PROJECT "TARGETED IMPLEMENTATION OF INTEGRATED PEST CONTROL UNDER CONDITIONS OF INTENSIVE FARMING", NO. 35BV-KK-17-1-03770-PR001

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CONTROL OF FUNGAL DISEASES IN WINTER WHEAT AND RAPESEED

Recommendations

The applicant is **the Lithuanian Research Centre for Agriculture and Forestry.**

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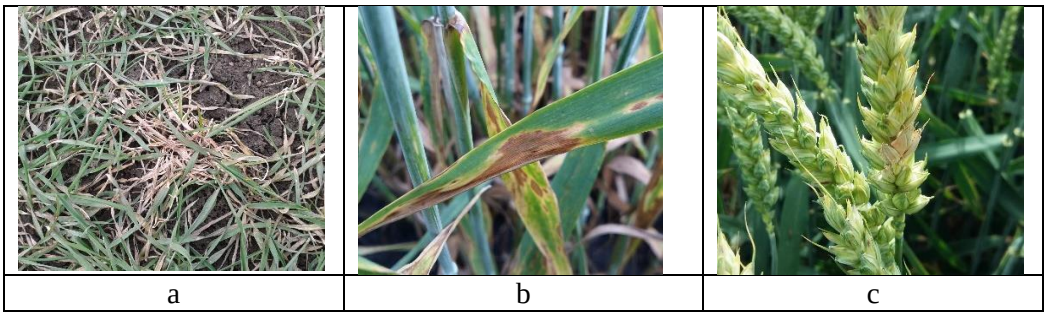
1. CONTROL OF FUNGAL DISEASES IN WINTER WHEAT

The most harmful diseases of winter wheat are pink snow mold *(Microdochium nivale),* strawbreaker *(Oculimacula spp.),* powdery mildew *(Blumeria graminis),* septoria leaf blotch *(Zymoseptoria tritici),* tan spot *(Pyrenophora tritici-repentis)* and fusarium ear blight *(Fusarium spp.).*

The spread of ***pink snow mold*** *(Microdochium nivale)* is promoted by snow cover on unfrozen ground, wet and cold spring with long-lasting snow. When the snow melts, you can see the areas of faded, rotten winter crops. The plants are clumped, covered with white, grey or pink spider web-type mycelium *(Figure 1 a).* In late spring, perithecia form on the lower ocrea of a plant, which in summer, in humid and cooler weather, scatter mature ascospores and infect leaves *(Figure 1 b)* and ears *(Figure 6 c).* Seed treating with effective treatments helps to reduce the disease spread. However, pink snow mold also spreads through soil, therefore, wheat monoculture in soil infested with couchgrass should be avoided. It is worth following the optimal sowing time, as the disease is more damaging to early-sown crops.



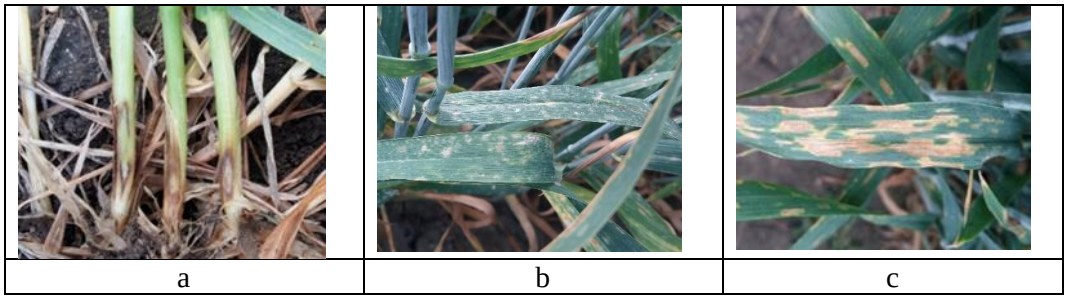
a	b	c

Figure 1. *Signs of pink snow mold in the crop in early spring (a), on leaves (b) and on ears (c).*

Long, warm autumns with frequent rains and mild winters are very conducive to the spread of ***strawbreaker*** *(Oculimacula spp.).* Very often signs of the disease are detected as early as autumn. To high extent, strawbreaker infection accumulates in couch-grass infested soils and when a large number of grasses are grown in crop rotation. The primary source of infection is conidia formed in cold and humid air on the residues of infected plants. The disease spreads with raindrops. In spring, characteristic oval-brown spots with a darker rings form on the damaged lower internodes *(Figure 2 a).* The critical stage of strawbreaker infection is the plant booting stage when the fungus penetrates to the stem through the covering ocrea. Early sowing, monoculture, direct sowing into stubble are the most significant risk factors for strawbreaker. Optimal seed rate and balanced fertilization help prevent over-dense crop, which increases the risk of strawbreaker spreading. Fungicides are the most appropriate to use when the infection has not yet spread to the stem, the number of damaged plants in the crop at the beginning of booting is 20–30%. and favourable conditions are in place for the disease spread. Powdery mildew often spreads during this period, making it more cost-effective to use fungicides containing active ingredients that are effective against both diseases.

Powdery mildew is especially dangerous when it spreads in the early stages of plant development. Severely damaged young shoots can wither, leading to poorer plant branching. A white fungal growth forms at the site of lesion, which darkens and turns brown as it ages *(Figure 2 b).* Periodically changing weather from warm and dry to rainy one is the most favourable for the spread of powdery mildew. Plants are infected by airborne conidia. To protect against powdery mildew, more resistant varieties of winter wheat should be chosen and sown at the optimal time, avoiding monoculture and the neighbourhood of spring and winter wheat, destroying germinated volunteer plants, balanced fertilization, especially avoiding rich fertilization with nitrogen fertilizers. Under favourable weather conditions, fungicides should be used at the first signs of the disease. ***Septoria leaf blotch*** *(Figure 2 c)* is spread during summer with humid weather and frequent rains. The first 8 signs of the disease may appear during the leaf development stages in autumn or early spring. Small,

indistinct watery blotches initially appear on damaged leaves. Later, they turn into large brown ones, usually located on leaf interveins, and black dots – picnidia form in their centre. In rainy weather, the infection is transmitted from the lower infected leaves to healthy upper ones. In order to reduce the spread of septoria leaf blotch by preventive measures, more resistant varieties of wheat should be grown, crop rotation should be followed, straw residues should be destroyed on the soil surface, and deep ploughing should be applied. Monoculture, reduced tillage and direct sowing into stubble are the most important risk factors for disease intensity in crops. Spray time is highly dependent on weather conditions during the disease spread. Depending on the intensity of the spread of septoria leaf blotch, fungicides are applied once or twice during the growing season. For the first time, fungicides are applied during the second-node stage, and for the second time they are sprayed after the last (apical) leaf has unfolded. If septoria leaf blotch does not spread by the time of heading, one spray of a broad-spectrum fungicide during the heading stage is sufficient.

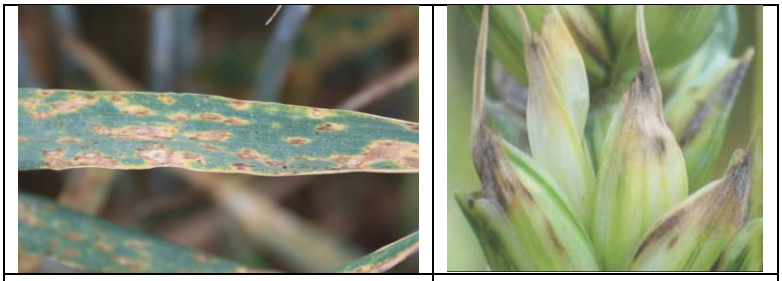


a b c

Figure 2. *Symptoms of strawbreaker on covering ocrea (a); powdery mildew(b) and septoria leaf blotch (c) symptoms on wheat leaves.*

Monoculture or sowing wheat into stubble and the presence of warm and humid weather with abundant dew and frequent rain, ***tan spot of wheat*** spreads rapidly in crops. Under favourable environmental conditions, this disease can spread very early in wheat crops. Initially, small yellowishbrown or brown spots appear on the leaves, followed by brown diamond-shaped blotchesringed about by a yellowish margin with a dark brown spot in the centre *(Figure 3a).* The spread of the disease is reduced by the cultivation of more resistant wheat varieties, destruction of germinated volunteers, and deep ploughing of stubble and straw residues. Depending on the intensity of the disease spread, crops are sprayed against tan spot once or twice. In spring, when the first symptoms of the disease are observed and under favourable weather conditions for the disease spread, fungicides should be used. If tan spot of wheat does not spread before heading, one spray of a broad-spectrum fungicide during the heading stage is sufficient.

Fusarium ear blight *(Fusarium spp.)* is a very harmful disease due to toxins found in grain that are dangerous to health and therefore undesirable in the products produced. Ears of plants become infected with *Fusarium spp.* at flowering when rainy weather prevails. Later, from glumes the mycelium develops into the rachis and the ear pales above the site where the rachis is damaged *(Figure 3 b).* Diseased grains are smaller than healthy ones, they are wrinkled and of low germination. Accumulations of fusarium ear blight infection are more abundant in soils where reduced tillage or direct sowing into stubble has been applied compared to those soils where plant residues have been deep ploughed. The risk of spreading the disease is reduced by growing winter wheat varieties more resistant to fusarium ear blight. Since rain during cereal flowering is the main condition for the disease spread, fungicides against this disease are used at flowering, when rainy weather prevails.



a b

Figure 3. *Symptoms of tan spot of wheat (a) and fusarium ear blight (b).*

Results of precision field experiments

The spread of fungal diseases is determined by the interaction of three main factors – the pathogen, the host and environmental conditions. However, one of the most important factors influencing the intensity of disease transmission in cereal crops is the prevailing weather conditions during plant development. Precision field experiments were performed at the Institute of Agriculture, LRCAF in 2018–2020 to evaluate the influence of spray time and number of sprays on leaf disease intensity and grain yield in winter wheat. Four spraying programmes were investigated in three different varieties of winter wheat: 1) sprayed once with fungicides at the flag leaf stage (BBCH 37–39), 2) sprayed once with fungicides at the heading stage (BBCH 51–55), 3) sprayed twice with fungicides during the booting (BBCH 32–33) and heading (BBCH 51–55) stages, 4) sprayed twice with fungicides during the booting (BBCH 32-33) and flowering (BBCH 65) stages.

During the study years, due to different meteorological conditions, diseases spread unevenly *(Tables 1 and 2).* An increased spread of diseases was observed in 2020, when rainy weather prevailed in June. In both years of the study, the use of fungicides significantly reduced the spread of diseases and resulted in higher winter wheat yields *(Table 3).* The study results showed that one spray of fungicides against septoria leaf blotch and tan spot at the beginning of the heading stage was sufficient in winter wheat crops.

Table 1. *Influence of spraying time and number of sprayings on leaf disease intensity in winter wheat: average data for varieties 'Etana', 'Famulus' and 'Arkadia' (2019)*

Spray time according to BBCH scale	**Intensity of septoria leaf blotch %**	**Biological effectiveness %**	**Intensity of tan spot of wheat %**	**Biological effectiveness %**
1. Not sprayed with fungicides	5,43	-	3,25	-
2. Sprayed at BBCH 37–39	1,36	74,95	1,82	44,00
3. Sprayed at BBCH 51–55	0,96	82,32	1,37	57,85
4. Sprayed at BBCH 32–33 and 51–55	0,42	92,26	1,21	62,77
5. Sprayed at BBCH 37–39 and 65	2,07	61,88	2,07	36,31

Table 2. *Influence of spraying time and number of sprayings on leaf disease intensity in winter wheat: average data for varieties 'Etana', 'Famulus' and 'Skagen' (2020)*

Spray time according to BBCH scale	**Intensity of septoria leaf blotch %**	**Biological effectiveness %**	**Intensity of tan spot of wheat %**	**Biological effectiveness %**
1. Not sprayed with fungicides	59,46	-	4,95	-
2. Sprayed at BBCH 37–39	35,26	40,70	4,76	4,07
3. Sprayed at BBCH 51–55	4,84	91,86	4,70	5,24
4. Sprayed at BBCH 32–33 and 51–55	3,98	93,30	4,73	4,74
5. Sprayed at BBCH 37–39 and 65	4,79	91,94	3,32	33,13

Table 3. *Influence of spraying time and number of sprayings on winter wheat yield: average data for varieties 'Etana', 'Famulus', 'Skagen' and 'Arkadia' (2019–2020)*

Spray time according to BBCH scale	Average yield t/ha		Yield increase t/ha	
	2019	2020	2019	2020
1. Not sprayed with fungicides	6,92	7,13	-	-
2. Sprayed at BBCH 37–39	7,35	7,62	+0,43	+0,49
3. Sprayed at BBCH 51–55	7,32	7,93	+0,40	+0,80
4. Sprayed at BBCH 32–33 and 51–55	7,39	7,79	+0,48	+0,66
5. Sprayed at BBCH 37–39 and 65	7,44	7,87	+0,53	+0,74

In both years of the study, the grain met the requirements of quality class I *(Tables 4 and 5).* In 2019, grain specific weight was >78, but protein content was less than 14%. In 2020, both protein and specific weight met the requirements of the extra class in most cases. In addition, there was a trend towards a slight decrease in protein content with increasing yield and grain weight.

Table 4. *Influence of spraying time and number of sprayings on quality indicators of winter wheat grain: average data for varieties 'Etana', 'Famulus' and 'Arkadia' (2019)*

Spray time according to BBCH scale	1000-grain weigh, g	Difference from control application	Protein content, %	Difference from control application	Specific weight, g	Difference from control application	Quality class according to LST standard
1. Not sprayed with fungicides	44,15	-	13,53	-	78,50	-	I
2. Sprayed at BBCH 37–39	45,32	+1,16	13,72	+0,18	79,01	+0,51	I
3. Sprayed at BBCH 51–55	44,33	+0,17	13,43	-0,10	78,98	+0,48	I
4. Sprayed at BBCH 32–33 and 51–55	45,22	+1,07	13,58	+0,04	79,37	+0,87	I
5. Sprayed at BBCH 37–39 and 65	44,92	+0,77	13,73	+0,19	78,93	+0,43	I

Table 5. *Influence of spraying time and number of sprayings on quality indicators of winter wheat grain: average data for varieties 'Etana', 'Famulus' and 'Skagen' (2020)*

Spray time according to BBCH scale	1000-grain weigh, g	Difference from control application	Protein content, %	Difference from control application	Specific weight, g	Difference from control application	Quality class according to LST standard
1. Not sprayed with fungicides	42,36	-	14,41	-	76,70	-	I
2. Sprayed at BBCH 37–39	45,15	+2,79	14,10	-0,31	76,68	-0,02	I
3. Sprayed at BBCH 51–55	45,91	+3,55	13,84	-0,58	77,81	+1,11	I
4. Sprayed at BBCH 32–33 and 51–55	47,12	+4,76	13,98	-0,44	77,50	+0,80	I
5. Sprayed at BBCH 37–39 and 65	46,00	+3,64	13,90	-0,51	77,30	+0,60	I

To optimize the use of fungicides in winter wheat, it is <u>RECOMMENDED TO</u>:

- follow crop rotation,
- sow at the optimal time,
- apply traditional tillage (ploughing) in monoculture,
- avoid direct sowing into the stubble in monoculture,
- to grow as resistant varieties to diseases as possible,
- sow the optimal seed rate,
- balance fertilization with nitrogen, phosphorus and potassium fertilizers.

2. CONTROL OF FUNGAL DISEASES IN WINTER RAPESEED

Winter rapeseeds can suffer from many fungal diseases, but only a few can cause greater economic losses. Warm and rainy weather is more favorable for the spread of diseases than drier ones, therefore, taking into account the prevailing meteorological conditions and monitoring the dynamics of the spread of diseases, it is possible to select the optimal time for the application of fungicides or to abandon some sprays altogether.

In autumn, there is an increased risk of spreading phomosis (*Leptosphaeria maculans, L. biglobosa*). The first symptoms of the disease usually appear in plants with 4–6 true leaves *(Figure 4a).* Gray concave spots with dark edges and black dots appear on the damaged leaves of the plant. It is important to control this disease in the autumn as the infection can get to the bottom of the stem and damage the root collar. If phomosis damages the winter rapeseed stems *(Figure 4 b)*, spraying with fungicides will be ineffective. At the same time as phomosis is spreading in winter rapeseed crops, symptoms of powdery mildew can also be found on the leaves of the plants, so a single spray would stop the spread of both diseases. Early sowing plants reach a 4-6 leaf stage in mid-September or early October, so fungicide spraying is recommended to slow plant development. In this case, a single spray can control leaf diseases and slow down plant growth.

Figure 4. *Symptoms of phomosis (Leptosphaeria maculans, L. biglobosa) on winter rapeseeds leaves (a) and stems (b)*

In the spring, when winter rapeseed begins to bloom, white (sclerotic) rot (*Sclerotinia sclerotiorum)* can begin to spread in the crop. Signs of this disease appear only during the maturation stage, when white spots appear on plant stems, lateral branches, in rare cases and on pods, which are covered with white fungus in wet weather *(Figure 5).* The infection begins to spread when the sclerotia in the soil germinate and ascospores are formed in them. However, sclerotia need moisture to germinate -both in the soil and a high relative humidity- so rainy weather provides higher probability to spread the disease. Fungicide spraying is recommended at the beginning of flowering (BBCH 63), when the first petals begin to fall and when rainy weather (at least 15 mm) prevails for 1 to 3 weeks before flowering. In dry weather, it is recommended to refuse spraying or to use minimum rates for registered products.

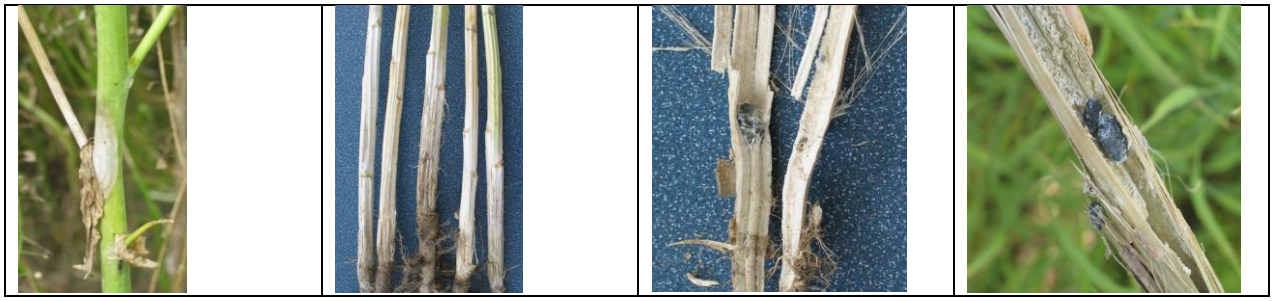


Figure 5. *Signs of white (sclerotic) rot (Sclerotinia sclerotiorum) on winter rapeseed stems*

Signs of alternaria brassicae (*Alternaria brassicae, A. brassicicola*) may appear after winter rapeseed has stopped flowering and pods have begun to form (BBCH 69-73) *(Figure 6).* The spots on the stems and pods are black, initially small, but in wet and warm weather they increase very rapidly and grow. Sick pods ripen prematurely, explode, and sick, not very germinating, small seeds grow in them. Frequent rains, wind and temperatures above +20 ° C are favorable conditions to the spread of black spot. The disease is more prevalent in dense, lush, dormant or even deciduous crops. However, in dry weather, the spread of the disease will be low and there will be no significant economic damage to rapeseed crops.

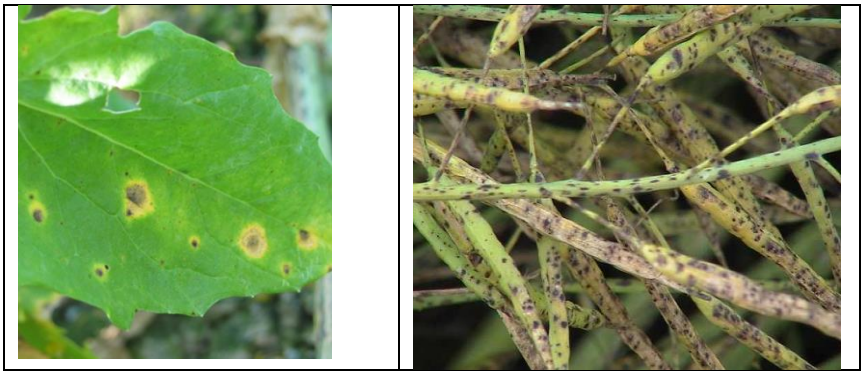


Figure 6. *Signs of black spots (Alternaria brassicae, A. brassicicola) on winter rapeseed leaves and pods*

Other diseases can be detected in winter rapeseed crops, such as circulatory spot *(Mycosphaerella brassicicola*), *Pyrenopeziza brassicae,* white rust *(Albugo spida), Pythium* spp., *Fusarium* spp., *Phoma* spp., *Alternaria* spp. and white leaf spot *(Mycosphaerella capsellae)*, but in many cases their spread is not intense and the use of fungicides from them would be economically unprofitable. In addition, the spraying of fungicides against major diseases partially reduces the spread of these diseases. Other diseases, such as verticillosis *(Verticillium longisporum)* or root tuber (*Plasmodiophora brassicae*), can also spread in the winter rapeseed crop. However, their control is carried out only through agrotechnical measures - proper crop rotation, soil liming - or by choosing more resistant varieties.

Results of precision field experiments

A study of the effectiveness of fungicides against diseases by spraying them in autumn and in spring was conducted at the Institute of Agriculture, LRCAF, Akademija, Kėdainiai D. In both years of the study, fungicides were applied to winter rapeseed at the 4–6 leaf stage in the autumn to control their growth. The spread of the disease was stopped by the same spray. No signs of phomosis were yet observed at the time of spraying, but there was a small spread and intensity of powdery mildew on the leaves. One month after spraying, phomosis was found in winter rapeseed. The use of fungicides reduced the spread and intensity of both diseases (Tables 6 and 7).

Table 6. *Winter rapeseed control in autumn: average data for DK 'Explicit' and 'Technic' varieties (2019)*

Spray time according to BBCH scale	Prevalence of diseases before spraying, %				Disease spread 30 days after spraying, %			
	spread of phomosis	intensity of phomosis	spread of powdery mildew	intensity of powdery mildew	spread of phomosis	intensity of phomosis	spread of powdery mildew	intensity of powdery mildew
1. Not sprayed with fungicides	0	0	14,0	0,14	6,5	0,06	32,0	0,33
2. 2. Spray BBCH in stages 14-16	0	0	14,0	0,14	1,8	0,05	18,0	0,18

Table 7. *Winter rapeseed disease control in autumn: average data of cultivars 'Kuga' and 'KWS Factor' (2019)*

Spray time according to BBCH scale	Prevalence of diseases before spraying, %				Disease spread 30 days after spraying, %			
	spread of phomosis	intensity of phomosis	spread of powdery mildew	intensity of powdery mildew	spread of phomosis	intensity of phomosis	spread of powdery mildew	intensity of powdery mildew
1. Not sprayed with fungicides	0	0	43,0	0,43	42,63	1,78	21,2	0,29
2. Spray BBCH in stages 14-16	0	0	43,0	0,43	19,20	0,46	17,2	0,24

From sclerotic rot, winter rapeseed was sprayed at the beginning of the flowering stage (BBCH 63). Under favorable conditions, the first signs of the disease begin to appear at the end of the flowering stage, but greatest spread is usually occurs at the beginning of the maturation stage (BBCH 81–83). In both years of the study, the use of fungicides reduced the intensity of sclerotic rot. There was also no significant difference between the different groups of fungicides or mixtures thereof. The yield supplement obtained in both years of the study was about 0.2 t / ha. (Tables 8 and 9).

The low prevalence of the disease was due to the unusually dry April in both years of the study. 2020 in April the total rainfall was 9.4 mm, and in 2019 did not rain at all. In May, when winter rapessed blooms intensively, the total rainfall was 55.4 (2019) and 50.1 (2020) mm; the multiannual average rate is 51.4 mm. However, this was not enough to make the spread of the disease much higher.

The intensity of black spot was also low in both years of the study, so the disease did not affect the yield of winter rapeseed.

Table 8. *Efficiency of different chemical groups of fungicides against diseases in winter rapeseed (2019)*

Efficiency of fungicide groups when spraying in mid-flowering (BBCH 63–65)	Intensity of sclerotic rot, %	Biological efficiency of fungicides, %	Alternative intensity on anthers, %	Biological efficiency of fungicides, %	Harvest t / ha	Harvest supplement t / ha
1. Do not spray	1,80	–	0,33	–	2,90	–
2. Sprayed with triazole (DMI) group fungicides	1,50	16,76	0,25	24,24	3,10	+0,20
3. Sprayed with strobilurin (QoI) group fungicides	1,00	44,45	0,25	24,24	3,08	+0,18
4. Sprayed with a mixture of DMI and QoI group fungicides	1,37	23,88	0,24	27,27	3,12	+0,22

Table 9. *Efficiency of different chemical groups of fungicides against diseases in winter rapeseed (2020)*

Efficiency of fungicide groups when spraying in mid-flowering (BBCH 63–65)	Intensity of sclerotic rot, %	Biological efficiency of fungicides, %	Alternative intensity on anthers, %	Biological efficiency of fungicides, %	Harvest t / ha	Harvest supplement t / ha
1. Do not spray	1,70	–	2,25	–	3,12	–
2. Sprayed with triazole (DMI) group fungicides	1,01	40,59	1,09	51,56	3,24	+0,12
3. Sprayed with strobilurin (QoI) group fungicides	1,40	17,65	1,30	42,22	3,28	+0,16
4. Sprayed with a mixture of DMI and QoI group fungicides	1,15	32,35	1,05	53,33	3,32	+0,20

To optimize the use of fungicides in winter rapeseed, it is RECOMMENDED TO:

- apply crop rotation so that winter oilseed rape grows in the same field after a break of at least three, and even better after four years;
- select suitable pre-crops so that the soil can be prepared in time and the plants do not have common harmful organisms;
- control the most harmful pests, as disease infections can enter plants through their areas of damage;
- sow as disease-resistant varieties as possible.