Biological efficiency of cultivation of new hybrids of spring rapeseed in Eastern Siberia

A N Khalipsky¹, E N Oleynikova¹,²,³ and I I Grishina¹,²

¹Krasnoyarsk State Agrarian University, 90, Mira Avenue, Krasnoyarsk, 660049, Russia
²Siberian Federal University, 79, Svobodny av., Krasnoyarsk, 660041, Russia
³E-mail: oen24@yandex.ru

Abstract. The work considered the development of technology for cultivating new hybrids of spring rapeseed breeding by LLC Jerman Sid Alliance Russ RAPOOL in the natural and climatic conditions of Eastern Siberia. The research was carried out in the production experience of grain- and-grains crop rotation at the field station of the ERPC "Borsky" in the conditions of the Krasnoyarsk forest-steppe. Six new spring rapeseed hybrids of RAPOOL's Clearfild ® breeding system were studied, advanced cultivation technology and a system for protecting the crop from harmful organisms were tested, biological and actual yields were assessed, and the main elements of the crop structure were determined. The seed oil grain of spring rapeseed hybrids in full protection versions was well made with almost the same weight of 1000 seeds and ranged from 4.0 to 4.5 g. An assessment of the biological yield from the main alimony of the crop structure shows that it varies by hybrids and varies from 3.3 t/ha in the Lagonda hybrid under control to 7.03 t/ha in the Drago hybrid with complete protection. The same assessment on Clearfild ® spring rapeseed hybrids showed a high biological yield, which varies from 5.6 t/ha in the Cyclus hybrid to 7.8 t/ha in the Chip CL hybrid. High harvest yields were formed by Contra CL and Chip CL hybrids, 9.5 and 9.4 t/ha, respectively. The highest actual seed yield with full protection was shown by the Drago hybrid (6.2 t/ha) and Chip CL hybrid (7.2 t/ha). The assessment of spring rapeseed hybrids from the Clearfild ® system group showed that their actual yield of oilseeds did not exceed the same in the first test using non-cryafield seeds.

1. Introduction
The intensification process and the high growth rate of the livestock industry, as well as the growing demand for vegetable oils in the Russian Federation and around the world, make it necessary to expand the production of oilseeds. An analysis of the current state of the oilseeds industry shows that the growth of oil seed production is achieved not only due to the expansion of agricultural areas under oilseeds, but also due to the development of new adaptive agricultural technologies. Agricultural producers and farmers should pay special attention to the use of new varieties and hybrids of oilseeds, which have recently appeared widely on the world and Russian markets. Developers and manufacturers of rapeseed, camelina and runch varieties and hybrids pay special attention to the following indicators: resistance to diseases, the combination of an improved fatty acid composition with a stable crop of marketable oil seeds. In Eastern Siberia, another indicator of the seed material of oilseeds is important - early and friendly ripening.
In 2020, the Government of the Russian Federation and the Ministry of Agriculture of the Russian Federation allocated 3.3 billion rubles of subsidies from the federal budget to stimulate an increase in soybean and rapeseed production, agreements were concluded with 39 regions of the country. Subsidies are aimed at compensating part of the costs that arise in the production of these crops.

In 2019, 2,307,68 thousand tons of rapeseed were produced in Russia, which is 4.1% more than the volume of production of the previous year. The leader of rapeseed production in (thousand tons) of the total produced volume for 2019 was the Siberian Federal District (hereinafter - SFD) with a share of about 34.4%. Krasnoyarsk Territory became the leader in the production of oilseeds not only in the SFD, but also in the Russian Federation. According to the Expert Analytical Center for Agribusiness, the agrarians of the Krasnoyarsk Territory in 2019 increased the production of rapeseed seeds by 22.2%, the gross collection of which amounted to 213.5 thousand tons (9.3% of the total collection of the Russian Federation). The average crop yield in the region was 17.0 c/ha [1].

The areas of oilseeds in the Krasnoyarsk Territory are also increasing due to the high export component of crops and the development of trade relations with Southeast Asia, in particular with Mongolia and China. In 2017, about 20 thousand tons of rapeseed were exported to these countries, in 2018 about 40 thousand tons of this crop were delivered there [2, 3]. In 2019-2020, exports increased by 4.5 and 6.1%, respectively.

The export of rapeseed oil from the Russian Federation in 2020 increased by 9.4%, but the size of the accumulated export of rapeseed seeds remains noticeably lower than last year - more than 329 thousand tons (-34.0%). Rapeseed exports to the world market in 2020 also showed a stable increase, both in the estimation of physical quantities and in the valuation: in physical indicators, export deliveries increased by 48%, the total volume of exports by value - by 67%.

Rapeseed consumption is also increasing in the Krasnoyarsk Territory itself [4, 5, 6, 7, 8]. Due to the limited resources of crop production area, a further increase in the production of spring rapeseed will not be associated with the expansion of sowing areas (about 137 thousand hectares in 2020), but with an increase in its yield due to the introduction of new varieties and hybrids and the optimization of plant protection from harmful organisms (weeds, pests and diseases) [9, 10]. In this regard, it becomes necessary to find new more effective means of protection for new varieties and hybrids, which form the highest yield in the forest-steppe conditions of the Krasnoyarsk Territory and early ripening.

Foreign scientists are also engaged in the study of new varieties and hybrids of spring rapeseed. Impact of application of new varieties and hydrides on increase of yield and calculation of economic effect from their introduction into production is considered by V.Krček. The study results that hybrid varieties can generate income by 5% more than linear varieties [11].

The purpose of the work is to improve the technology of cultivation and optimize the system of protection of spring rapeseed, to assess the biological and economic efficiency of using new hybrids of spring rapeseed breeding by Jerman Sid Alliance Russ LLC RAPOOL in the natural and climatic conditions of Eastern Siberia.

Sample: spring rapeseed.

Harmful objects: diseases, pests, weeds.

2. Research methodology

In 2020, on the pilot field of the ERPC «Borsky» FSBEI HE Krasnoyarsk SAU, which is located 51 km north of the Krasnoyarsk city, experiments were laid and studies were carried out to improve cultivation technology, optimize the protection system against harmful organisms, study yield and the main elements of the spring rapeseed harvest structure in the Krasnoyarsk forest steppe.

There were 8 hybrids in the experiment, 6 of which belong to the group of cryafield (CL) - Solar, Curie, Cebra, Cyclus, Chip and Contra [12]. Rapeseed hybrids were seeded along the vapor precursor without first etching the seeds. Rapeseed hybrids were treated with protective equipment by their manufacturer RAPOOL. The sowing period is on May 13, the norm for sowing hybrids is 70 pcs/m², the depth is 3-4 cm, grain seeder SPN-16, postsowing rolling down area is 2500 m². Each hybrid was embedded in repetitions, the placement of repetitions in two blocks is systematic. Plant care at the pilot
The site was carried out under the program of JSC «August». Research and analysis of integrated protection programmes involved the use of herbicides and pesticides on two experimental versions, compared to controls without the use of crop protection. Chemical protections are used when a harmful organism (weeds, pests and diseases) reaches the economic threshold of harmfulness (EToH).

Weed estimation was carried out in accordance with the guidelines of FSBSI VIZR [13] and before processing (initial percentage of impurities), 15, 30, 45 days after processing and before cleaning. At the first estimation, the number of weeds was considered; with subsequent ones - the number and mass of weeds separately by species. There were phases of weed development during the spraying period and symptoms of herbicidal activity during the vegetation period (photo-observation of weeds, dynamics of herbicidal activity of preparations on the main species of weeds).

The percentage of impurities is determined visually and is characterized as: no, weak (crop losses from 0% to 10%), average (crop losses from 10% to 30%), strong (crop losses from 30% to 50%), very strong (crop losses from 50%) [14, 15, 16].

Disease records were carried out in accordance with the guidelines of the FSBSI VIZR [13]. During the test period, it is necessary to mark the date of appearance of the first signs of the disease. It is recommended to consider the prevalence and degree of development of the disease before processing, follow-up accounting with an interval of 10-14 days, continuing until harvesting (at least 4 counts per season).

The degree of damage by diseases is determined visually and is characterized as: no, weak (crop losses from 0% to 10%), average (crop losses from 10% to 30%), strong (crop losses from 30% to 50%), very strong (crop losses from 50%) [14, 17, 18].

The degree of damage by pests is determined visually and is characterized as: no, weak (crop losses from 0% to 10%), average (crop losses from 10% to 30%), strong (crop losses from 30% to 50%), very strong (crop losses from 50%) [15, 17, 18].

A week before harvesting, sample sheaves were selected with each of the four typical 0.25 m$^2$ plots totaling one square meter to determine crop structure and biological yield. The number of plants was counted, the height of the plants was measured, the weight of the sheaf as a whole and the seeds were determined separately, the number of pods from each plant was calculated and 25 pods from each sheaf were selected (in total 100), and the number of seeds in the fruit was also calculated. The mass of 1000 seeds was determined after drying and adjusting to standard humidity.

The actual harvest was taken into account on September 22 by the TERRION 2010 breeding combine harvester. Yield resulted in 8% humidity (GOST 10583-76) and 100% purity [19, 20, 13].

3. Results
In 2020, the production experience was laid on an area of 3 hectares, each hybrid was sown with an area of 0.3 hectares. In the first version of the experience, a scheme was proposed for the protection of spring rapeseed hybrids not belonging to the cryfield (CL) group and showing high rates of biological efficiency in previous experiments in 2018-2019, Drago and Lagonda. The assessment of spring rapeseed hybrids in the first version on the main elements of the crop structure (table 1) showed a good survival rate of plants for harvesting was almost the same in two hybrids, with a sowing rate of 70 pieces per square meter for harvesting 56 plants remained in Drago and Lagonda, respectively, under the control of 50 pieces and 48 pieces, which amounted to 71-68% of the sown seeds.

Table 1. Crop structure and biological yield of spring rapeseed hybrids in the first variant of protection.

| Hybrid  | Plants, for harvesting pcs m$^2$ | Fruits on the plant, pcs. | Seeds in a pod, pcs. | Mass of 1000 seeds, g | Biological yield, seeds, t/ha |
|---------|----------------------------------|---------------------------|---------------------|-----------------------|-----------------------------|
| Drago   | 56                               | 126                       | 22                  | 4.2                   | 6.5                         |
| Lagonda | 56                               | 124                       | 24                  | 4.0                   | 6.6                         |
Drago (control)  50  101  22  3.3  3.6  
Lagonda (control)  48  102  21  3.2  3.3

According to the number of fruits, the Drago hybrid stood out on one plant. The seeds in the pod were larger in the Lagonda hybrid. The mass of 1000 seeds was higher in the Drago hybrid - 4.2.

An assessment of the biological yield from the main alimony of the crop structure shows that it varies by hybrids and varies from 3.3 t/ha in the Lagonda hybrid under control to 7.03 t/ha in the Drago hybrid with complete protection.

The same assessment on Clearfild® spring rapeseed hybrids in the second test, where the hybrids shown in table 2 were planted, shows a high biological yield which varies from 5.6 t/ha in Cyclus hybrid (lowest) to 7.8 t/ha in Chip hybrid.

**Table 2.** Crop Structure and Biological Yield of Clearfild® Spring Rapeseed.

| Hybrid      | Plants, for harvesting pcs m² | Fruits on the plant, pcs. | Seeds in a pod, pcs. | Mass of 1000 seeds, g | Biological yield, seeds, t/ha |
|-------------|-------------------------------|---------------------------|----------------------|-----------------------|-------------------------------|
| Solar CL    | 56                            | 136                       | 22                   | 4.2                   | 7.0                           |
| Curie CL    | 56                            | 124                       | 24                   | 4.0                   | 6.1                           |
| Cebra CL    | 52                            | 141                       | 22                   | 4.3                   | 6.9                           |
| Contra CL   | 58                            | 122                       | 21                   | 4.2                   | 6.2                           |
| Cyclus CL   | 52                            | 121                       | 22                   | 4.3                   | 5.6                           |
| Chip CL     | 56                            | 135                       | 23                   | 4.5                   | 7.8                           |

The survival rate of plants for harvesting was good and amounted to 80-83% of the sown seeds. The seed oil grain of spring rapeseed hybrids in versions with full protection was well made with almost the same weight of 1000 seeds.

An assessment of spring rapeseed hybrids from the actual harvest yield (table 3) by our combine harvester method showed that the ripening at the end of vegetation took place simultaneously.

**Table 3.** Rapeseed yield in 2020, t/ha in option 1.

| Hybrid | Humidity, % | Actual yield, t/ha | Under control without protection, /ha |
|--------|-------------|--------------------|---------------------------------------|
| Drago  | 8.7         | 6.2                | 3.0                                   |
| Lagonda| 9.4         | 5.4                | 2.8                                   |

The actual yield of oil seeds of spring rapeseed hybrids is reduced to 8% humidity and 100% physical purity of seeds. The highest seed yield in 2020 with complete protection was formed by the Drago hybrid, a yield of 6.2 tons/ha. In the control version, without the use of protective means, the yield was 2 times lower than that of Drago 3.0 t/g Lagonda 2.8 t/ha (figure 1).
Figure 1. Yield hybrids spring rapeseed t/ha.

Evaluation of spring rapeseed hybrids from the Clearfild® system group (table 4, figure 2) shows that the actual yield of oil seeds in the second variant is not much higher than in the first option.

Table 4. Yield of oil seeds of spring rapeseed hybrids of Clearfild® system in 2020 t/ha in option 2.

| Hybrid     | Humidity, % | Actual yield, t/ha | Under control without protection, t/ha |
|------------|-------------|--------------------|---------------------------------------|
| Solar CL   | 9.0         | 6.3                | 3.9                                   |
| Curie CL   | 7.7         | 5.8                | 3.6                                   |
| Cebra CL   | 8.4         | 6.4                | 3.6                                   |
| Contra CL  | 9.5         | 5.0                | 3.4                                   |
| Cyclus CL  | 8.7         | 5.2                | 3.1                                   |
| Chip CL    | 9.4         | 7.2                | 4.1                                   |

Figure 2. Yield of spring rapeseed hybrids of Clearfild® system t/ha.
Thus, on the basis of the above, it can be concluded that new hybrids of spring rapeseed in the conditions of the Krasnoyarsk forest-steppe form a high yield, which is economically justified by the complex protection of the drugs of JSC «August».

4. Conclusion
In modern agriculture, the role of varieties and hybrids is increasing, especially with such indicators as resistance to diseases, high level of adaptability, stability of production of commercial oil seeds [7].

When applying integrated agricultural technology for cultivating spring rapeseed in the Krasnoyarsk forest-steppe conditions, new breeding hybrids of RAPOOL showed good indicators of crop structure elements and high harvesting and actual yield.

Analysis of the results showed that the survival rate of plants for harvesting plants was good and was 75-83% of the sown seeds in all hybrids of spring rapeseed, it was best in the Contra CL hybrid. The lowest survival was in Cebra CL and Cyclus CL hybrids and was 75%. According to the number of fruits, the hybrids Cebra CL and Solar CL stood out on one plant. The seeds in the pod were larger in the hybrid of Curie CL and Lagonda. The seed oil grain of spring rapeseed hybrids in full protection versions was well made with almost the same weight of 1000 seeds and ranged from 4.0 to 4.5 g. High harvesting yield was formed by Contra CL and Chip CL hybrids, 9.5 and 9.4 t/ha, respectively. The highest actual seed yield with full protection in 2020 was shown by the Drago hybrid (6.2 t/ha) and Chip CL hybrid (7.2 t/ha). Evaluation of spring rapeseed hybrids from the Clearfild ® system group showed that their actual yield of oilseeds did not exceed the same in the first test using non-cryafield seeds.

Acknowledgments
The authors express gratitude to LLC Jerman Sid Alliance Russ RAPOOL and JSC «August» for the research materials provided.

The results were obtained with the financial support of the Ministry of Science and Higher Education of the Russian Federation (subsidy for the implementation of a comprehensive project to create high-tech production) as part of the research and development work on the topic "Creating an integrated high-tech production of vegetable oilseeds and its products in Siberia".

References
[1] Rapeseed: areas collections and yields in 2001-2019 Retrieved from: https://agrovesti.net/lib/industries/oilseeds/raps-ploshchadi-sbory-i-urozhajnost-v-2001-2019-gg.html
[2] Field Progress Retrieved from: http://krasagro.ru/pages/info/stat/pole
[3] Weekly Oilseeds Market Review November, 23 2020 Retrieved from:https://www.zol.ru/n/325bb
[4] Oleynikova E N, Yanova M A, Pyzhikova N I, Ryabtsev A A and Bopp V L 2019 Spring rapeseed – promising culture for the development of the agro-industrial complex of the Krasnoyarsk Territory Bulletin KrasSAU 1(142) 74-80
[5] Shorokhov L 2019 Forecast indicators indicate that the agro-industrial complex of the region in 2019 worked with dignity Retrieved from: http://krasagro.ru/news/1278
[6] Oleynikova E N, Yanova M A, Sharopatova A V and Grishina I I 2020 Comparative evaluation of the economic efficiency of the rapeseed cultivation by the traditional method and using the principles of organic production IOP Conf. Ser.: Earth Environ Sci 421 32005
[7] Halipsky A N, Oleynikova E N, Pyzhikova N I and Grishina I I 2019 The cultivation efficiency of new hybrids of spring rape in the conditions of the Krasnoyarsk Region IOP Conference Series: Earth and Environmental Science, Sci. 315 22076
[8] Khalipsky A N, Oleynikova E N, Pyzhikova N I and Grishina I I 2020 Productivity and economic efficiency of protection products on spring rape hybrids in the conditions of the Krasnoyarsk forest-steppe IOP Conf. Series: Earth Enviro Sci 548 22068
[9] Bopp V L, Pyzhikova N I, Kurachenko N L and Valova T I 2019 Substantiation of methods and timing of oilseeds harvesting (rapeseed, ginger, mustard) in the conditions of the Kansk forest-
steppe Bulletin KrasSAU 6(147) 52-8

[10] Khalipsky A N 2020 Effectiveness of the application of protective means on spring rapeseed in the conditions of the Krasnoyarsk forest-steppe Science and Education: experience problems development prospects 297-301

[11] Krček V and Baranyk P 2013 Comparison of the economic efficiency, growing hybrid and op winter oilseed rape varieties Konference MendelNet 89-93

[12] State Register of Selection Achievements Admitted to Use Retrieved from: https://gossort.com/docs/REESTR_2018.pdf

[13] Lukomets V M 2010 Methods of conducting field agricultural experiments with oilseeds (Krasnodar) 327

[14] Spaar D 2004 Plant Protection in Sustainable Land Use Systems 3 (Minsk) 337

[15] Strizhkov N I et al. 2017 Integrated technology for protection of field crops against diseases, pests and weeds based on biological and chemical methods Practical recommendations (Saratov) 56

[16] Errors in the cultivation of spring rapeseed Retrieved from: https://www.rapool.ru/index.cfm/article/4653.html

[17] Khokhryakov M K, Potlaichuk V I, A. Semenov Y and Elbakyan M A 1984 Determinant of crop diseases (Leningrad: Kolos) 304

[18] Beglyarov G A et al. 1983 Chemical and biological protection of plants (Moskow: Kolos) 351

[19] GOST 10583-76 Rapeseed seeds are industrial raw materials with amendments dated November 22 1990 No. 2897 https://docs.cntd.ru/document/1200024525

[20] Dospekhov B A 1985 Field experience methodology (with the basis of statistical processing of research results) (Moscow: Agropromizdat) 351