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RESISTANT CULTIVAR – A BIOLOGICAL WAY TO CONTROL FLAX FUNGAL DISEASES

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Abstract

This paper discusses the resistance of some flax cultivars and new breeding lines to harmful flax diseases – anthracnose (*Colletotrichum lini* (Westerd.) Tochinai), fusarium (*Fusarium* spp.) and pasmo (*Septoria linicola* (Speg.) Garass.). The cultivars and breeding lines were investigated in the field of the Upytė Research Station of LIA during 2001–2003. All the tested accessions were affected by anthracnose moderately or severely at the seedling stage and at harvesting (early yellow ripening stage). The highest number of the fusarium wilt affected seedlings (5.0%) was identified in the plots of the breeding line 01149-14. The lowest disease incidence (1.5%) was recorded for the breeding line 2027-6. Moderately resistant to fusarium browning (up to 30% of affected plants) were found to be cvs. 'Baltučiai', 'Hermes' and the breeding lines 1698-13a, 1864-24, 1963-12, 2176-2, 2912-4 and 2912-6. The greatest incidence of pasmo disease was recorded for cvs. 'Ariane' and 'Belinka' with affected stems accounting for 45.4 and 36.7%. The lowest number of pasmo-affected stems in 2001 was identified for the breeding lines 1698-13a (16.9%) and 2912-6 (18.4%), which suggests that these breeding lines may be moderately resistant.

Key words: breeding line, cultivar, fibre flax, disease, incidence, resistance, severity.

Introduction

Wilt, anthracnose and pasmo disease are listed among the most common and harmful flax diseases /Loshakova, 1992; Mercer, 1992/. The incidence and severity of certain diseases depend on many factors – climate conditions, varietal peculiarities, crop hygiene and availability of pathogens /Mercer, 1992; Рожмина, 2004/. Chemical and crop husbandry measures cannot always provide the crop with proper protection against pathogens /Loshakova, 1992/. Therefore, disease resistance of cultivars is a very important factor contributing to flax yield increase and quality improvement, and healthier environment. For the majority of the countries disease resistance is the main criterion for a new variety to be included in the National Catalogue of Plant Varieties. Belarus scientists point out that cultivation of disease resistant varieties could help clean the soils from pathogens, causing such diseases as *Fusarium* spp., *Colletotrichum lini* and others /Портянкин, Адушкевич, 1997/.

Research on flax resistance to different diseases is done in France /Beaudoin, 1995/, Czech Republic /Ondrej, 1985/, Poland /Andruszewska, Byczynska, 1998/,

Russia /Loshakova, 2002; Крылова, 2002/, Belarus /Портянкин, Карачан, 2000/, Lithuania /Bačelis, 1998 a; Bačelis, 2002/ and other countries.

Resistance of cultivars and breeding lines is very important at all stages of breeding work. Due to very small amount of seeds at the initial stages of breeding, it is very difficult to conduct disease resistance tests. Disease resistance tests are generally started with investigation of collections (gene fund), which leads to identification of resistant parental forms /Andruszevska, Byczynska, 1998; Bačelis, 1998 b; Brutch et al., 1998; Bačelis, 2000/. Then resistance is tested at other stages of breeding – in hybrids, selection and control nurseries, initial and competitive variety testing trials /Bačelis, 2002; Крылова и др., 2002/. The valuable material obtained is used for the development of new breeding material and is also transferred to the Gene Banks for storage /Bačelis, 2000; Bačelis, 2002/.

Results of contemporary research demonstrate that genes responsible for flax resistance to different diseases – rust /Brutch et al., 1998; Staples, 2000/, fusariose /Brutch et al., 1998/, fusarium wilt /Brutch et al., 1998/, etc. have been identified.

A special attention is given to the findings suggesting that plants containing disease resistance genes very often have some negative characteristics – low yield and poorer fibre quality and sensitivity to environmental factors. As a result, development of high yielding, disease resistant flax cultivars is a very hard task for flax breeders /Рожмина, 2004/.

The aim of the present study was to estimate the incidence and severity of flax diseases at flax seedling and early yellow ripening stages (at harvesting) and to identify the cultivars and breeding lines with the highest disease resistance.

Materials and Methods

The resistance of flax cultivars and new breeding lines to the flax diseases – seedling blight, anthracnose (*Colletotrichum lini* (Westerd.) Tochinai), fusarium wilt (*Fusarium oxysporum* Schltdl.), fusarium browning (*Fusarium* spp.), and pasmo (*Septoria linicola*) was tested on the natural background at the competitive variety testing trials carried out at the Upytė Research Station of LIA during the period 2001–2003.

In 2001 nine fibre flax breeding lines 2912-6; 2912-4; 2176-8; 2176-2; 1963-3; 1864-24; 1698-13a; 01057-12; and four cultivars (‘Ariane’, ‘Belinka’, ‘Baltučiai’ and ‘Hermes’) were tested in the competitive variety testing trials. In 2002 five breeding lines 1963-3; 1864-24; 1698-13a; 01057-12; 2017-3 and five cultivars (‘Hermes’, ‘Belinka’, ‘Baltučiai’, ‘Vega 2’ and ‘Kastyčiai’) were tested. In 2003 eleven breeding lines 1963-3; 1864-24; 1698-13a; 01057-12; 2017-3; 01149-14; 1698-3; 1878-9; 1963-17; 2027-6; 2030-5 and four cultivars (‘Belinka’, ‘Baltučiai’, ‘Hermes’ and ‘Kastyčiai’) were tested. Only four breeding lines 01057-12; 1698-13a; 1864-24, 1963-3 and two cultivars (‘Belinka’, ‘Baltučiai’) were tested in the competitive variety trials for three years.

Soil preparation and flax cultivation and management practices were performed following the recommendations for flax growing in Central Lithuania. The trial was conducted on a sandy loam *Eutri-Endohypogleyic Cambisol* /Buivydaitė, 2001/. The preceding crop for flax was winter cereal grown after perennial grasses. In the competitive cultivar trials the plots were sown by a sowing machine SL-16 at a seed rate of

22 million seed per hectare, with 10 cm spaces between rows. The competitive cultivar trials involved 4 replications. The size of a record plot was 16.0 m^2. All field trials were conducted (with a few modifications) in compliance with the published methodology /Роташ и др., 1987/. The incidence and severity of fungal diseases was assessed at flax seedling and early yellow ripeness stages.

Flax diseases were identified according to visible symptoms, following disease descriptors and methodology rules /Пидопличко, 1978; Лошакова и др., 2000; Žemės ūkio …, 2002/.

The data were analysed by ANOVA, and means of LSD at P = 0.05 are presented /Tarakanovas, Raudonius, 2003/.

The weather conditions during the experimental years were diverse. In 2001 at the beginning of May the weather conditions for flax emergence were not favourable. In 2001 the weather conditions were favourable for the occurrence of diseases. In June the hydrothermal coefficient (HTK) was 2.0, and there were 11 days with rainfall. The mean air temperature in June was lower than the long-term average. Flax in the experimental plots was slightly lodged by the rainfall at flowering and green ripening stages. Heavy rainfall and strong wind on July 17 lodged the flax stand, the hail injured flax green capsules and stems. The incidence of diseases was higher also because of mechanically injured cuticle on flax stems. Flax remained lodged until harvesting. The year 2002 was characterised by a shortage of moisture during the growing season. The weather conditions for flax emergence were not favourable. Because of the lack of precipitation, the incidence of diseases on flax stems in 2002 was much lower than that in 2001. Flax started flowering and ripened much earlier than usual – on July10–18. In 2003 the weather was changeable. Because of the lack of precipitation in the first half of the growing season, flax did not perform well. July was warm and normally wet, only at the end of the month (on 26th) heavy rainfall (26.1 mm per day) and wind partially lodged the crop. The first ten-day period of August was dry and warm, and the conditions for flax harvesting were favourable.

Results and Discussion

Seedling blight (*Colletotrichum lini* (Westerd.) Tochinai) affected flax seedlings every year of the study. The highest incidence of seedling blight (Table 1) was recorded in the spring of 2001, when the weather conditions were not favourable for flax emergence because of the lack of precipitation and cold weather. The lowest incidence of this disease was found on flax seedlings in 2003, when the weather was favourable for flax germination.

In 2001 the highest amount of seedling blight-affected plants was found in the plots of the breeding line 1963-3 (92.5%) and cultivar ‘Ariane’ (90.0%). The severity of the disease was the highest in the plots of the breeding lines 1963-3 (40.63%), 2176-2 (35.00%), 1864-24 (31.25%). The lowest incidence of seedling blight was found on the seedlings of the cultivar ‘Hermes’, nevertheless, it was still high – 40.0%. The lowest severity of seedling blight was detected in the plots of the breeding lines 2912-6 and 01057-12 (16.25% for both breeding lines), the incidence of the disease was 62.0% and 60.0%, respectively. In 2002 the lowest amount of seedling blight-affected plants was found in the plots of the cultivar ‘Kastyčiai’ (30.0%) and the breeding lines 1698-13a

(31.2%) and 01057-12 (34.5%). The lowest incidence of seedling blight in 2003 was detected for the cultivar 'Kastyčiai' (6.3%) and the breeding lines 1698-13 (8.8%) and 01057-12 (7.8%). The severity of the disease was the lowest in the same plots (2.19%; 3.75% and 3.25%, respectively).

Table 1. The incidence and severity of seedling blight on flax at seedling stage
Upytė, 2001–2003

Cultivar or breeding line	2001		2002		2003	
	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %
'Ariane'	90.0	28.75	–	–	–	–
'Baltučiai'	72.5	26.88	51.2	12.75	14.0	6.63
'Belinka'	70.0	27.50	67.5	21.50	15.0	6.25
'Hermes'	40.0	21.88	–	–	12.3	7.38
'Kastyčiai'	–	–	30.0	12.51	6.3	2.19
'Vega 2'	–	–	47.3	14.00	–	–
01057-12	60.0	16.25	34.5	11.13	7.8	3.25
1698-13a	52.5	19.63	31.2	10.25	17.3	8.06
1864-24	87.5	31.25	50.5	17.79	17.5	7.50
1963-3	92.5	40.63	45.1	13.53	8.8	3.75
1963-12	67.5	21.34	39.0	9.75	–	–
2176-2	87.5	35.00	–	–	–	–
2176-8	55.0	25.63	–	–	–	–
2912-4	72.5	20.78	–	–	–	–
2912-6	65.0	16.25	–	–	–	–
01149-14	–	–	–	–	20.0	11.88
1878-9	–	–	–	–	17.5	7.50
1963-17	–	–	–	–	17.5	5.00
2017-3	–	–	–	–	23.5	11.25
2027-6	–	–	–	–	22.5	10.00
2030-5	–	–	–	–	17.5	5.63
Mean	70.2	25.52	44.0	13.69	15.5	6.88
LSD_{05}	4.79	1.601	1.54	0.698	1.91	0.553

Lesions of anthracnose were found on flax stems in each experimental year. An especially high incidence of anthracnose on flax stems was found in 2001 – from 31.8% (1698-13a) to 59.7% ('Ariane') of infected plants per plot (Table 2). The lowest incidence of anthracnose was recorded in the plots of the breeding line 1698-13a (31.8%) and cultivar 'Baltučiai' (37.7%). In 2002 and 2003 the incidence of anthracnose on flax stems was much lower – 1.0–5.0%. In 2002 the breeding line 1963-12 was found to be the most resistant to anthracnose (the incidence of the disease was as low as 1.0%). In 2003 the lowest incidence of anthracnose was detected on the flax stems of the cultivar 'Hermes' (1.9%) and the breeding line 2027-6 (1.9%), the disease severity was 0.35 and 0.21%, respectively. The cultivar 'Baltučiai' exhibited good resistance results during 2001–2003.

Table 2. The incidence and severity of anthracnose on flax stems at early yellow ripening stage

Upytė, 2001–2003

Cultivar or breeding line	2001		2002		2003	
	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %
‘Ariane’	59.7	18.91	–	–	–	–
‘Baltučiai’	37.7	13.73	2.0	1.17	2,8	0,53
‘Belinka’	50.4	14.83	3.0	1.50	3,3	0,72
‘Hermes’	51.2	19.73	–	–	1,9	0,35
‘Kastyčiai’	–	–	3.5	1.67	3,2	0,91
‘Vega 2’	–	–	2.5	0.83	–	–
01057-12	44.7	17.91	2.0	0.75	2,7	0,61
1698-13a	31.8	9.53	3.5	1.92	3,3	0,59
1864-24	44.5	15.13	2.0	1.25	3,8	0,73
1963-3	49.5	20.69	2.3	1.25	2,7	0,61
1963-12	51.4	16.45	1.0	0.67	–	–
2176-2	57.9	19.76	–	–	–	–
2176-8	59.6	23.18	–	–	–	–
2912-4	54.7	18.85	–	–	–	–
2912-6	59.0	21.44	–	–	–	–
01149-14	–	–	–	–	3,8	0,72
1878-9	–	–	–	–	2,6	0,62
1963-17	–	–	–	–	4,1	0,89
2017-3	–	–	–	–	3,3	0,77
2027-6	–	–	–	–	1,9	0,21
2030-5	–	–	–	–	2,1	0,19
Mean	50.2	17.70	2.4	1.22	3.0	0.60
LSD_{05}	0.86	0.766	0.13	0.171	0,13	0,029

Fusarium wilt (causal agent *Fusarium oxysporum*) was identified on flax seedlings in each experimental year, but the incidence and severity of the disease was rather low (0.8–5.0% and 0.33–2.67%, respectively). The weather conditions were diverse over the experimental period, but the disease incidence did not differ between the years. The highest fusarium wilt incidence on flax seedlings (5.0%) was identified in 2003 in the plots of the breeding line 01149-14 with a disease severity of 2.67%. The seedlings of the breeding line 2027-6 were the most resistant to the fusarium wilt (incidence 1.5 %, severity 0.92%). In 2001 the most resistant were seedlings of ‘Baltučiai’ (the disease incidence was 1.0%), 2176-2 (1.5%), in 2002 – of ‘Belinka’ (0.8%), 1698-13a, 1963-3 and 1963-12 with 1.0% of affected plants. The cultivar ‘Baltučiai’ showed good resistance results during 2001-2003.

In 2001 the incidence of fusarium browning on the stems at early yellow ripening stage varied from 18.5 to 36.8%. The plants of the breeding line 1698-13a were the most resistant to fusarium browning (incidence 17.0%). The plants of the accessions ‘Baltučiai’, ‘Hermes’, 1698-13a, 1864-24, 1963-12, 2176-2, 2912-4 and 2912-6 were

moderately resistant to fusarium browning (the incidence of the disease up to 30%). In 2001, the severity of fusarium browning on flax stems was rather high. Even at low incidence the severity of the disease was high. In 2002 and 2003 the incidence of fusarium browning on flax stems was very low (0.3–5.0%), therefore, all tested accessions showed good results. The lowest incidence was identified for 'Baltučiai', 01057-12, 1864-24 and 1963-12 in 2001 and for 'Belinka', 01057-12, 1698-13a and 1963-17 in 2003.

No symptoms (lessions) of pasmo disease (causal agent *Septoria linicola* (Speg.) Garass.) were found on flax seedlings during the whole experimental period. But it was severe on flax stems in 2001. The incidence of pasmo ranged from 16.9 to 45.4% (Table 3). The lowest incidence and severity of pasmo on flax stems was found in the plots of the breeding lines 1698-13a (16.9% and 11.14%), 2912-6 (18.4% and 9.20%), thus we can suppose that these breeding lines are moderately resistant to pasmo. 'Ariane' was the most sensitive to pasmo – with a disease incidence of 45.4% and severity of 22.58 %.

Table 3. The incidence and severity of pasmo on flax stems at early yellow ripening stage Upytė, 2001–2003

Cultivar or breeding line	2001		2002		2003	
	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %
'Ariane'	45.4	22.58	–	–	–	–
'Baltučiai'	28.0	15.19	0.0	0.00	2.9	1.31
'Belinka'	36.7	18.85	0.0	0.00	1.3	0.56
'Hermes'	27.6	13.11	–	–	4.9	2.19
'Kastyčiai'	–	–	0.5	0.31	1.7	0.63
'Vega 2'	–	–	0.0	0.00	–	–
01057-12	30.9	17.08	0.3	0.13	3.3	0.69
1698-13a	16.9	11.14	0.0	0.00	1.4	0.45
1864-24	25.7	17.04	0.0	0.00	2.7	0.88
1963-3	30.0	12.44	0.0	0.00	5.9	0.63
1963-12	21.3	12.90	0.0	0.00	–	–
2176-2	22.4	12.95	–	–	–	–
2176-8	30.4	15.01	–	–	–	–
2912-4	22.3	12.28	–	–	–	–
2912-6	18.4	9.20	–	–	–	–
01149-14	–	–	–	–	3.0	1.56
1878-9	–	–	–	–	1.0	0.88
1963-17	–	–	–	–	3.7	0.56
2017-3	–	–	–	–	2.1	1.75
2027-6	–	–	–	–	1.8	0.56
2030-5	–	–	–	–	2.9	1.13
Mean	27.4	14.60	0.1	0.05	2.8	0.98
LSD_{05}	2.06	1.046	–	–	0.04	0.543

In 2002 the incidence of pasmo on flax stems was very low and quite low in 2003. It is likely that the pasmo incidence depended on the weather conditions in the

second half of the growing season. For example, in 2001 it was wet and warm at the end of the growing season. The crop lodged because of the heavy rains and favourable conditions for infection occurred.

In 2002, only a few injured plats were found in the plots of 'Kastyčiai' and 01057-12. In 2003, the symptoms of pasmo disease were spotted only after heavy rains (26 mm per day). The pasmo disease on flax stems was detected on all accessions tested, and the disease incidence was 1.0–6.0% in 2003. The lowest incidence was found in the plots of 'Belinka' (1.3%), 'Kastyčiai' (1.7 %), 1698-13a (1.4%), 1878-9 (1.0%), 2027-6 (1.8%).

Conclusions

Summing up the results of the investigations carried out during the period 2001–2003 at the Upytė Research Station of the Lithuanian Institute of Agriculture on the resistance of the flax cultivars ('Ariane', 'Baltučiai', 'Belinka', 'Hermes', 'Kastyčiai', 'Vega 2') and the new breeding lines (01057-12; 1698-13 a; 1864-24; 1963-3; 1963-12; 2176-2; 2176-8; 2912-4; 2912-6; 01149-14; 1878-9; 1963-17; 2017-3; 2027-6; 2030-5) to flax diseases on natural background, the following conclusions were drawn:

1. Seedling blight (anthracnose) occurred on flax in each experimental year, the incidence varied from 6.3 to 92.5% depending on the year. None of the tested cultivars and breeding lines showed distinct resistance to anthracnose. The cultivar 'Kastyčiai' and the breeding line 01057-12 were less sensitive to seedling blight than the other accessions tested. Fusarium wilt affected 0.8–5.0% of flax seedlings, the disease severity was 0.33–2.67%.

2. The results of anthracnose tests on flax stems suggest that the breeding line 1698-13a and the cultivar 'Baltučiai' were the least affected (31.8% and 37.7%, respectively), and the disease severity was 9.53% and 13.73%, respectively.

3. The breeding line 1698-13a (17.0% of affected plants) exhibited the highest resistance to fusarium browning. The plants of the accessions 'Baltučiai', 'Hermes', 1698-13a, 1864-24, 1963-12, 2176-2, 2912-4 and 2912-6 exhibited moderate resistance to fusarium browning (the disease incidence up to 30%).

4. The cultivar 'Ariane' was the most sensitive to pasmo. The disease incidence was 45.4% and severity 22.58%. The breeding lines 1698-13a and 2912-6 are considered to be moderately resistant to pasmo, because the lowest incidence and severity of pasmo was identified on their stems.

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