

Original Research Paper

# Expanding the Rapeseed Cultivation Area in the South and South-Eastern Regions of Kazakhstan with the Introduction of its Winter Variety

<sup>1</sup>Galiolla T. Meirman, <sup>1</sup>Sakysh T. Yerzhanova, <sup>1</sup>Serik S. Abayev, <sup>2</sup>Bakyt A. Ainebekova, <sup>1</sup>Amankeldi T. Kenebayev and <sup>1</sup>Galym O. Shegebayev

<sup>1</sup>"Kazakh Scientific-Research Institute of Agriculture and Plant Growing" LLP, Almaty, Kazakhstan

<sup>2</sup>"Kazakh Scientific-Research Institute of Livestock and Forage Production" LLP, Almaty, Kazakhstan

## Article history

Received: 30-07-2021

Revised: 24-11-2021

Accepted: 02-12-2021

Corresponding Author:  
Sakysh T. Yerzhanova  
"Kazakh Scientific-Research  
Institute of Agriculture and  
Plant Growing" LLP,  
Almaty, Kazakhstan  
Email: sakyshyer@mail.ru

**Abstract:** The paper examines the data on 86 rapeseed samples of various ecological and geographical origins, which were subjected to a long-term selection study with the criterion of winter hardiness to create a new Kazakhstani variety of winter rapeseed. For selection, plant indicators are used in terms of the number of leaves (at least 7), the diameter of the root collar (more than 6 mm), the height of the growth point (up to 3 cm), the weight of 1 plant should be more than 35 g, the correlation/regression method is used to determine the relationship between structural features and productivity. The purpose of the study is to expand the territory of winter rapeseed crops in the southern and southeastern regions of Kazakhstan. The first Kazakh winter rapeseed variety Pervenets Semirechya was created with the following indicators: Winter hardiness 79 to 91.3%, green mass yield 40.7 to 51.4 t/ha, oilseed yield 2.76 to 3.83 t/ha, oil content 46.3% and protein content 26%. Bioclimatic potential makes it possible to introduce winter rapeseed to an area of 50-70 thousand hectares in the system of crop rotation. The advantages of winter rapeseed over spring rapeseed are noted.

**Keywords:** Winter Apeseed, Variety, Introduction, Yield, Winter Hardiness

## Introduction

Rapeseed is a crop of versatile use: It can be used for the production of edible and industrial oil, for fodder purposes (early green fodder, haylage, frozen fodder, high-protein cake), and in the agrotechnical sense, it is used as a catch crop after early harvested crops. It plays an important role as an early green forage, covering the protein deficiency before the green biomass of alfalfa ripens. Alfalfa (*Medicago L.*) is a high-protein fodder crop (Humphries *et al.*, 2020).

Rapeseed is a good honey plant, with a flowering time of more than 30 days and a honey yield from each hectare up to 100 kg. It is considered a phytosanitary crop and is used as green manure (Pilyuk, 2007).

Research and forecasts clearly show that the area under rapeseed is increasing worldwide (Fig. 1). Rapeseed in Kazakhstan began to spread at the beginning of 2000 as one of the important aspects of production diversification, supported by state subsidies, and has become firmly established in the structure of crop rotations in the northern regions of Kazakhstan.

Goods manufacturers of Kazakhstan have already appreciated the benefits of rapeseed. In addition, an optimal technology for growing spring rapeseed has been developed in the main zones of its production, namely in North Kazakhstan, Akmola, Kostanay, East Kazakhstan, and Pavlodar regions. The annual cultivation area of spring rapeseed in Kazakhstan makes up 150-350 thousand hectares and rapeseed oilseeds have become an export product that is in stable demand. About 80% of rapeseed seeds are used to obtain oil that meets all the requirements for food quality (Torikov and Shakov, 2008). Cultivation of winter rapeseed in the southern and southeastern regions of Kazakhstan can become a reserve for increasing the production of oilseeds and fodder.

Winter rapeseed has a higher yield than spring rapeseed. It effectively uses soil moisture in the spring period and has some advantages over spring rapeseed, such as simplified cultivation technology, early maturity (harvesting for seeds between June 20 and June 30), the use of irrigation water in the non-growing season, a significant reduction in pesticide load or cultivation completely without pesticides.

Cultivation of winter rapeseed is more profitable than the cultivation of spring rapeseed since its yield is much higher. The overwintered rapeseed in the rosette phase grows quickly and forms buds 20 days after the beginning of the growing season and blooms 13-17 days after the beginning of budding. In this phase it can be used for fodder purposes, that is, in the early spring period before the green mass from alfalfa arrives (Humphries *et al.*, 2020). For fodder purposes, it can also be cultivated during spring sowing; the mowing ripeness of the herbage begins 50-60 days after the emergence of seedlings. In terms of use for fodder, it is a unique crop that can be used for post-cut crops and catch crops in the pure or mixed form under irrigated conditions in the south and southeast of Kazakhstan. Green mass (1 kg) contains on average up to 30 grams of digestible protein, 0.28 mg of carotene, and 0.16 feed units. The green mass has a high digestibility and a small amount of fiber, it is well consumed by all farm animals and is a valuable raw material for ensilaging. The yield of the green mass of winter rapeseed during autumn sowing reaches up to 40-50 t/ha (Kostin and Velichko, 1985).

Despite having such advantages, winter rapeseed has not yet found its rightful place in crop rotations in the southern regions, that is, in the zone where winter wheat is widespread. In terms of its winter hardiness, winter rapeseed is slightly inferior to winter wheat.

Winter rapeseed may well overwinter with an appropriate selection of winter-hardy varieties with the introduction of technologies that ensure its resistance to winter factors. Its cultivation is more technologically advanced. According to our estimates, in the conditions of the south and southeast, observing the principle of crop rotation under which rapeseed should be cultivated in its former place not earlier than six years, one can predict an increase to 50-70 thousand hectares in its area.

The study aims to expand the territory of winter rapeseed crops in the southern and southeastern regions of Kazakhstan.

## Materials and Methods

### *Place and Period of the Study*

The study was carried out at the stationary “Kazakh Scientific-Research Institute of Agriculture and Plant Growing” LLP in Almalybak, Almaty region of the Republic of Kazakhstan from 2009 to 2020. Breeding nurseries for the study of the collection and testing of numbers in the selection process and breeding sites were established in the conditions of the foothill zone of the Iliy Alatau (500-750 m above sea level) on light chestnut soils of medium texture. The areas of the plots where the sampling was carried out amounted to 100-200 m<sup>2</sup> and the areas of reproduction equaled 3-5

hectares. The main criteria for the selection of sites were their uniformity and typicality corresponding to the zone of distribution of winter rapeseed to soil and climatic conditions.

### *Field Experiments*

The predecessor crops were winter wheat and, in some years, barley. Sowing was carried out after water-charging (sprouting) irrigation, as well as without it. Main and pre-sowing treatment: Reverse plowing, careful cutting, and leveling of the surface layer. For the main treatment, phosphorus fertilizers were applied at 90 kg/ha. and for pre-sowing treatment nitrogen fertilizers were used at 50 kg/ha of the active substance and in spring on frozen soil, 60 kg/ha of nitrogen was used. In 2018 and 2019, rapeseed was sown for the first time with direct sowing on winter wheat stubble. Sowing was carried out at the optimal time in the first decade of September. The sowing method was wide-row (30 cm per row) with a sowing rate of 10-12 kg/ha, at a sowing depth of 2-3 cm. After sowing, the soil was rolled down. Harvesting of winter rapeseed for seeds was carried out at the onset of a yellow-green color in most of the pods when the seeds had acquired a dark shiny color and a crush-hard consistency. Before harvesting, desiccation was carried out with the Reglon preparation (made by Syngenta Crop Protection AG, Switzerland) for 5-7 days. Harvesting in nurseries was done manually and in production breeding plots John Deere and Vector combine harvesters were used.

### *Phenological Observations*

To assess the state of winter rapeseed crops in breeding nurseries and breeding sites, we took into account the yield of green mass at the beginning of flowering of plants and for seeds at maturity of 70-90% of pods, as well as winter hardiness, phenology, resistance to Alternaria blight. We also performed a structural analysis with a sample size of 50 plants according to the following characteristics: Growing season, plant height, lodging resistance, 1st order branching, height up to 1st branching, number of pods per plant, number of pods on the central cluster, number of seeds in a pod, the weight of 1,000 seeds.

In the pre-breeding work with winter rapeseed, the collection in the crops of 2009-2011 was first studied. with the identification of the most winter-hardy and productive samples. Then elite plants in the selected best samples were used as parental forms for hybridization. Hybrids were obtained from a combination of crossing.

Based on the results of a three-year screening, the following high-yielding and winter-hardy varieties with some other valuable traits and properties were selected from 86 samples: Leader, Svetlana, Zorin, and the Arctic. Elite plants of these varieties served as the initial form of further breeding work on hybridization and triple family-group selection of desired genotypes with increased winter hardiness.

### Breeding Study

Subsequently, they were subjected to a breeding study in the period from 2012 to 2020 by the method of family/group selection with line assessment in breeding nurseries. The main selection criterion at all stages of assessing the collection and breeding lines was the index of winter hardiness, which was determined by counting plants before leaving for winter and counting the surviving plants after overwintering with an intensive accumulation of biomass in the early spring period of growth. For the selection, we also used the indicators of plants in terms of the number of leaves (at least 7), the diameter of the root collar (more than 6 mm), the height of the growth point (up to 3 cm) and the weight of 1 plant (more than 35 g) (Belyavskii, 2005). To determine the relationship of structural features with productivity, a correlation/regression method was used.

Collection nurseries for the study of a collection of winter rapeseed, consisting of 86 samples of various ecological and geographical origins, were created in three replicates with a counting area of each sample of 3-6 m<sup>2</sup>. The collection was based on samples kindly donated by the renowned rapeseed breeder Ya. E. Pilyuk (Agriculture Research and Practice Center of the National Academy of Sciences (NAS) of Belarus, Zhodino).

Breeding nurseries with selected numbers were established on single-row plots 5 m long without repetition with a row spacing of 30 cm.

In the control nurseries, for the initial assessment of the selection efficiency, each number was placed on plots with an area of 10 m<sup>2</sup> in three replicates and the best numbers in competitive nurseries, as the final stage of the assessment, were tested on plots with a counting area of 25 m<sup>2</sup> in four replicates for three years in comparison with the Ivanna (standard) variety approved for use in the Almaty region since 1991, despite the small quantity of winter rapeseed in production. In all trials, the numbers studied were randomized.

In the creation of the first Kazakhstani variety Pervenets Semirechya, we used elite plants of winter-hardy varieties, such as Leader, Svetlana, Zorin, and the Arctic, applying a poly cross-method, followed by a three-fold family/group selection.

Protein content analysis was performed based on NIR spectroscopy using a FOSS DS 2500 instrument (FOSS, Denmark) calibrated according to the Kjeldahl method.

Analysis of the crude fat content in soybean seeds was carried out based on NIR spectroscopy using the FOSS DS 2500 instrument.

### Statistical Analysis

The processing of the experimental results to ensure the reliability of the data was carried out according to Dospekhov (1968).

### Results

In the conditions of the southeast Kazakhstan (Almaty region), when the tasks were set to expand the sown area of rapeseed as part of the diversification of production to solve the problem of providing the population with vegetable oil, we conducted a study on the selection and technology of cultivation of spring rapeseed. The first Kazakhstani varieties of spring rapeseed Maylı (Patent No. 1042, 2010), Shalqar 39 (Patent No. 2423, 2011), and Safiya (Patent No. 412, 2014) were created and technologies for their cultivation were developed experimentally by timing, methods, sowing rates, fertilizers, pest, disease and weed control, harvesting (Meirman *et al.*, 2011). However, at the stage of introducing spring rapeseed into production, some difficulties arose. First of all, the crops had to be protected from cruciferous fleas in the spring. It multiplied rapidly, destroying emerging seedlings. The delay in chemical treatment by 3-5 days led to the thinning and in some cases, the destruction of crops.

The surviving crops due to damage by pests (diamondback moth) during the summer and diseases (root rot, powdery mildew, Fusarium blight, etc.) sharply decreased the potential of the crop, the yield was 8-10 c/ha, which is 2-3 times less than in the case of timely organization of protective measures for chemical treatment of crops.

Climatic changes on our planet lead to the loss of potential yields when growing plants in specific conditions without adjusting the sowing time (Dolgikh and Abugalieva, 2007). Analysis of the bioclimatic potential of the south and southeast of Kazakhstan in terms of the main limiting parameters, such as temperature during the wintering period of winter rapeseed and precipitation in the main stages of the growing season makes it possible to justify the prospects for the cultivation of winter rapeseed. The level of overwintering is determined not only by the genotype but also to a large extent by the winter conditions, like the height of the snow cover, winter thaws, temperature fluctuations, ice crust, severe frosty days, etc. According to long-term meteorological data (2000-2020), the first stage of development (September-October), the overwintering (November, December, January, and February), and the second stage of development (March, April, May, and June; the ripening period) are characterized by the following parameters (Fig. 2 and 3).

Winter conditions, subject to timely sowing (55-60 days) and the provision of soil moisture in this zone during the autumn growing season, cannot be viewed as serious limiting factors. Therefore, it is necessary to choose more winter-hardy varieties. However, it is not always possible to obtain seedlings because of the often recurring autumn drought. Of the years studied, autumn 2020 was found to have very low precipitation. Seedlings appeared in the spring and the plants further developed in a spring-like manner. To ensure the

emergence of seedlings and the development of plants in the autumn period, it is recommended to carry out sprouting irrigation as an effective measure in the technology of cultivation of winter rapeseed.

The main advantages of winter rapeseed over spring rapeseed are as follows:

- During the emergence of winter rapeseed seedlings, that is, in the autumn period, harmful insects (in particular cruciferous fleas) are not as active as in spring and the plants are not damaged. Accordingly, insecticidal treatments are excluded
- In spring, and winter rapeseed develops quite intensively, accumulating biomass and in most cases, chemical treatments against pests, diseases, and weeds are not necessary
- Winter rapeseed ripens in the second half of June and is not affected by the summer heat

By the combination of its advantages, it can be considered that winter rapeseed is more environmentally friendly than spring rapeseed. In the crops of the latter, chemical treatment is carried out 3-4 times during the growing season. The parameters of the bioclimatic potential of the south and southeast of Kazakhstan meet the biological requirements for the growth and development of winter rapeseed. Its cultivation in these regions gives a new impetus to strengthening the fodder base of animal husbandry and the production of oilseeds for technical use. The prospect of such a view on the issue is also determined by the fact that the reproduction rate of winter rapeseed is very high (not less than 1: 300), which makes it possible to accelerate its introduction at high rates.

There is a need to create high-yielding varieties, both in terms of green mass and seeds. In parallel, we carried out the selection of winter rapeseed. For this purpose, a collection of winter rapeseed was studied. Subject to the technology, especially the sowing time, the yield of samples of the collection of winter rapeseed was quite

high, within the range of 25-34 c/ha with winter hardiness of 53-92% in 2014, 15-46 c/ha with winter hardiness of 28-84% in 2016, 27.6 c/ha with winter hardiness of 80.1% in 2018 (on average) and 38.3 c/ha with winter hardiness of 91.3% in 2020. The appearance of rapeseed pests and diseases was not observed on crops of winter rapeseed in the autumn when shoots appeared and developed before hibernation (September to October). It also was not necessary to carry out weed control measures.

In spring, after successful overwintering, winter rapeseed begins to actively vegetate under conditions of spring moisture and an increase in positive temperatures. Plants quickly gain weight, outstripping the development of insects, and pests and they do not pose a danger in reducing productivity, even in the production of oilseeds, especially for the production of early green feed.

For the selection of winter rapeseed, the degree of expression of indicators of the elements of structure and productivity is important. We have established the strength of the connection between the structural elements which is determined by the conditions of the year and the density of the stand. The latter is a direct reflection of the level of overwintering (Fig. 4).

In the course of the work of the hybrid population, selections were carried out with the selection of more than 2 thousand desirable lines and they were evaluated in breeding nurseries after each selection (three times) and at the final stages were tested in control nurseries and competitive variety trials.

The results of testing the newly created variety Pervenets Semirechya (breeding number OR-48-51-4) are presented in Fig. 5 and Table 1. The yield of green mass in the new variety of winter rapeseed Pervenets Semirechya during the test years was 40.7 to 51.4 t/ha and oilseed yield was 2.76-3.83 t/ha with an average oil content of 46.3% and protein content of 26.0%. Winter hardiness averaged 83.6% with annual fluctuations of 79.3 to 91.3%. The area of the newly introduced variety in 2019 was 112 hectares and in 2020 it had expanded to 714 hectares.

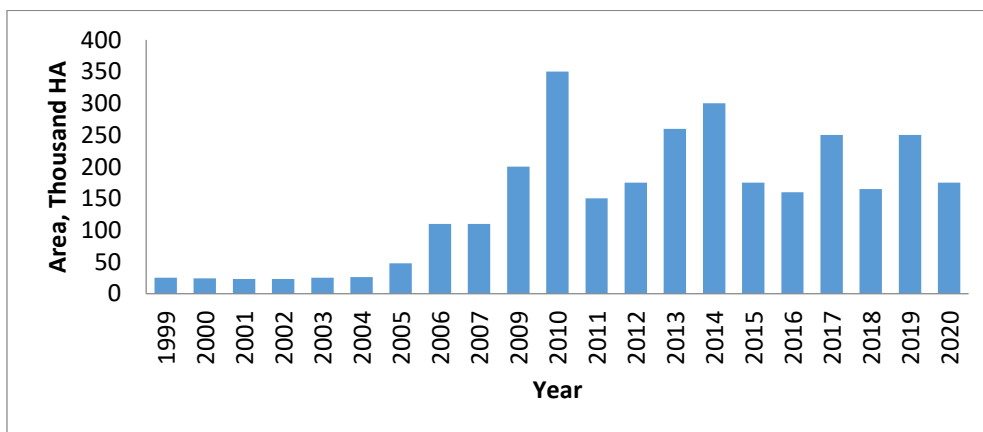


Fig. 1: Growth of the cultivated areas of spring rapeseed in Kazakhstan, per thousand hectares (according to statistics)

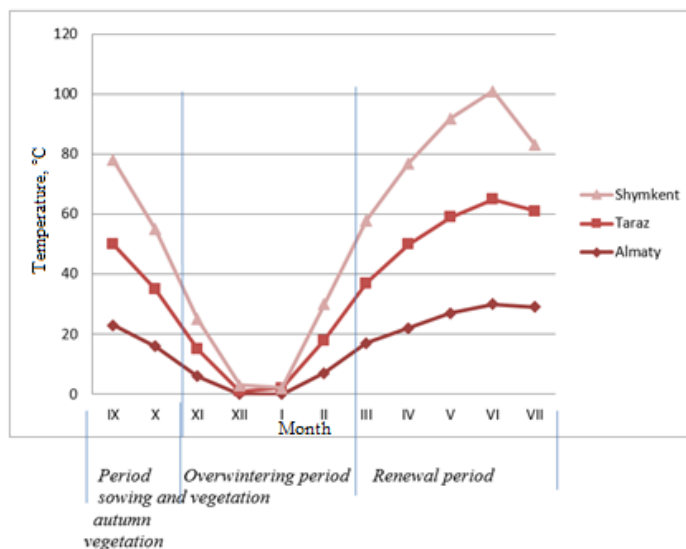


Fig. 2: Long-time average annual temperature by month

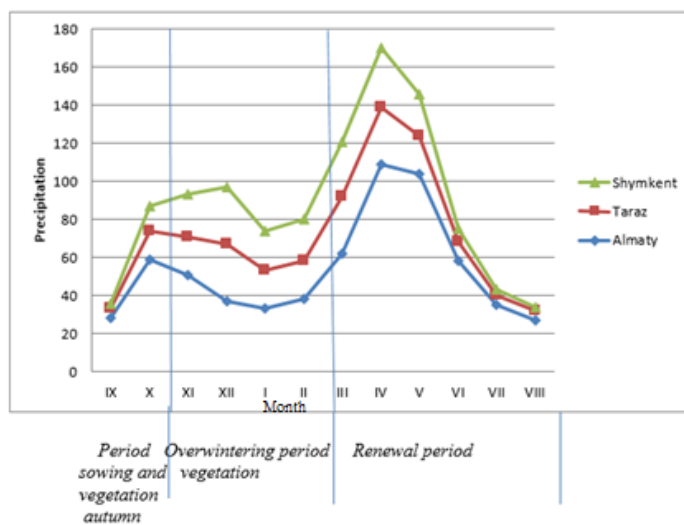


Fig. 3: Long-time average annual precipitation by month

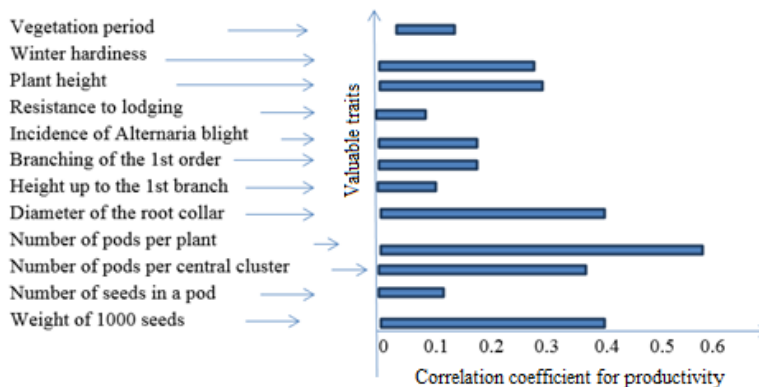


Fig. 4: Coefficients of the correlation between the structural features of winter rapeseed of the Pervenets Semirechya variety and its productivity



**Fig. 5:** General view of the crops of winter rapeseed variety Pervenets Semirechya (2020)

**Table 1:** Indicators of the new winter rapeseed variety pervenets semirechya (according to the competitive variety testing)

Indicator	Unit of measurement	Pervenets Semirechya				Ivanna			
		2018	2019	2020	Average	2018	2019	2020	Average
1. Seed yield (at standard moisture %)	t/ha	2.76	3.01	3.83	3.20	2.35	2.41	3.23	2.67
Least Significant Difference (LSD) <sub>095</sub>	%	0.16	0.23	0.25					
2. Winter hardiness	day	80.1	79.3	91.30	83.60	77.20	73.10	81.30	77.20
3. Vegetation period	-	290	283	296.00	289.00	294.00	287.00	300.00	294.00
4. Ripeness at the same time	pcs	290	283	296.00	289.00	294.00	287.00	300.00	294.00
5. Number of pods on the central cluster	pcs	Uneven	Uneven						
6. Number of branches of the 1 <sup>st</sup> order	pcs	35.0	31.3	44.20	37.30	33.00	29.60	40.40	34.30
7. Number of seeds in the pod on the central cluster	g	13.0	13.4	15.20	13.90	13.00	11.00	13.20	12.40
8. Weight of 1000 seeds	%	26.0	27.3	28.90	27.40	26.40	27.40	25.50	27.70
9. Fat content	%	5.2	6.0	5.40	55.00	5.00	5.70	5.00	5.20
a) in abs. dry seeds	%	45.0	46.3	47.60	46.30	43.70	45.70	46.40	45.30
b) in the kernel	t/ha	45.4	46.8	47.90	46.70	44.00	45.90	46.80	45.60
10. Protein content in seeds	t/ha	25.0	26.3	26.80	26.00	25.00	25.80	25.00	25.30
11. Yield of green mass	5.2	6.0	5.4	5.50	5.00	5.70	5.00	5.20	
LSD <sub>095</sub>	40.7	43.2	51.4	45.10	32.70	35.90	41.30	36.60	
	0.48	0.43	0.4						

## Discussion

The concept of winter hardiness includes the ability of plants to withstand a complex of adverse effects of the external environment during the autumn/winter and early spring periods (the effect of negative temperatures, winter thaws, and spring thawing with a sharp transition to frost, soaking, and damping, etc.). To establish these natural situations as a background for selection, breeding work with winter rapeseed lasted for 15 years, which made it possible to differentiate genotypes according to the level of winter hardiness in different winter conditions.

A collection of rapeseed with a description of productive samples was studied by Dolgikh and Abugalieva (2007).

According to long-term data from the Agriculture Research and Practice Center of the NAS of Belarus, winter rapeseed overwinters better when, before overwintering, its plants are characterized by the following development

parameters: The number of leaves from 6 to 10, the diameter of the root collar more than 6 mm, the height of the growing point up to 3 cm, the weight of 1 plant more than 35 g.

As our observations show, such a state of winter rapeseed plants in southeast Kazakhstan is achieved when sowing in the first half of September. At the same time, the duration of the autumn growing season is 55 to 60 days, which is sufficient for the accumulation of sugar in plants as the main factor providing a high level of survival after overwintering. The sugar content in plants before winter is the main quality indicator of winter rapeseed (Zelenyuk *et al.*, 2010).

## Conclusion

As a result of many years of research, the goal was achieved—the first Kazakh winter rapeseed variety Pervenets Semirechya was created. It is distinguished by high winter hardiness at the level of 79.3 to 91.3%, with a

yield of green mass of 40.7 to 51.4 t/ha and an oilseed yield of 2.76 to 3.83 t/ha. In 2020, 3.4 t/ha of oilseeds and 51.4 t/ha of green mass were obtained from production breeding plots on an area of 58 hectares.

The bioclimatic potential of the south and southeast of Kazakhstan makes it possible to cultivate winter rapeseed successfully. In these regions, winter rapeseed is more productive than spring rapeseed. Winter crops are of fodder value when cultivated in the main crops, catch crops, and post-cut crops.

Elite seeds of the Pervenets Semirechya variety were collected in the amount of 30 tons. Winter rapeseed was introduced with scientific support on an area of 613 ha in different ecological areas.

## Acknowledgment

The study was carried out within the framework of Grant Funding by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (MES RK) (Project No. AP0895651, "Introduction of winter rapeseed culture in the south and southeast of Kazakhstan").

## Author's Contributions

All authors equally contributed to this study.

## Ethics

This article is original and contains unpublished material. The corresponding author confirms that all other authors have read and approved the manuscript and no ethical issues have been involved.

## References

- Belyavskii, V. M. (2005). K metodike seleksii ozimogo rapsa na zimostoikost [On the method of breeding winter rapeseed for winter hardiness]. *Materialy Mezhdunarodnoy nauchno-prakticheskoy konferentsii* [Materials of the international research and practice conference], Zhodino, July 14-15, Institut zemledeliya i seleksii NAN Belorusi, Minsk, pp, 158-164. ISBN 985-6782-05-8.
- Dolgikh, L. A., & Abugalieva, A. I. (2007). Izuchenie sortov rapsa v Kazakhstane [Study of rapeseed varieties in Kazakhstan]. *Issledovaniya, rezultaty*, 3, 36-40.
- Dospekhov, B. A. (1968). Metodika polevogo opyta; s osnovami statisticheskoi obrabotki rezul'tatov issledovaniy. <https://agris.fao.org/agris-search/search.do?recordID=US201300320169>
- Humphries, A., Ovalle, C., Hughes, S., del Pozo, A., Inostroza, L., Barahona, V., Yu, L., Yerzhanova, S., Rowe, T., Hill, J., Meirman, G., Abayev, S., Ch. Brummer, E., Peck, D. M., Toktarbekova, S., Kalibayev, B., Espinoza, S., Ivelic- J., Saez, Bingham, E., Small, E., & Kilian, B. (2020). Characterization, preliminary evaluation, and pre-breeding of diverse alfalfa crop wild relatives originating from drought-stressed environments. *Crop Science*, 61 (1), 69-88. doi.org/10.1002/csc2.20274
- Kostin, N. F., & Velichko, P. K. (1985). Ozimyi raps [Winter rapeseed]. Kainar, Alma-Ata. pp: 92.
- Meirman, G. T., Kaltaev, S. K., Rakhimzhanova, Sh. S., Masonich-Shotunova, R. S., & Abdullaev, A. A. (2011). Rekomendatsii po tekhnologii vozdeleyvaniya yarovogo rapsa v usloviyakh Yugo-vostoka Kazakhstana [Recommendations on the technology of cultivation of spring rapeseed in the south-east of Kazakhstan]. *Almalybak*. Pp, 11. <https://www.slideshare.net/slavalist/ss-11797624>
- Patent No. 1042 (2010). Na sort rapsa yarovogo Mayli [Patent No. 1042 for spring rapeseed Mayli], 2010. Avtorskoe svidetelstvo [Author's certificate].
- Patent No. 2423 (2011). Na sort yarovogo rapsa Shalqar 39 [Patent No. 2423 for spring rapeseed Shalqar 39], December 21, 2011. Avtorskoe svidetelstvo No. 599 13.03.2017 g. [Author's certificated No. 599 dated 13.03.2017].
- Patent No. 412 (2014). Na sort rapsa yarovogo Safiya [Patent No. 412 for spring rapeseed Safiya], February 19, 2014. Avtorskoe svidetelstvo [Author's certificate].
- Pilyuk, Ya. E. (2007). Raps v Belarusi (biologiya, selektsiya i tekhnologiya vozdeleyvaniya) [Rapeseed in Belarus (biology, selection, and cultivation technology)]. *Biznesofset*, Minsk. Pp, 239. ISBN-10: 978-985-6649--53-3.
- Torikov, V. E., & Shakov, V. M. (2008). Osobennosti vozdeleyvaniya ozimogo rapsa na semena [Features of the cultivation of winter rapeseed for seeds]. *Vestnik Bryanskoi GSKhA*, 5, 15-19. <https://cyberleninka.ru/article/n/osobennosti-vozdeleyvaniya-ozimogo-rapsa-na-semena>
- Zelenyak, V. V., Pilyuk, Ya. E., & Belyavskii, V. M. (2010). Razvitie rastenii ozimogo rapsa v osennii period, soderzhanie i dinamika raskhoda sakharov v period perezimovki [Development of winter rapeseed plants in the autumn period, the content and dynamics of the consumption of sugars during the wintering period]. In: *Sb. nauchnykh trudov Zemledelie i selektsiya v Belarusi* [A collection of research papers on Agriculture and breeding in Belarus], Nauch.-prakt. tsentr NAN Belorusi po zemledeliyu, Minsk, pp, 292-299. <http://www.cnsrb.ru/journals/2012/0606/0237966X/0237966X.pdf>