Technical efficiency of spring rapeseed protection scheme

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Abstract. The species composition of weeds and pests in the crops of spring rape of the variety Nadezhny 92 was determined, the technical effectiveness of the protection scheme of the Syngenta company was evaluated. The results of the study showed that the prevailing species were cereal weeds of 17.9 units / m². Dicotyledonous weeds amounted to 13.6 units / m². A decrease in the moisture supply of the vegetation period entailed an increase in weediness. The highest weediness was recorded in 2019, when the number of weeds was higher than in 2017 and in 2018 on 23.5 - 18.0 pcs / m². Of the pests, cruciferous fleas, rapeseed beetle, rape sawfly, and caterpillars of cabbage were found in the crop. Spring rape protection scheme: presowing treatment with Cruiser Rapeseed, KS, Zellek Super, KE Galea Super, BP, Karate Zeon, MKS showed high technical efficiency. Technical efficiency against cereal weeds was 84.4%, against dicotyledons - 90.4%. On average, the protection effect on spring rape crops was 86.3%. The use of an insecticide allowed reducing the number of pests in crops below the economic threshold of harmfulness or completely destroying them.

1. Introduction
In terms of food and feed advantages, rapeseed surpasses many agricultural crops. Its seeds contain 40-48% fat and 21-33% protein. According to the concentration of exchange energy, it exceeds cereals (oats, barley) by 1.7-2.0 times, legumes (peas, soy) - by 1.3-1.7 times. In terms of fat content, the sum of fat and protein in seeds, rapeseed is significantly superior to soy, but slightly inferior to sunflower [1, 2]. In the Krasnoyarsk Territory, areas under spring rape are growing annually; this is facilitated by the stable demand for rape seeds and their high price in comparison with grain crops. So, in 2018, the area under this crop in the region amounted to 111.2 thousand ha, and in 2019 - 147.7 thousand ha [3].

Rapeseed from seedlings to harvest is affected by a large number of pests; a wide range of weeds are found in rapeseed crops. Losses of the spring rape seed crop from pests and weeds can be on average 30-40%, and in the years of mass distribution of pests they can reach 70–80% [4, 5]. The use of herbicides contributes to an increase in rape yield by 13.2-20% [6].

In the Krasnoyarsk Territory, weeds and pests cause the most damage to spring rape. Weeds significantly reduce rape productivity, competing with plants for light, water and nutrients. In the initial period of development, rapeseed grows rather slowly and is strongly inhibited by weeds; therefore, it requires mechanical and chemical cleaning of weeds. More than 60 species of weeds grow in rapeseed,
more than 20 species are found almost everywhere: Panicum capillare (L.), Panicum milleaeceum, Avena fatua, Chenopodium album, Polygonums, Capsella bursa-pastoris, types of sonchus arvensis, types of chamomile, Eletrigia repens, Galeopsis tetrahit, Stellaria media, Raphanus raphanistrum, Cannabis ruderalis, Artemisia, Amaranthus retroflexus, etc. Hard-to-separate weed plants — Sinapis arvensis, Barbarea vulgaris, Raphanus raphanistrum, and Gallium aparine [7, 8, 9].

In spring rape crops, the most common pests are: cruciferous fleas, rapeseed flower eater, rapeseed Sawfly, cabbage moth, cabbage and turnip whiteflies, in some years, the mass distribution of meadow moth is possible [10].

In modern conditions, there is a need to take seriously pesticides and their use, the main emphasis is on minimizing their use. It is necessary to conduct a more thorough survey of crops, establish the species composition and number of harmful organisms. If according to the results of the counting of the number of weeds, pests and the forecast of the possible level of damage from pests, the loss of quantity and quality of the seed crop will be insignificant, then the dosage of the drug used can be reduced or its use can be noted thereby increasing the profitability of spring rape seed production [11]. Therefore, the development and study of protection schemes for spring rape against weeds and pests is an important task in the cultivation of this crop in the Krasnoyarsk Territory.

The purpose of the research is to optimize the technology of spring rapeseed cultivation in the forest-steppe of the Krasnoyarsk territory through the use of chemicals.

Research objectives:
1. Determine the species composition, the number of weeds and pests in the sowing of spring rapeseed varieties Nadezhny 92;
2. Evaluate the technical effectiveness of drugs included in the Syngenta protection scheme.

2. Materials and methods
The research was conducted in 2017-2019 at the Minino permanent establishment of the Krasnoyarsk Research Institute of Agriculture (KRIA), located in the Krasnoyarsk forest-steppe. The soil of the experimental plot is represented by leached black-soil, low-power, low-humus, moderately degraded, heavy loam granulometric composition. The repeatability of the experience is 3 times. The area of plots is 40 m². Tillage typical for the zone: in autumn-plowing with a 20-22 cm layer turnover; in spring-early spring harrowing with cultivation as the soil is ready, inset fertilizers, pre-sowing cultivation, seedling, rolling.

We studied the scheme of protection of spring rape in comparison with the control one:
1. Control (without the use of chemical plant protection products);
2. Protection scheme: prescribed etching: Kuizier Rapeseed, CS (A.S. tiametoxam, 280 g/l, mfenoxam, 32.3 g/l, fludioxonyl, 8 g/l) – 15.0 l/t, herbicides: Zellek Super, KE (A. S. haloxifol-rovaya acid, 104 g/l) – 0.5 l/ha, Galera Super, BP (A. S. clopiralid, 267 g/l, picloram, 80 g/l, aminopyralide, 17 g/l) – 0.3 l/ha, insecticide: Karat Zeon, MKS (A. S. lambda-cygalotrin, 50 g/l/) – 0.15 l/ha [12].

The spring rape variety Nadezhny 92 was used as an object of study. Lemon-yellow pod, without anthocyanin, not pubescent, slightly tuberous cusps. Seeds are oval-round, black. The weight of 1000 seeds is 3.3 - 4.1 g. The vegetation period before seed ripening is 93 - 114 days [13].

The experiments and observations were carried out according to the method of state variety testing [14]. We took into account the contamination of crops on an area of 0.25 m². The total number of weeds was calculated and their species composition was determined. Pest control was carried out using a size frame (25 x 25 cm), which is imposed on the soil. Plants and soil are carefully examined and their number is calculated. Statistical processing of the results was performed using the methods of B. A. Dospekhov using SNEDECOR statistical software package [15].

The climate of the production unit is sharply continental. According to the Minino weather station, the average long-term air temperature is -0.7°C. The warmest month is July, and the coldest is January. The period with an average daily temperature above 0 °C begins in mid-April and lasts for 182-192 days.
The weather conditions of the growing season of 2017 (Table 1) were characterized by a lack of moisture in June and July (19 and 33 mm below normal, respectively). August was very moist. In July and August, the air temperature was slightly lower than the mean annual values. June was the warmest month, the temperature of this month was 3.6 °C higher than the mean annual value.

The growing season of 2018 was characterized by a lack of moisture. July and August were particularly dry, with precipitation 35.0 and 37.0 mm below normal, respectively. The average monthly temperature in June and August was higher than the average annual values, July on the contrary was cooler.

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Table 1. Characteristics of the meteorological conditions of the vegetative period of years of research (meteorological station Minino, Emelyanovsky district).

| Month  | Air temperature, °C | Average long-term value | Precipitation quantity, mm | Average long-term value |
|--------|----------------------|-------------------------|-----------------------------|-------------------------|
|        | 2017                 | 2018                    | 2019                        | 2017                    | 2018                    | 2019               |
| May    | 10.4                 | 7.9                     | 10.1                        | 10.4                    | 61.2                    | 38.0               | 20.0               | 44.0               |
| June   | 19.5                 | 19.8                    | 18.1                        | 15.9                    | 44.0                    | 55.0               | 44.3               | 63.0               |
| July   | 18.8                 | 17.7                    | 18.8                        | 18.7                    | 43.0                    | 41.0               | 80.0               | 76.0               |
| August | 16.5                 | 18.0                    | 18.2                        | 15.7                    | 190.0                   | 30.0               | 58.0               | 67.0               |
| September | 8.2                 | 10.5                    | 10.3                        | 9.7                     | 45.0                    | 60.1               | 50.3               | 51.8               |
| Amount | 2246.0               | 2261.3                  | 2310.3                      | 2154.2                  | 383.2                   | 224.1              | 252.6              | 301.8              |

3. Results and discussion
To assess the technical effectiveness of herbicides, 5 points were recorded on each variant with the maximum number of weeds. Weeds were counted twice – the first before treatment with herbicides, the second 21 days after treatment. The infestation of spring rape on fixed sites in 2017 was 22.0 pcs / m2 (Table 2).

Table 2. Technical efficiency of the tank mixture of herbicides, 2017.

| Type of weed              | Quantity of weeds, pcs / m2 | Protection effect, % |
|--------------------------|----------------------------|----------------------|
|                          | Before treatment | After treatment |                     |
| Avena fatua              | 5.7                        | 1.0                | 82.5               |
| Echinochloa crusgalli P.B.| 2.0                        | 0.3                | 85.0               |
| Panicum capillare        | 3.9                        | 0.5                | 87.2               |
| Setaria viridis L. Beauv | 1.3                        | 0.0                | 100.0              |
| Chenopodium album        | 2.4                        | 0.0                | 100.0              |
| Amaranthus retroflexus   | 4.8                        | 0.5                | 89.0               |
| Cannabis ruderalis Janisch.| 1.2                         | 0.7                | 41.7               |
| Sonchus arvensis         | 0.3                        | 0.1                | 66.0               |
| Cirsium arvense          | 0.4                        | 0.0                | 100.0              |
| Total                    | 22.0                       | 3.1                | 85.9               |
| SSD_{0.5}                | 1.43                       | 0.72               |                     |

Type of blockage - cereal-dicotyledonous. The predominant species of weeds were oatmeal (Avena fatua), Amaranthus retroflexus and millet (Panicum miliaceum ruderale). Herbicides included in the
Syngenta tank mix successfully combated all weeds represented in the crop. The overall effect of the use of herbicides in the tank mixture reached the level of 85.9%, which is a very good result (table 2).

Cruciferous fleas, rapeseed flower eaters, and aphids were observed in spring rape crops in 2017 during the growing season. Cruciferous fleas in the control variant and crops with etched seeds appeared on cotyledon leaves in a small amount of 2-3 per 0.25 m². In the 3-4 leaf phase, the number of fleas in the control increased to 1-2 per plant; in the treated version, their number remained practically unchanged. Damage to leaf blades in the variant with protection schemes averaged 8 - 10%. Damage in the control 30%, in some plants - up to 70%, which led to their death.

Fleas were activated by the end of June on all variants of the experiment, and in the phase of the beginning of budding, insecticide treatment was applied in a tank mixture with herbicides. Treatment provided the elimination of fleas that harmed on rapeseed. Rapeseed flower beetle appeared late, during the period of full flowering of plants, when all buds were opened, in the amount of 3-4 beetles per plant, it did not bring harm to plants.

In 2018 weed control was carried out before treatment with a tank mixture of herbicides (June 27) and 21 days after treatment the crops (July 18). The type of blockage is cereal-dicotyledonous. According to the classification of CRIASA (Central Research Institute of Agrochemical Services for Agriculture) the level of clogging is average. The predominant species of weeds were: Avena fatua, Amaranthus retroflexus and Panicum miliaceum ruderalie. The contamination of spring rape crops on fixed sites was 27.0 PCs/m². The use of a tank mixture of the studied herbicides allowed to reduce the contamination of rapeseed crops. The technical efficiency of the tank mixture of herbicides was 89.3% (table 3).

| Type of weed          | Quantity of weeds , pcs / m² | Protection effect, % |
|----------------------|------------------------------|----------------------|
|                      | Before treatment  | After treatment |                      |
| Avena fatua          | 7.1              | 1.1              | 84.5                 |
| Panicum capillare    | 4.9              | 0.5              | 89.8                 |
| Eródium cicutárium   | 0.5              | 0.1              | 80.0                 |
| Cannabis ruderalis Janisch. | 1.9          | 0.2              | 89.5                 |
| Amaranthus retroflexus| 6.0             | 0.3              | 95.0                 |
| Setaria viridis L. Beauv | 0.7          | 0.2              | 71.4                 |
| Portulaca oleracea   | 1.0              | 0.1              | 90.0                 |
| Chenopodium album    | 2.5              | 0.1              | 96.0                 |
| Sonchus arvensis     | 1.1              | 0.1              | 90.9                 |
| Cirsium arvense      | 1.3              | 0.2              | 84.6                 |
| Total                | 27.0             | 2.9              | 89.3                 |
| SSD₀.₅               | 1.91             | 0.70             |                      |

During the growing season of 2018, we observed cruciferous fleas, rapeseed flower eaters, and cabbage whitefish caterpillars in rapeseed crops. The number of cruciferous fleas on the treated variant was insignificant, this is primarily due to the protective effect of preparations that were used for pre-sowing seed treatment. Damage to leaf plates in the variant with protection schemes was an average of 10%. Damage in the control variant was 30 - 35%, in some plants was up to 70% and above, which led to their death. The insecticide treatment in the tank mixture with the herbicide in the phase of the onset of budding contributed to the almost complete destruction of cruciferous fleas on rapeseed. The greatest damage was caused by the rapeseed flower-eater (Meligethes aeneus). Rapeseed flower-eater appeared early in the sowing, in the phase of budding. The number of beetles per plant was 12-14, which was significantly higher than the economic threshold of harmfulness (ETH) during budding (6-10 beetles/plant). After chemical treatment of crops, the number of rapeseed flower-eaters decreased...
significantly (up to 1-2 PCs./plant), but three weeks later, the second wave of pest development was noted. The number of beetles per plant in a month after treatment with insecticide was 7-9 pieces.

In crops, we observed larvae of rapeseed sawfly (Athalia rosae). In crops, the number of rapeseed Sawfly larvae was 6-8 larvae per m², which was more than ETH (5 larvae per m²). After the use of insecticide, the number of sawfly decreased sharply.

In 2019, weeds were accounted for on July 2 before treatment with a tank mixture of herbicides and 21 days after treatment of crops on July 23. The type of blockage is cereal-dicotyledonous. In accordance with the classification of CRIASA, the level of clogging is high. The contamination of spring rape crops on fixed sites was 45.5 PCs/m². The predominant species of weeds were: Panicum miliaceum ruderale, Amaranthus retroflexus and Avena fatua. In seeding, there were fewer Cirsium arvense, Sonchus arvensis, Cannabis ruderalis Janisch, and Chenopodium album. Especially there was a lot of Panicum capillare, its quantity made up to 70% of all weeds in the sowing of spring rape. The use of a tank mixture of herbicides has reduced the contamination of spring rape crops. The technical efficiency of the tank mixture under study was 84.6% (table 4).

| Type of weed                | Quantity of weeds , pcs / m² | Protection effect, % |
|----------------------------|-------------------------------|-----------------------|
|                            | Before treatment | After treatment |                                |
| Panicum capillare          | 16.0             | 3.6             | 77.5                             |
| Avena fatua                | 8.0              | 1.4             | 82.5                             |
| Amaranthus retroflexus     | 9.5              | 0.9             | 90.5                             |
| Cirsium arvense            | 3.2              | 0.4             | 87.5                             |
| Sonchus arvensis           | 1.8              | 0.2             | 88.9                             |
| Setaria viridis L. Beauv   | 4.0              | 0.4             | 90.0                             |
| Chenopodium album          | 3.0              | 0.1             | 96.7                             |
| Total                      | 45.5             | 7.0             | 84.6                             |
| SSD₀.₅                     | 2.35             | 1.01            |                                   |

During the growing season of 2019, cruciferous fleas, rapeseed flower eaters, cabbage aphids, and cabbage whitefly caterpillars were observed in spring rape crops. Weather conditions of the end of May – June (hot and dry weather) contributed to the active development of cruciferous fleas in spring rape crops. The number of cruciferous fleas in the control variant averaged 10-12 beetles per 1 m², which significantly exceeded the ETH, the damage of leaf blades was 40-50%, on some plants - 70% and more, which led to their death. Pre-sowing seed treatment has reduced the adverse effects of fleas.

In the crops, we noted the rapeseed flower-eater. At the beginning of budding, the number of beetles per plant was 8-10 PCs./plant. After the treatment of crops with the insecticide Karate Zeon, the number of rapeseed flower-eater significantly decreased to an average of 1-2 PCs./plant.

Cabbage aphids were observed in rapeseed crops at the beginning of the budding phase, appeared in seats, 3-5% of plants with small colonies of aphids, this is less than ETH. After treatment with insecticides, this pest was completely destroyed. Caterpillars of cabbage whitebait were found in sowing seats, the number of pests was 2-3 caterpillars per plant. After treatment with insecticides, this pest was completely destroyed.

According to three-year studies, the presented tank mixture of Syngenta herbicides had a high degree of effectiveness against both cereals and dicotyledonous weeds in spring rape crops. On average, over three years, the effectiveness against grass weeds was 84.4%, against dicotyledons 90.4%, which is a very good result (table 5).
Table 5 Technical Efficiency of Syngenta Herbicide Tank Mix, 2017-2019.

| Index            | Quantity of weeds, pcs / m² | Protection effect, % |
|------------------|-----------------------------|----------------------|
|                  | Before treatment | After treatment |                  |
| **2017**         |                 |                   |
| Cereal weeds     | 12.9            | 1.8              | 86.0             |
| Dicotyledonous   | 9.1             | 1.3              | 85.7             |
| Total weed       | **22.0**        | **3.1**          | **85.9**         |
| **2018**         |                 |                   |
| Cereal weeds     | 12.7            | 1.8              | 85.8             |
| Dicotyledonous   | 14.3            | 1.1              | 92.3             |
| Total weed       | **27.0**        | **2.9**          | **89.3**         |
| **2019**         |                 |                   |
| Cereal weeds     | 28.0            | 5.4              | 80.7             |
| Dicotyledonous   | 17.5            | 1.6              | 90.9             |
| Total weed       | **45.5**        | **7.0**          | **84.6**         |
| **The average (2017-2019)** | | | |
| Cereal weeds     | 17.9            | 2.8              | 84.4             |
| Dicotyledonous   | 13.6            | 1.3              | 90.4             |
| Total weed       | **31.5**        | **4.5**          | **86.3**         |
| SSD 0.5 A (year)| 0.40            |                   |                   |
| SSD 0.5 A (weed)| 0.33            |                   |                   |

4. Conclusions

1. The species composition, the number of weeds and pests depended on the weather conditions of the years of research. Sufficient moisture conditions in May and June 2017, 2018 contributed to the predominance of oatmeal in crops. In the dry conditions of the first half of the vegetation period in 2019, the predominant weed in rapeseed crops was Panicum capillare. The deterioration of moisture availability in May and June in the form of precipitation contributed to an increase in the total number of weeds in 2019 to 45.5 PC/m² at 22 PC/m² and 27 PC/m² in 2017 and 2018. In spring rape crops, cereal weeds predominated – 17.9 PC/m², while the same figure for dicotyledonous weeds was 13.6 PC/m².

2. Of the pests, cruciferous fleas (Phyllotreta nemorum), rapeseed beetle (Meligethes aeneus), rapeseed sawfly (Athalia rosae), and cabbage larvae (Pieris brassicae) were prevalent in the crops. In 2017 and 2019, the number of cruciferous fleas was 8-12 PCs/1 m² above the economic threshold of harmfulness; in 2018, the number of rapeseed flower eaters exceeded the economic threshold of harmfulness and was by 12-14 PCs/plant.

3. The use of herbicides and an insecticide in accordance with the regulations for use can reduce the adverse effects of pests on spring rape plants. The presented scheme of protection of spring rape has shown high technical efficiency, both against weeds and pests. The use of the insecticide Karate Zeon, MKS allowed to reduce the number of pests in the spring rape crop below the economic threshold of harmfulness or destroy them completely.

4. Technical efficiency against weeds in 2017 was 85.9%, in 2018 - 89.3%, in 2019 - 83.7%. On average, the protection effect on spring rape crops in the conditions of the Krasnoyarsk forest-steppe was 86.3%, it was more than 90.4% when controlling dicotyledonous weeds. In the fight against cereal weeds, the protective effect was 84.4%.

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