50) and 0.66 (Calena).

ODR value for false flax reaches up to 0.7 in FEORZhYaFD form, and 0.81 in variety Evro-12. As it has been established by us for foreign analogues ODR values reached from 0.76 (SO-60) to 0.79 (SO-30) due to the low content of oleic acid (C18:1). The highest index of LDR value has been found also in false flax seed due to the high content of linolenic acid (C18:3). For camelina forms breeded in National Botanical Garden LDR reaches 0.65 (FEORZhYaFD form), while for varieties widely used in the world for biodiesel production it reaches 0.66 (for Calena) and 0.65 (for SO-60). This difference is due to the lower content of linoleic acid (C18:2) in oil of Calena variety (19.11 %) compared with FEORZhYaFD form (20.45 %) that changes this figure despite higher contents of linolenic acid (C18:3) in FEORZhYaFD form (38.27 %) compared to Calena (36.91 %) .

Oil content parameters allow certain forms and varieties, breeded in the National Botanic Garden, to compete with the false flax varieties known in the world. Chosen forms and varieties exceed most common North American and European varieties (SO-30, SO-40, SO-50, SO-60, Blaine Creek and Calena) on oil yield (36.6-43.9 % in comparison 36.8-37.6 %) [2, 6-8].

Taking into account the data obtained (Table 3) the camelina FEORZhYaFD form was chosen by us as the most perspective oil source for biofuel (biodiesel) production. Oil from this form is characterized by a high content of unsaturated fatty acids – 86.42 % and polyunsaturated fatty acids – 61.21 %; the highest PU/MU – 2.43, low ER – 0.13, high DR – 0.7, ODR – 0.81, LDR – 0.65. In view of this, the oil from FEORZhYaFD seeds and derived from it esters may be characterized by higher volatility, lower cloud and pour point, lower viscosity that enable to obtain the fuel with more high quality. Also, according to [2] FEORZhYaFD form exceed most Ukrainian and cultivated worldwide forms and varieties by oil productivity (42.6 %).

Conclusion

According to comparison of spring camelina forms (breeding lines) and cultivars breeded in the National Botanical Garden of Natl. Academy of Sciences of Ukraine with reference varieties of Ukrainian, European and North American origin it was established that the most suitable source for biodiesel production is form FEORZhYaFD due to its fatty acids composition and several agronomical traits, especially oil productivity (42.6 %). Oil from this form is characterised by a high content of unsaturated (86.42 %) and polyunsaturated (61.21 %) fatty acids, the highest value of polyunsaturated/monounsaturated fatty acid ratio (PU/MU) – 2.43, low elongation ratio (ER) – 0.13, high desaturation ratio (DR) –0.7, oleic desaturation ratio (ODR) –0.8, linoleic desaturation ratio (LDR) – 0.65.

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Frontline Demonstration Programme: An effective transfer tool for adoption of *B. rapa* production technology under temperate agroclimatic conditions of Kashmir Valley

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Abstract

The FLDs in brown sarson were conducted during 2010-11 to 2015-16 over area of 20 ha in three districts of Kashmir valley under AICRP rapeseed-mustard for demonstration of high yielding varieties and its improved package of practice to the farmers. The results have revealed that the HYVs have significantly out yielded the farmers varieties (check) by a yield superiority of 21.99 %

Introduction

Brown sarson (*B. rapa var. brown sarson*.) is one of the most important oleiferous Brassicas cultivated in the north western regions of India. In Kashmir valley and high altitude regions of Jammu division, brown sarson is the only edible oilseed crop being cultivated during *rabi* season. It is a major oilseed crop (90%) of Kashmir grown, because of its having good buffering capacity to withstand severe winters. In Jammu & Kashmir (table-1), the crop occupies an area of about 65950 hectares with a production of 58380q and an average productivity of 8.85 kg/ha (Anonymous, 2015-16). The little adoption of high yielding varieties is one of the causes of low productivity of rapeseed-mustard in Jammu & Kashmir.

Material and methods

The MRCFC Khudwani is a lead research station of the University for carrying out research and technology transfer of the oilseed crops. The Frontline Demonstrations (FLDs) on rapeseed-mustard under the sponsoring agency of All India Coordinated Research Project for Rapeseed-Mustard, Rajasthan (AICRP-RM), were conducted in *B. rapa var. brown sarson* over an area of 20 ha from 2010-11 to 2015-16 , for demonstrating the yield potential of the released varieties (*Gulchin & Shalimar Sarson-1*) and its improved package of practice to the farmers (Table-2&3). The demonstration of the trials was conducted in three districts of Kashmir valley viz., Pulwama, Anantnag & Kulgam in collaboration with Scientists from respective KVKs.

Results and Discussion

Brown Sarson (*B. rapa var. Brown sarson*), is a major oilseed crop of Jammu and Kashmir which is grown in rabi season, due to its excellent combination with Rice based cropping system. The results have indicated that the average yield superiority of 21.99 % was realized from the improved varieties and improved package of practice in comparison to Local variety / local package of practice practiced by the farmers. The benefit cost ratio of demonstration plots were more than the farmer's practice in all the years which indicates that the cultivation of Gulchin/Shalimar Sarson-1 varieties of brassicas are more profitable (1:1.39) than check variety (farmers variety). Similar results have also been reported by Mishra *et al* (2007) and Sachan *et al* (2009) in rapeseed-mustard. The districts in which FLDs were conducted are the predominant oilseed belts of Kashmir valley and replacing these varieties will not only enhance the productivity but will enhance their farm income as well. Futhermore the area expansion programme may be undertaken by the Department of Agriculture Kashmir with public-private-partnership mode by involving NGOs, Corporate sectors etc. for economic benefit for farmers.

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Table 1. Area, Production & Productivity of Rapeseed-Mustard in Jammu & Kashmir

District	Village	No. of EntriesTested	Total no. of Mother Trials
Pulwama	Padgampora, Khenbagh	7+1	02
Anantnag	Wonpoh	7+1	02
Kulgam	Ruhpoora, Sursuroo	7+1	02
Total			**06**

Year	Area (000ha)	Production (000q)	Yield (q/ha)
2010-11	27.2	32.5	11.93
2011-12	26.4	30.0	11.35
2012-13	28.2	32.40	11.48
2013-14	65.73	588.3	8.95
2014-15	65.95	583.8	8.85

Anonymous, 2015-16

Table 2. Production technologies developed by SKUAST-K under AICRP-RM

Technology Developed	Detail of Technology
Sowing Time	Ist week of oct to 15th oct
Spacing (cm)	30x10 i.e Row to distance 30cm & Plant to plant distance 10cm
Seed rate (Kg ha^{-1})	8 Kgha^{-1}
Ferrtilize Responsiveness	80:50:40 of N, P_2O_5 and K_2O
Harvesting	2nd to 3rd week May
Weed management	1 kg *a.i* Pendimethalin to be applied as pre-emergence 2-3 DAS

Table 3. Results of Frontline demonstrations conducted under AICRP-RM during 2010-11 to 2015-16

Component	Ecosystem	Variety	Year	Area (ha)	Yield improvement over farmers practice	Cost benefit ratio
Whole Package Component	Rainfed	Gulchin	2010-11	6	32.0	1: 1.25
			2011-12	4	19.2	1:1.34
			2012-13	4	20.9	1:1.45
		Shalimar Sarson-1	2013-14	2	31.1	1:0.90
			2014-15	2	15.98	1:2.11
			2015-16	2	12.8	1.1.34
Average performance over the years				**3.33**	**21.99**	**1:1.39**

SKUAST-K : Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, India

KVK: Krishi Vigyan Kendra (Farm Science Centre)

AICRP-RM: All India Coordinated Research Project on Rapeseed-Mustard

Participatory varietal selection in oilseed Brassicas under temperate conditions of Kashmir

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Abstract

The six mother trials were conducted in brown sarson using participatory varietal selection approach during *rabi,* 2013-14 in three districts viz., Pulwama, Ananatnag & Kulgam of Kashmir valley. All the trials were managed by the farmers. A group of farmers were selected for ranking of genotypes prior to the harvest of the crop based on their preference. KBS-49 a prereleased variety of rapeseed has been selected by all the farmers for high biomass & early maturity across all the studied locations.

Key words: *B.rapa*, PVS, Farming system research, Technology transfer

Introduction

The present study was undertaken to assess and then decide the suitable alternative to already existing varieties in brown sarson cultivated by the farmers of valley. In Kashmir valley, brown sarson *(B. rapa var brown sarson)* is among the only oilseed crop being cultivated during *rabi* season after the harvest of paddy crop, because of having strong buffering capacity to withstand severe winters and produces good crop with the onset of spring season. Rice-sarson is the most prevalent cropping system adapted in the valley. The state of Jammu & Kashmir has low seed replacement rate in oilseed (around 10%) and having different agroecologies, our university initiated a PVS programme under RKVY-1 project in in oilseed. The PVS allows the farmers to evaluate varieties for all traits and to make trade of between traits and tests varieties across more of the physical niches in which the crop is grown because the trials are replicated across more locations (Witcombe *et al*., 2005).

Material and methods

The six mother trials were successfully conducted across three districts (Pulwama, Anantnag & Kulgam) of Kashmir, India (Table1) which consisted of seven entries including released, prereleased & pipeline entries along with farmers variety as a check. Each test entry was grown on $10m^2$ area. All the trials were designed by the researcher but laid and managed by the farmers. A farmer walk was organized in front of the trials at maturity & farmers were allowed to select preferred genotypes & they cast their votes in a ballot box. The preferential score (PS) was calculated using De-Boef and Thijssen, (2007) as

$$PS = \frac{\text{No. of positive votes} - \text{No. of negative votes}}{\text{Total no. of votes}}$$

Results and Discussion

In the present investigation, seven test entries including farmers variety as check were evaluated through Mother trial evaluation system and based on farmer's skill and knowledge preferential ranking was carried out at all locations of three districts of Kashmir valley. Just one week before harvest at respective locations, Focal Group Discussions (FGD) and farmer walks were organised to evaluate the trials. In the overall ranking of varieties, KBS-49 (a prereleased variety) was top ranked by most of the farmers (cumulative rank) across all the three districts of Kashmir with a pooled preference of 2.45 . Similarly Shalimar sarson-1 (released variety of SKUAST-K) was ranked 2nd by the farmers with a pooled preference of of 2.04. Farmers variety was ranked 6th (Pooled prefence -0.02). The least preferred variety was KBS-1 and was at par with farmer's variety. Farmers selected the varieties on the basis of biological yield (biomass) & early maturity. The PVS approach has been employed by many workers to evaluate, identify and disseminate different genotypes on farmer's field as per his tastes regarding various traits and their perception about varietal specification in various crops (Witcombe *et al*. 2005; Gyawali *et al.* 2010; Yadavendra and Witcombe 2013, Mehraj et al, 2015). The genotypes selected are being evaluated further using Baby Trial evaluation system on big plot size and over many more locations to corroborate the real performance and finally to recommend the varieties for up scaling through participatory seed production under such ecologies. The use of such participatory approach through identification of suitable choices and popularization of the variety(ies) are effectively meeting the needs of poor and marginal farmers having poor access to new varieties & would also strengthen local seed system

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Table 1. Description of mother trials conducted during *rabi,* 2013-14

District	Village	No. of EntriesTested	Total no. of Mother Trials
Pulwama	Padgampora, Khenbagh	7+1	02
Anantnag	Wonpoh	7+1	02
Kulgam	Ruhpoora, Sursuroo	7+1	02
Total			**06**

Table 2. Preferential scoring of the genotypes identified as per farmer's preferences for different agro ecozones of Kashmir during *rabi,* 2013-14

Genotypes	Individual Ranks			Cumulative Rank	Average of Ranks	Pooled Preference
	Padgampora, Khenbagh, (Pulwama)	Wanpoh, (Anantnag)	Ruhpoora, Sursuroo, (Kulgam)			
KBS-49*	1	1	1	3	1.0	2.45
KBS-1	8	6	8	22	7.3	-0.53
KBS-2	6	8	5	19	6.3	0.01
KBS-3	4	5	4	13	4.3	0.76
KBS-4	5	3	7	15	5.0	0.5
KBS-5	3	3	3	9	3.0	1.4
Shalimar Sarson-1	2	2	1	5	1.6	2.04
Farmers Variety	6	6	6	18	6.0	-0.02

**KBS: Khudwani Brown Sarson*

SKUAST-K : Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, India

RKVY: Rashtriya Krishi Vigyan Yojna*. *Govt of India

Fatty acid profiles of seed oil from new winter tyfon varieties obtained by reciprocate breeding

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Abstract

Genus *Brassica* includes number of economically important oilseed species. From this reason creation of new varieties and hybrids promises to be an effective way to increase productivity of respective oil cultures. In our study new hybrid winter culture called tyfon (*B. rapa* (*ssp. rapifera X ssp. pekinensis*) *X B. rapa ssp. oleifera*), obtained in National Botanical Garden named M.M. Hryshko of National Academy of Sciences of Ukraine by reciprocate crossbreeding of original spring tyfon (*B. rapa ssp. rapifera. X B. rapa ssp. pekinensis*) with winter turnip rape (*B. rapa ssp. oleifera*) form was analysed for identifying of fatty acid profiles. Oil from new hybrid possessed high content of monounsaturated fatty acids up to 63.13 % in tyfon variety Fitopal. Also, tyfon posses high oil (up to 45.1 %) and seed (up to 2254 kg/ha) productivity. Due to indentified characteristics tyfon oil could be used as a lubricant or raw material for further processing because of high content of monounsaturated fatty acids.

Key words: *Brassica rapa*, breeding, hybrids, tyfon, oil, fatty acids

Introduction

Many representatives of family *Brassicaceae*, especially of genus *Brassica*, are widely used as vegetable, forage and oil cultures. *Brassica* includes number of economically important oilseed species: rapeseed (*Brassica napus*), turnip (*B. rapa*, syn. *B. campestris*), brazilian mustard (*B. juncea*) and ethiopian mustard (*B. carinata*), which provide 12% of world oil production [14]. From this reason creation of new *Brassica* varieties and hybrids promises to be an effective way to increase productivity of mentioned oil cultures. Also new hybrid cultures could potentially be more tolerant to climate conditions and could have higher disease resistance.

In our study we are considering one of oilseed hybrid cultures called tyfon. Originally tyfon was obtained by crossbreeding between rapini turnip (*B. rapa ssp. rapifera* Metzger) and chinese cabbage (*B. rapa ssp. pekinensis* (Lour.) Hanelt) in late 70s-80s in Netherlands [4]. Dutch tyfon, also called "Holland greens", mostly used as forage or as leaf vegetable culture [11].

Therefore, the original tyfon hybrid (*B. rapa ssp. rapifera. X B. rapa ssp. pekinensis*) does not possess appropriate low temperature resistance and as a result could not be grown in climate conditions of such countries as Ukraine. The reason of such low tolerance to temperature is that original tyfon was created by hybridisation of two spring cultures [4, 7, 8, 12]. To overcome it reciprocate crossbreeding of original tyfon with winter turnip rape (*B. rapa ssp. oleifera*) form was conducted in National Botanical Garden named M.M. Hryshko of National Academy of Sciences of Ukraine (Kyiv). As a result of years of breeding new winter tyfon hybrid (*B. rapa* (*ssp. rapifera X ssp. pekinensis*) *X B. rapa ssp. oleifera*) was created which could grow under low temperature conditions. These new plants possess not only high productivity of green mass, but also high seed and oil yield.

Therefore, the main goal of this research was to study fatty acid composition of seed oil from new winter tyfon genotypes and conduct out a comparative analysis of their fatty acid profiles.

Material and methods

Seed oil of new tyfon cultivars (*B. rapa* (*ssp. rapifera X ssp. pekinensis*) *X B. rapa ssp. oleifera*) of Ukrainian breeding was used for investigation. The form EOTFV and varieties Orakam, Obriy and Fitopal were obtained from the National Botanical Garden named M.M. Hryshko of Natl. Academy of Sciences of Ukraine (Kyiv) [12].

Oil extraction from respective seed samples was done using the manual press Prom-1 (Olis, Ukraine). Determination of the fatty acid composition of the seed oils of mentioned above form and varieties was conducted out by the method of gas-liquid chromatography using chromatograph GC 2014 (Shimadzu, Japan). Identification of fatty acids was carried out by comparing the received chromatograms with chromatograms of such standard solutions as methyl esters of fatty acids C_6-C_{24}.

Formulas to calculate the basic ratios, which were used for the fatty acid composition analysis are presented in Fig. 1 and Fig. 2. Coefficients of ER (elongation ratio), DR (desaturation ratio), ODR (oleic desaturation ratio), LDR (linoleic desaturation ratio) were estimated by methods described by Velasco et al. [15] and Pleines and Friedt [11]. Fatty acid ratios were estimated according to Budin et al. [5].

$$\mathrm{ER} = \frac{\%C20:1 + \%C22:1}{\%C20:1 + \%C22:1 + \%C18:1 + \%C18:2 + \%C18:3} \qquad \mathrm{ODR} = \frac{\%C18:2 + \%C18:3}{\%C18:1 + \%C18:2 + \%C18:3}$$

$$\mathrm{DR} = \frac{\%C18:2 + \%C18:3}{\%C20:1 + \%C22:1 + \%C18:1 + \%C18:2 + \%C18:3} \qquad \mathrm{LDR} = \frac{\%C18:3}{\%C18:2 + \%C18:3}$$

Figure 1. Main coefficients using for analysis of fatty acid composition in different plant oil samples: ER - elongation ratio, DR - desaturation ratio, ODR - oleic desaturation ratio, LDR - linoleic desaturation ratio.

$$S/U = \frac{Saturated\ fatty\ acids}{Unsaturated\ fatty\ acids} \qquad PU/MU = \frac{Polyunsaturated\ fatty\ acids}{Monounsaturated\ fatty\ acids}$$

Figure 2. Main coefficients using for analysis of saturated and unsaturated fatty acid ratio in different plant oil samples.

Results and Discussion

Tyfon seed yield can consist from 1590 kg/ha to 2254 kg/ha. Analysed cultivars are characterized by high oil content in seeds: 40.9–45.1 %. The variety Obriy possesses by the highest yield (2254 kg/ha), the highest oil content (45.1 %) and the largest output of oil per hectare (1017 kg/ha) [2].

Figure 3. Tyfon in leaf rosette phase
Figure 4. Tyfon in mass blooming phase

The results of the chromatographic analysis (Table 1) shown that tyfon seed oil contains the high amount of erucic acid. Depending on the genotype (form or variety) the content of erucic acid has changed from the 23.89 to 25.69 %. Besides erucic acid, tyfon oil contains high percentage of oleic (18:1) (25.11–26.66 %), linoleic (18:2) (18.12–18.78 %), linolenic (18:3) (9.15–9.91 %) and gondoic (20:1) (9.74–10.59 %) fatty acids. Also oil of investigated tyfon genotypes has palmitic (16:0) (5.22 %), stearic (18:0) (2.18 %) and arachidic (20:0) (1.09 %) fatty acids. The highest content of linolenic (18:3) fatty acid has been found in variety Obriy (9.78%), linoleic (18:2) acid – in variety Orakam (18.46 %), oleic (18:1) (26.58 %) and erucic (22:1) (25.89 %) acids – in variety Fitopal.

Fatty acid composition plays a decisive role for the direction of technological use of oils from different oilseed crops [1, 6, 9, 10, 13]. Assessment of fatty acid composition of the oils is a difficult task because of the large number of various fatty acids, each of which has specific properties. For this reason, some coefficients are using for more accurate assessment of the qualitative composition of different oil types: ER (elongation ratio), DR (desaturation ratio), ODR (oleic desaturation ratio), LDR (linoleic desaturation ratio) [6, 14, 16]. ER shows ratio of unsaturated fatty acids with long chain to the total number of major unsaturated fatty acids and indicates higher or lower activity of different fatty acid elongases. DR reflects the ratio of the major polyunsaturated fatty acids and the total number of major unsaturated fatty acids indicates higher or lower activity of different fatty acid desaturases. ODR underlines the ratio of polyunsaturated fatty acids with short chain to all unsaturated fatty acids with short chain and indicate activity of desaturase, which provide synthesis of linoleic (18:2) fatty acid from oleic (18:1). LDR reflects the ratio of polyunsaturated fatty acids with short chain to linolenic (18:3). LDR value indicates activity of fatty acid desaturases, which responsible for synthesis of linolenic (18:3) and linoleic (18:2) fatty acids. Also to assess the results of the chromatographic analysis we used such indicators as S/U (saturated fatty acids/unsaturated fatty acids) and PU/MU (polyunsaturated fatty acids/monounsaturated fatty acids). Calculated ratios could be useful instrument for further breeding of varieties with high-quality oil [11, 16].

Table 1. Oil fatty acid composition of different tyfon (*B. rapa* (*ssp. rapifera X ssp. pekinensis*)) varieties (%)

№	CN:DB	EOTFV	Orakam	Obriy	Fitopal
1	16:0	4.83	5.22	4.73	4.62
2	16:1	0.28	0.31	0.22	0.25
3	18:0	2.11	1.81	2.18	2.04
4	18:1	26.66	25.16	26.28	26.58
5	18:2	18.78	18.26	18.12	18.24
6	18:3	9.51	9.91	9.78	9.15
7	20:0	1.01	1.09	0.77	1.04
8	20:1	10.59	9.74	10.04	10.39
9	20:2	0.79	0.83	0.85	0.87
10	22:0	0.46	0.81	0.49	0.66
11	22:1	23.89	25.69	25.22	24.89
12	24:0	0.09	0.19	0.14	0.11
13	24:1	0.38	0.51	0.43	0.41

We have calculated these values for studied tyfon varieties (Table 2). The results of our analysis shown that the content of unsaturated fatty acids in tyfon oil reached up to 91.68 % in variety Obriy, while the ratio of PU/MU up to 0.47 in varieties Orakam and EOTFV.

Table 2. Main coefficients using for analysis of fatty acid composition of seed oil calculated for different varieties of of tyfon (*B. rapa* (*ssp. rapifera X ssp. pekinensis*))

Parameter/Variety	EOTFV	Orakam	Obriy	Fitopal
Total sat. (%)	8.5	9.11	8.32	8.47
Total unsat. (%)	90.86	90.36	90.94	90.78
Total monounsat. (%)	61.78	61.36	62.19	62.53
Total polyunsat. (%)	29.08	29.0	28.75	28.26
ER	0.39	0.4	0.39	0.4
DR	0.32	0.32	0.31	0.31
ODR	0.51	0.53	0.51	0.51
LDR	0.34	0.35	0.35	0.33
S/U	0.09	0.1	0.09	0.09
PU/MU	0.47	0.47	0.46	0.45

It is necessary to note that tyfon genotypes have high ER values (up to 0.4), because of the large quantity of erucic (22:1) and gondoic (20:1) acids in oil, comparing with *Camelina sativa* [3]. DR values were low (0.31-0.32), because of small amount of polyunsaturated fatty acids comparing with monounsaturated. ODR values were quite low for tyfon (0.51–0.53) because of the low content of polyunsaturated fatty acids. LDR values were quiet low also: up to 0.35 only, respectively to low amount of polyunsaturated fatty acids.

Conclusion

Due to indentified characteristics tyfon oil could be used as a lubricant or raw material for further processing because of high content of monounsaturated fatty acids: up to 26.58 % of oleic acid and up to 25.82 % of erucic acid. The best variety for such usage direction is Fitopal. Oil of this cultivar has 63.13 % of monounsaturated fatty acids, including 26.58 % of oleic (18:1), 10.39 % of gondoic (20:1) and 25.49 % of erucic (22:1) acid. Also, this variety has high oil productivity, which makes this cultivar more commercially attractive.

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CRUCIFERAE NEWSLETTER Nr. 37
Instructions to the authors – 2018

Deadline for contribution submission: **April 1st 2018**

The next issue of the Cruciferae Newsletter (vol. 37) will be published online during Spring 2018 from the Brassica website (http://www.brassica.info/info/publications/cruciferae-newsletter.php). Online process will ensure rapid publication of your contribution. Therefore, we should be grateful if you would, please, follow the instructions below.

1- All contributions should be written in **English**.

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3- As previously contributions must not exceed **2 pages**, including tables, figures and photographs. **Arial 10** character is expected with single spacing (**please use the submission form below**).

4- The heading of the paper must be written in boldface letters and must include the title (1st line), followed by the author names (lines below) and their address (3rd lines) with the email address of the corresponding author.

5- Tables, figures and photographs must be included in, or at the end of the text.

6- While submitting their contributions, authors should mention **one of the listed topics** that is the most relevant to their work (see the list below), in order to facilitate the editing process.

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Table 1. Title

Figure 1. Title