

The spread of ergot (*Claviceps purpurea*) on *Poaceae* plants and incidence on cereals in Lithuania

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Abstract

Research on the new host-plants of ergot pathogen *Claviceps purpurea* (Fr.) Tul of *Poaceae* (R. Br.) Bernhart family in Lithuania and the distribution of ergot in the crops of winter rye and winter triticale varieties and breeding lines was carried out at the Lithuanian plant variety testing stations and Šiauliai University's Botanical Garden.

Ten new *Poaceae* family plant species affected by ergot over the 2001–2009 period – *Bromus secalinus* L., *Deschampsia flexuosa* (L.) Trin., *Elymus pungens* (Pers.) Melderis, *Festuca pseudalmatica* K., *Helictotrichon sempervirens* (Vill.) Pilg., *Melica altissima* L., *Phalaris paradoxa* L., *Secale montana* L., *Spodiopogon sibiricus* Trin., *Stipa turkestanica* K. were identified during expeditions arranged in different regions of Lithuania.

In the plant variety testing stations winter rye was found to be more affected by ergot than winter triticale. Of the winter rye varieties tested the most susceptible to ergot were 'Joniai' and the breeding line No. 339, while the least ergot-affected were found to be hybrid varieties 'Fernando' F₁, 'Picaso' F₁, 'Apart' F₁, and the breeding line No. 346. Of all winter triticale varieties tested the most susceptible were the breeding line LP9845.1.95, 'Fidelio' and 'Vitalis' varieties, while the least ergot-affected were 'Michas', 'Alzo', 'Focus' and 'Woltario'.

The data averaged over the three trials conducted on the infection background at the Botanical Garden suggest that the local tetraploid winter rye variety 'Rūkai' exhibited the highest ergot susceptibility. The most ergot susceptible winter triticale variety was found to be 'Marko', while moderately susceptible were identified to be 'Tewo', 'Tornado', and 'Lamberto'. Winter rye varieties 'Walet', 'Motto', 'Hacada' and winter triticale variety 'Alzo' were found to be least infected by ergot.

Ergot significantly reduced the number of grain and grain weight per ear. Depending on the amount of ergot sclerotia the number of grains per ear declined by 10–80%, and grain weight by 25–93%.

Key words: ergot, *Claviceps purpurea*, *Poaceae*, winter rye and winter triticale varieties.

Introduction

Cultivated and wild plants of *Poaceae* family are very common throughout Lithuania. In total 163 *Poaceae* (R. Br.) Bernhart plant species, including spontaneous

and introduced ones, grow in Lithuania /Gudžinskas, 1997/. *Poaceae* plants are affected by fungous diseases and one of these fungi, *Claviceps purpurea* (Fr.) Tul., causes ergot. This fungus is of wide specialization and can affect up to 400 *Poaceae* plant species /Bove, 1970/. It is widespread in the moderate climate regions /Pažoutova, 2001/. In Lithuania the first list of host-plant species of ergot pathogen was made by S. Brundza in 1961. It included 15 plant species. Comprehensive research into ergot host-plants was done by M. Strukčinskis (1965), M. Strukčinskis, D. Radaitienė (1977) and A. Minkevičius, I. Pocius (1975). 20 species were included in the list of ergot-affected plants. Over the period 1979–1983, in different regions of Lithuania as well as at the Lithuanian Institute of Agriculture's collection and nurseries there were collected 71 species and forms of cultivated and wild plants affected by ergot. Out of them, 37 plant species and forms were identified for the first time in Lithuania /Дабкявичюс, Струкчинскас, 1985/. In Lithuania, there had been known 79 wild and cultivated *Poaceae* family plant species and forms to be affected by ergot before we started our research. The ergot was found in 6 cereal species, 33 plant species spontaneously growing in natural habitats, 22 species introduced or ornamental grown in the collections, 4 weed species, 14 cultivated forage grass species of which 3 are interspecific hybrids and 2 tetraploid forms /Dabkevičius, Semaškienė, 1998/.

Initially, ergot affects wild *Poaceae* plants and from them during the secondary infection it spreads in the crops of cultivated plants. Instead of kernels or seed, ergot-affected plants produce ergot sclerotia that are dispersed on the soil surface during harvesting or get into storage houses with harvested grain. Up to 24.5% of sclerotia can remain in seeds, therefore seeds have appeared to be an additional source of infection /Soroka et al., 2001/. Ploughless soil tillage and increasingly larger area of *Poaceae* plants in a crop rotation result in an abundant occurrence of ergot in winter triticale, barley, and especially in winter rye crops /Soroka et al., 2001/. Of cereal crops, winter rye and winter triticale are the most affected by ergot in Lithuania /Dabkevičius, Semaškienė, 2001/. Depending on the disease severity, the yield losses in cereal crops may range from 5.0% /Chielkowski, 1991/ to 13.0% /Soroka et al., 2001/. Ergot reduced the number of winter rye grain per ear and absolute kernel weight /Немкович, Буга, 2000; Dabkevičius, Semaškienė, 2001/. Various measures are used to control the spread of ergot, however not all of them are effective /Cagaš, 1992/.

Cultivation of disease resistant varieties is one of the most efficient control methods, however, the gene responsible for ergot resistance or inhibition of pathogen infection in the initial stage has not been identified yet /Tudzinsky, Scheffer, 2004/. Hybrid and tetraploid varieties are especially susceptible /Betz, Mielke, 1996; Mielke 2000/. Experimental evidence indicates that hybrid winter rye varieties are more severely affected by this pathogen compared with the conventional winter rye varieties /Mielke, 1993/. It has been also noted that local hybrid varieties are more susceptible to artificial ergot infection /Betz, Mielke, 1996/. Male sterile lines exhibit high ergot susceptibility /Maluszynska et al., 1998/. Barley mutants are affected by ergot too /Balčiūnienė, Mačkinaite, 2002/. Winter triticale, which is a relatively new crop, is also susceptible to ergot /Naylor, Munro, 1992/. In Poland, it has been determined that triticale varieties that have a longer flowering period are heavily affected by *Claviceps purpurea* /Zamorski, Schollenberger, 1995/. Cereal crops differ in their resistance to

ergot, therefore growing more resistant varieties is recommended in the areas with a severe disease occurrence /Pageau et al., 1994; Miedaner et al., 2005/. Production of lines with ergot resistance is seen as necessary for successful hybrid rye breeding /Wolski, Pietrusiak, 1995/.

With an introduction of new *Poaceae* plant species in Lithuania and with the spread of adventitious plants, it is likely that still not identified host-plants of this fungus grow in Lithuania. As a result, it is expedient to study the susceptibility of winter rye and winter triticale varieties to ergot on the infection background and new tested winter rye and triticale varieties and breeding lines in the plant variety testing stations in Lithuania.

This research work was aimed to determine the spread of ergot (*Claviceps purpurea* (Fr.) Tul.) on *Poaceae* family plants and incidents on winter rye and winter triticale varieties or breeding lines.

Materials and methods

Expeditionary, field and laboratory experiments and laboratory analyses were done to accomplish the tasks set for the research work. Field and laboratory experiments were conducted at Šiauliai University's Botanical Garden and Department of Environmental Research of the Faculty of Natural Sciences during the period 2001–2009. For the identification of *Claviceps purpurea* (Fr.) Tul. affected new-host *Poaceae* (R. Br.) Bernhart) plant species, ergot-infected species were collected in ornamental plant collections in private and Botanical Gardens.

Experiments with a view to determining the distribution of ergot in the crops of winter rye and winter triticale varieties and breeding lines were carried out at the Kaunas, Pasvalys, Plungė, Šilutė, and Vilnius plant variety testing stations during the period 2001–2004. 10 winter rye varieties and breeding lines were tested in 2001, 7 in 2002, 8 in 2003, and 5 in 2004. Varieties and breeding lines of winter triticale were tested respectively – 13 in 2001, 8 in 2002, 10 in 2003, and 6 in 2004. At plant hard maturity stage (BBCH 89–91), assessments of winter rye and winter triticale varieties and breeding lines were carried out in record 20 m² plots in 4 replications. The number of ergot-affected ears and sclerotia were determined per each experimental plot.

Research on the susceptibility to ergot of 8 winter rye and 7 winter triticale varieties recommended in Lithuania was done during 2001–2004. The plot size was 1 m². Each variety was replicated 4 times. To form infection background, 10 g of ergot was buried between the plots of the varieties. Flowering dynamics of cereals was assessed every three days on 25 ears per each experimental plot. At hard maturity stage (BBCH 89), percentage of ergot-affected ears and the number of sclerotia per 1 m² were estimated.

Tests on ergot harmfulness for winter rye were done in 2004 and 2005. In cereal large-scale production crops, at hard maturity (BBCH 89), healthy winter rye ears and those having 1, 2, 3, 4, 5, 6–9 and more than 10 sclerotia were collected. 400 ears of each treatment were collected (100 ears in each of the 4 replications). The ears were threshed in the laboratory and were studied for the average number of grain per ear, grain and sclerotia weight per ear and 1 000 grain weight.

Experimental data were processed by analysis of variance and correlation – regression analysis methods. Winter rye and winter triticale varieties and breeding lines data were estimated using the Duncan's multiple range test and significance was

reported at $P < 0.05$. Significance of the winter rye ears data was estimated according to Fisher's criterion. Significant differences in the tables are marked by different letters. Statistical analysis was done using statistical data processing programme package *Selekcija* (software *Anova*).

During the study period the climatic conditions were diverse. Precipitation and temperatures in 2001 were close to normal. The year 2002 was relatively dry and warm. The years 2003 and 2004 were cooler with more precipitation than in 2002. In 2005, the rate of precipitation was lower than average and the temperatures varied by season – were close to average in spring and warm in summer.

Results and discussion

During the expeditionary tests there were identified 10 new ergot host-plants in Lithuania: *Melica altissima* L. was found at Vilnius University's Botanical Garden, *Spodiopogon sibiricus* Trin. – in a private ornamental plant collection in Radviliškis district, and the *Bromus secalinus* L., *Deschampsia flexuosa* (L.) Trin., *Festuca pseudalmatica* K., *Helictotrichon sempervirens* (Vill.) Pilg., *Phalaris paradoxa* L., *Secale montana* L., *Stipa turkestanica* K., and *Elymus pungens* (Pers.) Melderis – at Šiauliai University's Botanical Garden.

Herbarium samples of each newly found ergot host-plant are composed of 1 to 10 ears, composite ears or panicles. The number of ergot sclerotia per ear, composite ear or panicle varied from 1 to 25 (Table 1).

Table 1. Newly found ergot-affected host-plants and description of their sclerotia in 2001–2009

1 lentelė. *Naujai aptikti 2001–2009 m. skalsių pažeisti augalai maitintojai ir skalsių skleročių apibūdinimas*

Plant species <i>Augalų rūšys</i>	Number of affected inflorescences per plant <i>Pažeistų žiedynų kiekis vnt.</i>	Number of sclerotia found <i>Aptiktų skleročių kiekis vnt.</i>	Ergot sclerotia measurements <i>Skalsių skleročių matmenys</i> mm	
			length <i>ilgis</i>	width <i>plotis</i>
1. <i>Bromus secalinus</i> L.	1	2	4.2–6.5	2.4–3.5
2. <i>Deschampsia flexuosa</i> (L.) Trin.	2	3	4.9–8.8	0.9–1.5
3. <i>Festuca pseudalmatica</i> K.	6	10	4.2–6.6	0.8–1.0
4. <i>Helictotrichon sempervirens</i> (Vill.) Pilg.	2	3	7.4–8.4	1.0–1.6
5. <i>Melica altissima</i> L.	3	6	10.5–15.9	0.9–1.3
6. <i>Phalaris paradoxa</i> L.	1	2	8.1–14.2	0.8–2.5
7. <i>Secale montana</i> L.	3	4	8.2–13.0	1.7–2.6
8. <i>Stipa turkestanica</i> K.	2	3	7.1–10.4	1.0–1.4
9. <i>Elymus pungens</i> (Pers.) Melderis	3	9	3.4–8.7	0.7–0.9
10. <i>Spodiopogon sibiricus</i> Trin.	10	119	1.4–6.3	0.7–1.1

Note. Ergot sclerotia measurements are indicated from the lowest to the highest.

Pastaba. Skalsių skleročių matmenys nurodyti nuo mažiausio iki didžiausio.

Ergot sclerotia were longer than the seed of host-plants, e.g. *Deschampsia flexuosa* seed length was 2.5–3.5 mm and thickness – 0.5–0.7 mm /Grigas, 1986/, whereas sclerotia length was 4.9–8.8 mm and thickness – 0.9–1.5 mm.

Analysis of the data of all research done in Lithuania, including our data, suggests that currently there are 89 host-plants known in Lithuania: 35 plant species spontaneously grow in natural habitats, 24 species (introduced or ornamental) are grown in the collections, 5 weed species, 6 cereal species, 19 cultivated forage grass species of which 3 are interspecific hybrids and 2 tetraploid forms /Брундза, 1961; Струкчинскас, 1965; Minkevičius, Pocius, 1975; Струкчинскас, Радайгиене, 1977; Дабкявичюс, Струкчинскас, 1985; Dabkevičius, Semaškiene, 1998, Mikaliūnaitė, Dabkevičius, 2007/. Ergot occurs most heavily on the plants of *Poaceae* family *Pooideae* sub-family.

In the plant variety testing stations the incidence of ergot on winter rye varieties and breeding lines was low in 2001 (Table 2). In all plant variety testing stations the variety 'Apart' F₁ was found to be the least affected by ergot. In this variety there were identified on average 1.08 ergot-affected ears and 1.83 ergot sclerotia per plot. The variety 'Hacada' was susceptible to ergot, there were found on average 4 ergot-affected ears and 4.75 sclerotia per plot.

Table 2. Incidence of ergot in winter rye varieties and breeding lines grown at the Lithuanian plant variety testing stations

2 lentelė. Skalsių pažeistų žieminių rugių veislių bei selekcinijų numerių varpų ir skleročių kiekis Lietuvos augalų veislių tyrimo stotyse

No. Eil. Nr.	Variety, breeding line Veislė, selekcinis numeris	Average number of ergot-affected ears <i>Skalsių vidutiniškai pažeistų varpų kiekis vnt.</i>				Average amount of ergot sclerotia <i>Skalsių skleročių vidutinis kiekis vnt.</i>			
		2001	2002	2003	2004	2001	2002	2003	2004
1.	'Duoniai'	1.92abcd	13.81abc	–	–	3.50ab	17.25abc	–	–
2.	'Joniai'	3.08abcd	13.69a	24.13b	59.42b	3.67ab	18.25abc	39.94c	108.83b
3.	'Walet'	1.42ab	–	–	–	1.83ab	–	–	–
4.	'Motto'	1.75abcd	–	–	–	2.17ab	–	–	–
5.	'Apart' F ₁	1.08a	–	–	–	1.83ab	–	–	–
6.	No. 339	1.42ab	28.00c	16.75ab	–	1.50a	35.75c	29.19abc	–
7.	No. 346	2.75abcd	8.38a	11.75ab	–	4.17ab	10.88a	24.00abc	–
8.	No. 395	3.08bcd	21.19abc	14.94ab	–	4.25ab	28.50abc	26.94abc	–
9.	'Esprit'	2.25abcd	–	–	–	2.88ab	–	–	–
10.	'Hacada'	4.00d	–	–	–	4.75b	–	–	–
11.	'Picaso' F ₁	–	10.69a	9.50ab	4.58ab	–	12.75a	4.88a	13.25ab
12.	'Matador'	–	15.75abc	8.31ab	44.42ab	–	21.5abc	17.75abc	72.25ab
13.	'Recrut'	–	–	18.31ab	10.67ab	–	–	37.81bc	28.75ab
14.	'Fernando' F ₁	–	–	7.69ab	3.83ab	–	–	12.06abc	6.08ab

Note. Means of columns with different letters indicate significant differences between varieties and breeding lines ($P < 0.05$) by Duncan's multiple range test.

Pastaba. Reikšmės stulpeliuose, pažymėtos skirtingomis raidėmis, rodo esminį skirtumą tarp veislių ir linijų ($P < 0,05$) pagal Dunkano kriterijų.

In 2002, the least ergot-affected was found to be the breeding line No. 346, in which there were found on average 8.38 ergot-affected ears with on average 10.88 sclerotia per plot. The most heavily ergot-infested was found to be the breeding line No. 339, in the plots of which there were found on average 28.00 ergot-affected ears and 35.75 sclerotia.

In 2003, the lowest ergot incidence was identified for the hybrid variety 'Fernando' F₁, there were found on average 7.69 ergot-affected ears and 12.06 sclerotia per plot. The highest ergot incidence was identified on the variety 'Joniai', there were found on average 24.13 ergot-affected ears and 39.94 sclerotia per plot.

In 2004, only 5 winter rye varieties were grown in the plant variety testing stations, of which the least ergot-affected was found to be the hybrid variety 'Fernando' F₁ in which there were found on average 3.83 ergot-affected ears and 6.08 sclerotia per plot. In terms of ergot infestation level, the hybrid variety 'Picaso' F₁ was similar to 'Fernando' F₁, there were found by on average 0.75 more ergot-affected ears and 7.17 more sclerotia, compared with 'Fernando' F₁. Like in 2003, the most susceptible to ergot, was found to be the variety 'Joniai', where there were found on average 59.42 ergot-affected ears and 108.83 sclerotia per plot.

Summarising the data from the 2001–2004 period we can state that the hybrid varieties 'Fernando' F₁, 'Picaso' F₁ and 'Apart' F₁ were the least affected by ergot. However, some literature sources indicate that hybrid varieties are more susceptible to ergot /Mielke, 1993; Betz, Mielke, 1996/. Under our conditions these varieties mature earlier than the local variety 'Joniai', therefore it is likely that they are less affected by ergot. The most susceptible to ergot were variety 'Joniai' and breeding line No. 339.

In the experimental years, winter triticale was less affected by ergot than winter rye (Table 3). The data from the year 2001 showed that the varieties 'Michas' and 'Alzo' were least affected by ergot. There were found on average 0.25 ergot-affected ears that matured 1 sclerotium per plot. The varieties 'Michas' and 'Mara' were not affected by ergot at the Šilutė and Vilnius plant variety testing stations. The occurrence of ergot in the breeding line LP9845.1.95 was influenced by the late sowing date and poor wintering, because of which the plants that had survived winter tillered abundantly in spring and formed adventitious – later flowering tillers. In the experimental plots of this breeding line there were found on average 26.42 ergot-affected ears and 34.50 sclerotia per plot.

In 2002, dry weather prevailing during the winter triticale flowering was not conducive to the spread of ergot ascospores and to the infestation on triticale floret ovaries. As a result, in Pasvalys and Vilnius plant variety testing stations winter triticale was not affected by ergot. In 2002, the variety 'Focus' was not affected by ergot. The variety 'Ulrika' was only weakly affected – there were found on average 0.06 ergot-affected ears that matured 1 sclerotium per plot. The variety 'Fidelio' was more susceptible – there were found on average 2.06 ergot-affected ears and 3.06 sclerotia per plot.

After unfavourable 2003 winter condition same winter triticale varieties disappeared: in Pasvalys plant variety testing station 2 and in Vilnius plant variety testing station 7 varieties. Of all the varieties grown in plant variety testing stations in 2003 the least ergot-affected was 'Focus' in which there were found on average 0.50

ergot-affected ears and 1.00 sclerotia per plot. The most ergot-susceptible variety was identified to be 'Vitalis' in which there were found on average 8.08 ergot-affected ears and 11.75 sclerotia per plot.

In 2004, the least ergot-affected was 'Woltario' variety. There were found on average 3.56 ergot-affected ears and 7.31 sclerotia per plot. The most susceptible variety was found to be 'Vitalis' in which there were found on average 53.69 ergot-affected ears and 78.38 sclerotia per plot.

Table 3. Incidence of ergot in winter triticale varieties and breeding lines grown at the Lithuanian plant variety testing stations

3 lentelė. Skalsių pažeistų žieminių kvietrugių veislių bei selekcinų numerių varpų ir skleročių kiekis Lietuvos augalų veislių tyrimo stotyse

No. <i>Eil.</i> <i>Nr.</i>	Variety, breeding line <i>Veislė,</i> <i>selekcinis</i> <i>numeris</i>	Average number of ergot-affected ears <i>Skalsių vidutiniškai pažeistų varpų</i> <i>kiekis vnt.</i>				Average amount of ergot sclerotia <i>Skalsių skleročių vidutinis kiekis</i> <i>vnt.</i>			
		2001	2002	2003	2004	2001	2002	2003	2004
1.	'Tewo'	0.75a	–	–	–	0.83a	–	–	–
2.	'Fidelio'	7.08a	2.06c	2.00a	26.06abc	9.08a	3.06c	2.69a	42.38ab
3.	'Michas'	0.25a	–	–	–	0.25a	–	–	–
4.	'Mara'	0.33a	–	–	–	0.33a	–	–	–
5.	'Lamberto'	1.92a	–	–	–	2.08a	–	–	–
6.	'Lupus'	0.33a	–	–	–	0.33a	–	–	–
7.	'Alzo'	0.25a	–	–	–	0.25a	–	–	–
8.	'Tornado'	2.42a	–	–	–	2.67a	–	–	–
9.	'Marko'	7.42a	–	–	–	13.67abc	–	–	–
10.	LP2122.4.92	4.33a	–	–	–	5.25a	–	–	–
11.	LP9845.1.95	26.42b	0.13abc	–	–	34.50c	0.13 abc	–	–
12.	SW112	0.50a	0.31abc	–	–	0.50a	0.31 abc	–	–
13.	'Ulrika'	0.58a	0.06abc	1.42a	–	0.58a	0.06 abc	2.08a	–
14.	'Nargess'	–	0.38abc	–	–	–	0.38 abc	–	–
15.	'Focus'	–	0a	0.50a	–	–	0a	1.00a	–
16.	'Passo'	–	0.31abc	1.50a	–	–	0.31 abc	2.00a	–
17.	'Vitalis'	–	0.44abc	8.08b	53.69c	–	1.50abc	11.75b	78.38c
18.	'Versus'	–	–	1.25a	–	–	–	2.13a	–
19.	'Falmoro'	–	–	1.25a	16.88abc	–	–	1.38a	21.56ab
20.	'Triamant'	–	–	0.50a	–	–	–	2.63a	–
21.	'Woltario'	–	–	1.38a	3.56abc	–	–	1.69a	7.31abc
22.	'Talentro'	–	–	0a	3.19a	–	–	0a	5.56a
23.	'Tritikon'	–	–	–	6.44abc	–	–	–	12.01abc

Note / Pastaba. Explanation under Table 2 / Paaiškinimas po 2 lentele.

Having summarised the incidence of ergot in the crops of winter triticale varieties and breeding lines, it was found that the infection level is very much dependent on the plant genotype and local conditions. Of all winter triticale varieties tested the least

ergot-affected were 'Michas', 'Alzo', 'Focus' and 'Woltario', while the most susceptible were the breeding line LP9845.1.95, and 'Fidelio' and 'Vitalis' varieties.

Under artificial infection conditions the tested winter rye varieties were infested with ergot in all experimental years: the content of ergot-infested ears was from 0.23% to 10.80% and the number of sclerotia from 1.50 to 70.75 per 1 m² (Table 4). In 2002, with prevailing hot, dry weather and very short rye flowering period the incidence of ergot in rye crops was low. The varieties 'Duoniai' and 'Rūkai' started to flower later, when fungus sclerotia had produced ascocarps in large quantities. The plants were most severely infested by ergot: the content of ergot-infested ears was 1.82% and 4.37% and the number of sclerotia was 13.00 and 23.25 per 1 m². The tetraploid rye variety 'Rūkai' was significantly more heavily affected by ergot compared with the diploid variety 'Duoniai'. The incidence of ergot on the other four varieties was significantly lower and did not differ significantly between the varieties.

Table 4. Occurrence of ergot in winter rye varieties, recommended in Lithuania
4 lentelė. Lietuvoje rekomenduotų auginti žieminių rugių veislių užsikrėtimas skalsėmis

Variety <i>Veislė</i>	Ergot affected ears % <i>Skalsėtų varpų %</i>			Number of sclerotia 1 m ² <i>Skleročių kiekis 1 m²</i>		
	2002	2003	2004	2002	2003	2004
'Duoniai'	1.82b	7.55bcd	4.58ab	13.00b	49.25bcd	33.25a
'Rūkai'	4.37c	7.54bcd	10.80d	23.25c	37.00ab	63.75c
'Motto'	0.23a	2.77a	4.54ab	1.50a	20.00a	36.75abc
'Hacada'	0.44a	3.66ab	3.71a	3.75a	21.25a	31.00a
'Esprit' F ₁	0.52a	5.01ab	3.63a	4.25a	38.25ab	36.00abc
'Zduno'	0.66a	2.83a	7.14b	4.25a	20.05a	47.50abc
'Joniai'	–	9.77d	5.15ab	–	70.75d	43.50abc
'Walet'	–	2.80a	2.52a	–	23.75ab	24.50a

Note / *Pastaba.* Explanation under Table 2 / *Paaiškinimas po 2 lentele.*

In 2003, due to later rye flowering there were affected from 2.77% to 9.77% of ears of the rye varieties. There were found from 20.00 to 70.75 sclerotia per 1 m². The highest ergot severity was identified for the varieties 'Duoniai', 'Rūkai' and 'Joniai' flowering 3–6 days later. An especially high ergot infection level was identified for the variety 'Joniai', the number of sclerotia per 1 m² was significantly higher than that for the other varieties. The hybrid variety 'Esprit' was also heavily infested with ergot. The varieties 'Motto', 'Hacada', 'Zduno', and 'Walet', characterised by a shorter growing period and earlier onset of flowering, were less severely affected by ergot.

The incidence of ergot in the varieties of winter rye in 2004 was the highest. The most heavily ergot-affected was found to be the variety 'Rūkai', for which ergot-affected ears amounted to 10.80%, there were 63.75 ergot sclerotia per 1 m². The ergot infection level in the other varieties even that of later flowering 'Duoniai' and 'Joniai' was lower and did not differ significantly between the varieties. The variety 'Walet' was found to be the least affected by ergot, the content of ergot-affected ears was as low as 2.52%, there were found 24.50 sclerotia per 1 m². This might have been influenced by the short

flowering period when more than 10% of flowers simultaneously flowered for only 12 days and during the peak period only 49% of ears flowered. The other rye varieties were more severely affected by the pathogen, however, the experimental results did not differ significantly.

The data averaged over three years suggest that the winter rye tetraploid variety 'Rūkai', characterised by a late and lengthy flowering period, was the most susceptible to ergot. The local diploid varieties 'Duoniai' and 'Joniai', flowering at a similar time to 'Rūkai', but having a less expressed flowering peak were slightly less (in 2002 and 2004) or similarly (in 2003) infected with ergot. In our tests, the hybrid variety 'Esprit' was not distinguished as the one heavily affected by ergot. This variety was more severely affected by ergot only in 2003, although many authors /Gainariu et al., 1989; Betz, Mielke, 1996/ have reported that hybrid varieties are most susceptible to this disease. Of the varieties tested, 'Walet' was found to be the least affected by ergot. This variety was distinguished by a short flowering period and a low number of simultaneously flowering ears.

A strong negative correlation at 99% significance level ($r = -0.88$) was determined between the number of productive ears per area unit and the number of ergot-affected ears per area unit. These experimental findings agree with those obtained in Germany, where a negative correlation was determined between stand density and ergot incidence /Rothacker et al., 1988/.

Under artificial infection conditions winter triticale varieties were less infected than rye. Hot and dry weather in 2002 determined very early and short triticale flowering period, therefore ergot affected only three varieties – 'Marko', 'Tewo' and 'Tornado', for which ergot-affected ears accounted for 0.07–0.45% (Table 5).

Table 5. Occurrence of ergot in winter triticale varieties, recommended in Lithuania
5 lentelė. Lietuvoje rekomenduotų auginti žieminių kvietrugių veislių užsikrėtimas skalsėmis

Variety Veislė	Ergot affected ears % Skalsėtų varpų %			Number of sclerotia 1 m ² Skleročių kiekis 1 m ²		
	2002	2003	2004	2002	2003	2004
'Tewo'	0.07ab	1.63b	1.84ab	0.75a	17.50c	10.00c
'Alzo'	0.00a	0.67a	0.44a	0.00a	6.00a	3.25a
'Tornado'	0.07ab	1.88b	1.68ab	0.50a	19.50d	10.25c
'Fidelio'	0.00a	1.07ab	1.36ab	0.00a	11.70b	8.00b
'Lupus'	0.00a	3.56d	1.06ab	0.00a	22.25e	7.00b
'Marko'	0.45b	2.80c	4.43b	2.75b	23.50e	25.50e
'Lamberto'	–	2.55c	2.10ab	–	20.75d	11.75d

Note / Pastaba. Explanation under Table 2 / Paaiškinimas po 2 lentelės.

In 2003, ergot affected all winter triticale varieties tested – there were found from 0.67% to 3.56% ergot affected ears. The most ergot-affected varieties were 'Lupus', 'Marko' and 'Lamberto', characterised by a longer flowering period, in the plots of which there were found more than 2% of ergot-affected ears.

In 2004, ergot affected 0.44–4.43% of ears of winter triticale varieties, and there were found from 3.25 to 25.50 sclerotia per 1 m². The variety ‘Marko’ was especially heavily affected by ergot, while ‘Tewo’, ‘Tornado’, and ‘Lamberto’ were moderately susceptible. The variety ‘Alzo’, characterised by the shortest flowering period was found to be the least ergot-affected.

During the experimental period we established, that the winter triticale variety ‘Alzo’, that flowered earlier and for a shorter period, was the least affected by ergot. In all experimental years most susceptible to ergot was winter triticale variety ‘Marko’. Moderately susceptible to ergot were three varieties – ‘Tewo’, ‘Tornado’ and ‘Lamberto’, when the weather conditions were cool and wet during the flowering stage (2003, 2004). In Poland, it was determined that triticale varieties that have a longer flowering period are heavily affected by *Claviceps purpurea* /Zamorski, Schollenberger, 1995/.

Ergot harmfulness in winter rye. In 2004, winter rye ears not affected by ergot produced on average 36.35 grain per ear whose weight was 1.38 g, and in 2005 – 40.95 grain per ear whose weight was 1.83 g (Table 6). Even one sclerotium significantly reduced grain number and weight per ear. When there were more than 9 sclerotia per ear, grain number declined by 24.82–32.88 and weight by 1.01–1.51 g. The weigh of 1 sclerotium, depending on their number per ear, decreased on average from 0.09–0.16 g, when there was 1 sclerotium per ear to 0.036–0.078 g, when there were 5 sclerotia per ear.

Table 6. The effect of ergot sclerotia on the biometrical data of winter rye ears
6 lentelė. Skalsių skleročių įtaka žieminių rugių varpų biometriniam duomenims

Number of sclerotia per ear <i>Skleročių kiekis varpoje vnt.</i>	Number of grain per ear <i>Grūdų kiekis varpoje vnt.</i>		Grain and sclerotia weight per ear <i>1 varpos grūdų ir skleročių masė</i>		Sclerotia weight <i>Skleročių masė</i>		1 000 grain weight <i>1 000 grūdų masė</i>	
			g		g		g	
	2004	2005	2004	2005	2004	2005	2004	2005
0	36.35a	40.95a	1.38a	1.83a	–	–	40.42a	49.15a
1	28.65bc	36.75bc	1.12b	1.54b	0.09f	0.16e	35.53b	35.38b
2	27.47c	34.54c	0.99cd	1.33c	0.13e	0.24de	31.87c	32.58bc
3	24.48de	29.27d	0.85de	1.16d	0.14de	0.27cd	29.32d	30.19cd
4	22.08ef	24.29e	0.74ef	0.93e	0.16cd	0.29cd	27.09e	27.51cde
5	20.64f	21.40f	0.70f	0.92e	0.18c	0.35bc	26.61e	26.15cde
6–8	16.43g	14.24g	0.58g	0.71f	0.23b	0.39b	22.99f	23.78e
<9	11.53h	8.07h	0.54g	0.65f	0.33a	0.52a	18.87g	–
LSD ₀₅ / R ₀₅	2.742	2.665	0.116	0.146	0.020	0.088	2.178	5.123

Note. Means of columns with different letters indicate significant differences between treatments at 95% significance level by Fisher’s criterion.

Pastaba. Reikšmės stulpeliuose, pažymėtos skirtingomis raidėmis, rodo esminį skirtumą tarp variantų, tikimybės lygiui esant 95 % pagal Fišerio kriterijų.

Sclerotia significantly reduced 1 000 grain weight: in 2004 from 40.42 to 18.87 g, and in 2005 from 49.15 to 23.78 g. Grain number per ear, depending on the

number of sclerotia, declined by 10.25% to 80.29% compared with healthy ears not affected by ergot. Sclerotia weight, from the total ear weight, increased from 8.00% to 80.00% compared with healthy ears. In ergot-affected ears the average weight per ear, depending on the number of sclerotia, declined from 24.59% to 64.48% compared with healthy ears.

During the experimental period, ergot sclerotia found in ears exerted the greatest influence on grain weight: more than 9 sclerotia per ear reduced grain weight by 85.05% in 2004 and by 92.90% in 2005.

Conclusions

Summarising the experimental results obtained during the period 2001–2009 on ergot occurrence and harmfulness in winter cereals the following conclusions were made:

1. During the expeditionary tests, 10 ergot *Claviceps purpurea* new host-plants *Bromus secalinus* L., *Deschampsia flexuosa* (L.) Trin., *Elymus pungens* (Pers.) Melderis, *Festuca pseudalmatica* K., *Helictotrichon sempervirens* (Vill.) Pilg., *Melica altissima* L., *Phalaris paradoxa* L., *Secale montana* L., *Spodiopogon sibiricus* Trin., *Stipa turkestanica* K. were collected in Lithuania for the first time. Presently, 89 *Poaceae* family's wild, cultivated, introduced and adventitious plant species are known to be infested by ergot in our country.

2. The data obtained from the Lithuanian plant variety testing stations suggest that the incidence of ergot in the crops of winter rye and winter triticale varieties and breeding lines is highly dependent on the plant genotype and local conditions. Of all winter rye varieties tested the least affected by ergot were found to be 'Fernando' F₁, 'Picaso' F₁, 'Apart' F₁, and the breeding line No. 346, while the most susceptible were 'Joniai', the breeding line No. 339.

3. In the variety testing trials, winter triticale was less affected by ergot than winter rye. The least affected by ergot varieties were identified to be 'Michas', 'Alzo', 'Focus' and 'Woltario', while the most susceptible were breeding line LP9845.1.95 and 'Fidelio' and 'Vitalis' varieties.

4. Of the 8 winter rye varieties tested on the infection background, 'Rūkai' was found to be the most susceptible, while the least affected by ergot was found to be 'Walet', whose flowering was the shortest and not many ears flowered simultaneously.

5. Of the 7 winter triticale varieties tested on the infection background, the most ergot susceptible was found to be 'Marko', while moderately susceptible were identified to be 'Tewo', 'Tornado', and 'Lamberto'. The least affected by this pathogen was 'Alzo', which did not have strongly expressed flowering peak.

6. Higher incidence of ergot in the crops of winter rye and winter triticale varieties occurred when the weather was wetter and cooler in 2003, when cereal flowering lasted longer than in the other experimental years (2002, 2004).

7. The greatest reduction caused by ergot occurred in the number and weight of grain per ear. Depending on the amount of ergot sclerotia, the number of grain per ear declined by 10–80% and grain weight by 25–93%.

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REFERENCES

1. Balčiūnienė L., Mačkinaitė R. Mutants of barley branched ear and tweeky spike and their susceptibility to micromycetes // *Zemdirbyste-Agriculture*. – 2002, vol. 78, No. 2, p. 78–85
2. Betz H. G., Mielke H. Prospects for the control of ergot // *Muhle + Mischfutter-technik*. – 1996, vol. 133, No. 44, p. 726–728
3. Bové F. J. The story of ergot. – Basel, 1970. – 296 p.
4. Čagaš B. Suppression of germination of ergot sclerotia (*Claviceps purpurea* (Fr.) Tul.) in grass seed by fungicidal treatment // *Ochrana Rostlin*. – 1992, vol. 28, No. 3, p. 177–183
5. Chełkowski J. Fungal pathogens influencing cereal seed quality at harvest // Chełkowski J. *Cereal grain: Mycotoxins, Fungi and Quality in Drying and Storage*. – Amsterdam, 1991, p. 53–65
6. Dabkevičius Z., Semaškienė R. Incidence of ergot in Lithuania and its control // *Abstracts of 7th international congress of plant pathology*. – Edinburg, 1998, vol. 3, theme 6, p. 6.2
7. Dabkevičius Z., Semaškienė R. Occurrence and harmfulness of ergot (*Claviceps purpurea* (Fr.) Tul.) in cereal crops of Lithuania // *Biologija*. – 2001, Nr. 3, p. 8–10
8. Gainariu O., Ignatescu I., Gaspar I. et al. Research regarding the production of the rye spur (*Claviceps purpurea* (Fr.) Tul.) // *Analele Institutului de Cercetari pentru Cereale si Plante Technice, Fundulea*. – 1989, vol. 57, p. 345–350
9. Grigas A. Lietuvos augalų vaisiai ir sėklos. – Vilnius, 1986, p. 480–481
10. Gudžinskas Z. Conspectus of alien plant species of Lithuania. 2. *Poaceae* // *Botanica Lithuanica*. – 1997, vol. 3, No. 2, p. 107–134
11. Maluszynska E., Kolasinska I., Madej L. Occurence of ergot in seed of male sterile lines of rye // *Biuletyn Instytutu Hadowli i Aklimatyzacji Roslin*. – 1998, No. 205–206, p. 117–123
12. Miedaner T., Wilde P., Wortmann H. Combining ability of non-adapted sources for male-fertility restoration in Pampa CMS of hybrid rye // *Plant Breeding*. – 2005, vol. 124, No. 1, p. 39–34
13. Mielke H. Investigations on the control of ergot // *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes*. – 1993, Bd. 45, Nr. 5–6, S. 97–102
14. Mielke H. Studien über den Pilz *Claviceps purpurea* (Fries) Tulasne unter Berücksichtigung der Anfälligkeit verschiedener Roggensorten und der Bekämpfungsmöglichkeiten des Erregers. – Berlin, 2000. – 66 S.
15. Mikaliūnaitė R., Dabkevičius Z. The new host-species of *Claviceps purpurea* (Fr.) Tul. from *Poaceae* family in Lithuania // *Journal of Plant Protection Research*. – 2007, vol. 47, No. 4, p. 409–416
16. Minkevičius A., Pocius I. Varpinių žolių ligos // *Žemės ūkis*. – 1975, Nr. 9, p. 17
17. Naylor R. E. L., Munro L. M. Effects of nitrogen and fungicide applications on the incidence of ergot (*Claviceps purpurea*) in triticale // *Tests of Agrochemicals and Cultivars*. – 1992, vol. 13, p. 28–29
18. Pageau D., Collin J., Wauthy J. M. A note on the resistance of soft wheat, durum wheat and triticale to ergot // *Phytoprotection*. – 1994, vol. 75, No. 1, p. 45–49
19. Pažoutová S. The phylogeny and evolution of the genus *Claviceps* // *Mycological Research*. – 2001, vol. 105, No. 3, p. 275–283
20. Rothacker D., Frauenstein K., Oertel K. Studies on the occurrence of ergot, *Claviceps purpurea* (Fr.) Tul., in winter rye multiplication crops // *Nachrichtenblatt für den Pflanzenschutz in der DDR*. – 1988, Bd. 48, Nr. 11, S. 220–222

21. Soroka S. V., Buga S. F., Zhukova M. I. et al. Main phytosanitary problems in Belarus and methods of their solution // Archives of Phytopathology and Plant Protection. – 2001, vol. 34, p. 73–83
22. Zamorski C., Schollenberger M. Occurrence of diseases of triticale in Poland // Biuletyn Instytutu Hadowli i Aklimatyzacji Roslin. – 1995, vol. 195–196, p. 197–207
23. Tudzynski P., Scheffer J. *Claviceps purpurea*: molecular aspects of unique pathogenic lifestyle // Molecular Plant Pathology. – 2004, vol. 5, No. 5, p. 377–388
24. Wolski T., Pietrusiak A. Situation in Polish rye breeding on the threshold of 1995 // Biuletyn Instytutu Hodowli i Aklimatyzacji Roslin. – 1995, vol. 195–196, p. 267–272
25. Брундза К. Паразитные грибы культивируемых растений в Литовской ССР. – Вильнюс, 1961. – 302 с.
26. Дабкявичюс З. В., Струкчинскас М. Т. Поражаемые грибами рода *Claviceps* Тул. злаковые растения в Литовской ССР // Труды Академии Наук Литовской ССР. – Вильнюс, 1985, т. 4, вып. 92, с. 3–11
27. Немкович А. И., Буга С. Ф. Вредоносность *Claviceps purpurea* (Fr.) Tul. на озимой ржи // Защита растений: сборник научных трудов / Беларусь. НИИ защиты растений. – Минск, 2000, вып. 19–23, с. 58–65
28. Струкчинскас М. Т. Некоторые данные о споринье в Литве // Проблемы изучения грибов и лишайников. – Тарту, 1965, с. 144–148
29. Струкчинскас М. Т., Радайтиене Д. И. Паразитная микрофлора растительности дюн города Паланги // Экологические особенности низших растений Советской Прибалтики: материалы к VIII симпозиуму Прибалтийских и Белорусских микологов и лихенологов. – Вильнюс, 1977, с. 236–237

Skalsių (*Claviceps purpurea*) sukėlėjo paplitimas miglinių šeimos augaluose ir javuose Lietuvoje

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Santrauka

Naujai aptikti skalsių (*Claviceps purpurea* (Fr.) Tul.) pažeisti miglinių *Poaceae* (R. Br.) Bernhart šeimos augalai maitintojai buvo surinkti 2001–2009 m. Lietuvoje ekspedicinių tyrimų metu. Skalsių paplitimas žieminių rugių ir žieminių kvietrugių veislių bei selekcinų numerių pasėliuose tyrinėtus Lietuvos augalų veislių tyrimo stotyse ir Šiaulių universiteto botanikos sode.

Įvairiuose šalies regionuose 2001–2009 m. vykdytų ekspedicinių tyrimų metu nustatyta 10 naujų miglinių šeimos augalų rūšių, pažeistų skalsių – *Bromus secalinus* L., *Deschampsia flexuosa* (L.) Trin., *Elymus pungens* (Pers.) Melderis, *Festuca pseudalmatica* K., *Helictotrichon sempervirens* (Vill.) Pilg., *Melica altissima* L., *Phalaris paradoxa* L., *Secale montana* L., *Spodiopogon sibiricus* Trin., *Stipa turkestanica* K.

Skalsių labiau pažeistos buvo žieminių rugių nei žieminių kvietrugių veislės augalų veislių tyrimo stotyse. Iš tirtų žieminių rugių veislių skalsėms jautriausi buvo veislė 'Joniai' ir selekcinis numeris Nr. 339, o mažiausiai pažeisti – hibridinės veislės 'Fernando' F₁, 'Picaso' F₁ bei 'Apart' F₁ ir selekcinis numeris Nr. 346. Iš tirtų žieminių kvietrugių veislių skalsėms jautriausi buvo selekcinis numeris LP9845.1.95 ir veislės 'Fidelio' bei 'Vitalis', o skalsių mažiausiai pažeistos buvo veislės 'Michas', 'Alzo', 'Focus' bei 'Woltario'.

Vidutiniais trejų metų tyrimų, atliktų Botanikos sode, duomenimis, infekciniame fone skalsėms jautriausia buvo vietinė tetraploidinė žieminių rugių veislė 'Rūkai'. Iš tirtų žieminių kvietrugių veislių skalsėms jautriausia buvo veislė 'Marko', o vidutiniškai jautrios – veislės 'Tewo', 'Tornado' bei 'Lamberto'. Mažiausiai pažeistos skalsių buvo žieminių rugių veislės 'Walet', 'Motto' bei 'Hacada' ir žieminių kvietrugių veislė 'Alzo'.

Skalsės iš esmės sumažino grūdų kiekį bei jų svorį varpoje. Priklausomai nuo skalsių skleročių kiekio varpoje, grūdų kiekis varpoje mažėjo 10–80 %, o jų masė – 25–93 %.

Reikšminiai žodžiai: skalsės, *Claviceps purpurea*, *Poaceae*, žieminių rugių ir žieminių kvietrugių veislės.