The response to crop health and productivity of field pea (*Pisum sativum* L.) at different growing conditions

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**ABSTRACT**

With increasing the area of legumes one of the most possible risks for productivity limitation is diseases. The research on the response to diseases and productivity of field peas was carried out during 2018–2020. The six cultivars and breeding lines were grown at two different infection levels: at natural field infection and under disease control using seed treatment and foliar fungicides. The main disease in field peas during the research year was Ascochyta blight at different intensities depending on year, cultivar/breeding line and disease control efficacy. Dominating pathogenic fungus *D. pisi* on harvested grains prevailed. Pea grain yield was significantly affected by cultivar/breeding line, experiments year and growing conditions. The highest yield difference between growing conditions (natural field infection and under disease control) was recorded in 2020 when Ascochyta blight and Grey mould gave the most severe attack. This finding illustrates the importance to eliminate one of the most important limiting factors for productivity – severe diseases. Future research on the forecast system of Ascochyta blight and other field pea diseases infection risk is needed. The response of cultivar/breeding line to weather conditions was established in this research as well. Tested breeding lines showed higher drought stress tolerance compared with commercial cultivars. More focus on environment stress-resistant cultivars is needed.

**INTRODUCTION**

Field pea (*Pisum sativum* L.) is an important leguminous plant in the structure of crops (Sainju et al. 2019). The increasing need for high-quality protein and the important role of this crop in rotations is driving interest in this crop. Also increasing interest in field peas as a component of intercrops (Lake et al. 2021). Pea is a perfect choice when it comes to the Farm to Fork Strategy because locks nitrogen in the soil and doesn’t need chemical fertilisers, contributing to greenhouse gas emission targets. With Greening requirements in 2015 area of peas in Lithuania has grown exceptionally from 24 thousand ha in 2012 to 148.7 thousand ha in 2016. With such a significant increase in area, the need for locally adapted cultivars, the new knowledge about cultivation technologies, risk of diseases and pest had increased. Among the diseases, root rot diseases caused by *Pythium ultimum, Rhizoctonia solani, Fusarium oxysporum* f. sp. *pisi* *Fusarium solani* and *Aphanomyces euteiches* are reported as important peas pathogens from all commercial pea growing areas of the world (Khan et al. 2016). Leaf and stem diseases of peas caused by the *Ascochyta* complex, *Peronospora viciae* and *Erysiphe pisi* are frequent in most pea-growing regions (Bretag et al. 2006; Lake et al. 2021). Ascochyta blight is caused by a complex of fungal pathogens. The most devastating host plant is *Ascochyta pisi* Lib. (teleomorph: *Didymella pisi* sp. nov.). This pathogen causes leaf, stem and pod spot. The second very important *Ascochyta* complex pathogen is *Ascochyta pinodes* L.K. Jones (teleomorph: *Mycosphaerella pinodes* (Berk. &Blox.) Vestergr.). This pathogen causes foot rot and leaf, stem and pod spot also. *Phoma pinodella* (L.K. Jones) Morgan-Jones & K.B. Burch symptoms can be identified on leaf, stem and foot rot (Davidson et al. 2009; Liu et al. 2013). The majority of mentioned diseases are highly significant in our region as well (Gauriļčikienė et al. 2008; Marcinkowska et al. 2009; Česnulevičienė et al. 2014; Brauna-Morževas et al. 2019). Breeding on yield limitations factors such as
diseases and abiotic factors play a significant role in improving field pea yield. The impact of these factors varies with agroecology and crop management practices and disease control as well.

The increasing requirements for the reduction of plant protection products and improvement of crop rotation structure with sustainable plants determine the increase in the area of leguminous plants, but obligates to manage effectively the mentioned risk factors limiting productivity.

The aim of this study was to evaluate the influence of pea cultivars and chemical control on pea productivity in managing diseases from early stages to harvest.

Materials and methods

The research was carried out at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry, Akademija, Kėdainiai District in Lithuania during 2018–2020.

The field experiments were established during three seasons. Three commercial cultivars (Astronaute, Jūra DS and Ingrid) and three breeding lines (3637-2 (Lina DS), 3784-1 and 3795-3 (Egle DS)) of field pea were grown. The field experiments were laid out at two different infection levels: natural field infection and under disease control using seed treatment and foliar fungicide.

For seed dressing commercial seed treatment fungicide, Maxim 025 FS (fluinoxam 25 g l⁻¹) at a rate of 2.0 l t⁻¹ was applied. For foliar application fungicide, Propulse (125 g l⁻¹ fluopyram and 125 g l⁻¹ prothiocynazole) was used at a rate of 0.8 l ha⁻¹.

The field experiments were established in a randomised complete block design with four replications. Each treatment was allocated randomly within the block and replicated four times.

For seedling, a mechanical small plot seeder was used. The plot size was 15 m² (10 x 1.5 m), 2-metre block-to-block distance and 0.25-metre plot-to-plot distance.

The field experiments were established in a randomised complete block design with four replications. Each treatment was allocated randomly within the block and replicated four times.

Assessments in the field experiments

Assessment descriptions from EPPO standards 'Leaf and pod spots of pea' PP 1/172(2) and 'Seed treatments against seedling diseases (trials under controlled conditions)' PP 1/125(4) were used.

For Ascochyta leaf assessment: on 25 stems, randomly distributed throughout the plot, the percentage of leaf area infected was estimated.

For Ascochyta and Botrytis pod assessment: 100 pods randomly distributed throughout the plot, estimated the percentage of surface infection on each pod.

For seedling blight and root rot infection: Twenty-five plants were randomly sampled from each plot at the early growing stage (BBCH 15) and at beginning maturity (BBCH 79-81) to set up a steam base infection and determine the incidence and severity.

Scale 1–5 scoring assessment was used. The scale was converted to disease index using the following formula:

\[
    x = \frac{(a \times 1) + (b \times 25) + (c \times 50) + (d \times 75) + (e \times 100)}{T} = \text{total number of plants}
\]

\[a, b, c, d, e = \text{number of plants in groups 1–5 as indicated from the assessment.}\]

The index values (x) can vary from 1 to 100.

At full maturity (BBCH 89), plots were harvested with a plot combined Wintersteiger Delta. After harvest 1.0 kg sample from each plot was taken for grain analysis. The infection level of harvested grains was established.

Laboratory analyses

The agar plate method (Mathur and Kongsdal 2003) was used for the determination of infection levels with pathogenic fungi of harvested pea grain. 100 grains from each harvested plot were assessed for grain infection with Ascochyta, Fusarium and Botrytis fungi genera. Grains were sterilised for 3 min in 1% sodium hypochlorite, washed three times in distilled water and planted on potato dextrose agar (‘Merk’, Germany). Plates with grains were incubated at the growing chamber at 22°C for 7 days, with 12 h light and 12 h darkness. Species were detected and identified under morphological features according to Mathur and Kongsdal (2003).

Meteorological conditions

Air and soil temperature and amount of precipitation during the growing season (April to August) were obtained from Dotnuva Meteorological Station located about 1.0 km from the experimental site (Figure 1). The two first growing seasons were similar.
Statistical analysis was made using statistical software SAS 9.4 (SAS Institute Inc., USA).

**Results and discussion**

The growing of sustainable crops, peas as well, is increasing and an environment-friendly approach to technologies or elements of technologies is needed. With the increase in the area of legume one of the most possible risks is the occurrence or event outbreaks of diseases. An earlier study in Lithuania showed that even at the seedling stage the pea can be heavily affected by a complex of seed and soil-borne pathogens. The authors of this study found that the main pathogens causing pea stem base and root rots were found to be *Phoma pinodella* and *Fusarium* genus fungi, among which the most prevalent were *F. oxysporum*, *F. moniliforme* and *F. avenaceum* (Gaurilčikienė et al. 2008). In our research foot rot in commercial cultivars and new pea breeding lines spread from the early growth stage in all experimental years at both infection levels: natural field conditions and in disease-controlled conditions. Foot rot severity depended on year, cultivar or breeding line and growing conditions (Table 1). The presented results from plots with natural field infection show that breeding lines 3784-1 and 3795-3 (Egle DS) were less damaged by foot rots in the early plant growth stage, while Jūra DS, 3637-2 (Lina DS) and 3795-3 were slightly healthier at the end of active vegetation (at BBCH 79-81) than other cultivars. Commercial pea cultivar Ingrid was more sensitive to the foot rots than other cultivars. Early seedling infection was very low in 2018 when favourable soil conditions (wet and warm) for germination prevailed. Moderate seedling blight infection was recorded when the disease index was at a moderate level. Other authors’ seed-treatment fungicides are identified as effective measures to manage field pea root rot. However, under a high disease pressure, traditional management practices such as seed treatment fungicides and crop rotation do not provide satisfactory management (Modderman et al. 2018; Gossen et al. 2016). Another study also indicated that seed treatment fungicides reduced the severity of stem base and root rot diseases in field peas (Gaurilčikienė et al. 2008). In our field experiments, foot rot index before the harvest was high for all cultivars and breeding lines. According to our findings, the seed treatment did not show any effect on foot rot severity at late growth stages. The results from our research on seedling blight and foot rot occurrence during the three-year period can be concluded.

**Figure 1.** Weather conditions during field pea growing seasons (2018, 2019 and 2020), Dotnuva Meteorological Station.

in the amount of precipitation, with 246.7 and 244.5 mm in 2018 and 2019. The average air temperature was 16.9°C and 15.6°C in 2018 and 2019, respectively. Differently, a higher amount of precipitation (332.9 mm) and lower average air temperature (14.5°C) during the growing season was in 2020. The average soil temperature at a 5 cm depth was 18.5°C in 2018 and 16.7°C in 2020.

**Statistical methods**

To analyse the dataset analysis of variance (ANOVA) was conducted. Data were compared using one-way and three-way analysis of variance (ANOVA) and means were separated using least significant difference (LSD) at a 95% probability level. The standard deviation of the seed infection variation on seeds was calculated.
that when favourable soil conditions (wet and warm) for crop germination prevailed, seedling blight infection was low at both infection levels: at natural field infection and under diseases control using seed treatment and foliar fungicides. At cool and dry weather conditions at germination and early growth stages, moderate seedling blight infection was recorded. Seed treatment effectively reduced seedling blight infection when the disease index was at a moderate level.

Ascochyta blight is a serious disease of peas worldwide. All above-ground portions at any growth stages of pea plants are susceptible (Skoglund et al. 2011). During our study, except in 2018, Ascochyta blight occurred in all field pea cultivars and breeding lines. The disease infested whole plants and pods as well (Table 2). According to Salam et al. (2011) pre-sowing rainfall significantly affected Ascochyta blight severity. The less disease severity was established when a higher amount of precipitation before sowing occurred.

In our study, similar results were obtained. No visible disease symptoms when a high amount of precipitation in April 2018 were recorded. Meanwhile, dry conditions in 2019 and 2020 spring probably resulted in the occurrence of Ascochyta blight. The pea cultivars showed different susceptibility to Ascochyta blight. Our results are comparable with Olle and Sooväli (2020) where the incidence of Ascochyta blight in field peas is dependent on the cultivar. In the present study, 3795-3 (Egle DS), 3637-2 (Lina DS) and 3784-1 were more resistant to Ascochyta blight on above-ground plants and pods, while commercial cultivars Astronaute, Ingrid and Jára DS were more sensitive. Fungicide seed and foliar treatment to 67.8% and 12.8% reduced Ascochyta blight severity on plants in 2019 and 2020, respectively. According to other authors, Ascochyta blight severity in peas was significantly reduced by seed treatment and/or by fungicide application (Česnulevičienė et al. 2014).

### Table 1. Seedling blight and foot rot disease index (%) in field pea during 2018–2020.

| Pea cultivars/lines BBCH 15 | 2018 | 2019 | 2020 | BBCH 79–81 | 2018 | 2019 | 2020 |
|----------------------------|------|------|------|------------|------|------|------|
| **Untreated**              |      |      |      |            |      |      |      |
| Astronaute                 | 0.8  | 9.3  | 8.4  | 24.0       | 79.8 | 54.8 |
| Júra DS                    | 4.3  | 5.3  | 11.0 | 28.0       | 58.6 | 56.4 |
| Ingrid                     | 1.3  | 10.0 | 8.4  | 38.5       | 73.6 | 57.4 |
| 3637-2 (Lina DS)           | 1.3  | 8.5  | 11.6 | 23.0       | 66.8 | 52.6 |
| 3784-1                     | 1.0  | 5.5  | 6.8  | 38.5       | 63.0 | 62.0 |
| 3795-3 (Egle DS)           | 1.0  | 6.0  | 8.6  | 24.5       | 59.8 | 57.8 |
| **LSD**                    | 3.24 | 4.13 | 4.14 | 11.69      | 15.55| 8.56 |
| **Treated**                |      |      |      |            |      |      |      |
| Astronaute                 | 0.3  | 4.0  | 4.0  | 19.5       | 76.6 | 55.6 |
| Júra DS                    | 1.0  | 4.5  | 3.8  | 23.5       | 55.8 | 54.2 |
| Ingrid                     | 1.8  | 6.8  | 3.8  | 34.5       | 70.6 | 57.0 |
| 3637-2 (Lina DS)           | 0.8  | 3.3  | 4.4  | 21.0       | 56.6 | 51.6 |
| 3784-1                     | 0.0  | 2.3  | 4.2  | 34.0       | 61.4 | 59.6 |
| 3795-3 (Egle DS)           | 0.8  | 2.3  | 3.2  | 17.5       | 55.6 | 55.9 |
| **LSD**                    | 2.64 | 3.05 | 2.38 | 12.04      | 11.39| 6.33 |

Note: LSD – least significant difference.

### Table 2. Ascochyta blight severity (%) in field pea during 2018–2020.

| Pea cultivars/lines Plants | 2018 | 2019 | 2020 | Pods | 2018 | 2019 | 2020 |
|----------------------------|------|------|------|------|------|------|------|
| **Untreated**              |      |      |      | **Treated** |      |      |      |
| Astronaute                 | 0    | 9.57 | 15.55| 0.02 | 0.55 | 0.24 |
| Júra DS                    | 0    | 6.79 | 19.00| 0.02 | 0.47 | 0.17 |
| Ingrid                     | 0    | 8.55 | 10.71| 0.01 | 0.27 | 0.32 |
| 3637-2 (Lina DS)           | 0    | 6.87 | 10.05| 0.02 | 0.26 | 0.10 |
| 3784-1                     | 0    | 6.06 | 8.20 | 0.01 | 0.36 | 0.09 |
| 3795-3 (Egle DS)           | 0    | 5.52 | 10.66| 0.04 | 0.29 | 0.04 |
| **LSD**                    | 1.52*| 3.88*|      | 0.03 | 0.17 | 0.14*|
| **Treated**                |      |      |      | **Treated** |      |      |      |
| Astronaute                 | 0    | 3.16 | 14.87| 0.03 | 0.19 | 0.13 |
| Júra DS                    | 0    | 3.09 | 10.45| 0.01 | 0.11 | 0.12 |
| Ingrid                     | 0    | 3.62 | 11.37| 0.01 | 0.07 | 0.14 |
| 3637-2 (Lina DS)           | 0    | 2.21 | 9.85 | 0.01 | 0.13 | 0.07 |
| 3784-1                     | 0    | 2.91 | 8.22 | 0.01 | 0.08 | 0.09 |
| 3795-3 (Egle DS)           | 0    | 1.89 | 9.30 | 0.01 | 0.10 | 0.01 |
| **LSD**                    | 0.84*| 5.04 |      | 0.02 | 0.04*| 0.09 |

Note: LSD – least significant difference at * – P < 0.05 and ** – P < 0.01.
Brauna-Morževska et al. (2019) specified that non-host-specific *Botrytis cinerea* was identified on 586 plant genera including field peas as well. This fungus causes a grey mould on leaves and pods. In our experiment damaged plants and pods by grey mould were more severe in the last experiment year (Table 3) when favourable weather conditions for *B. cinerea* infection dominated. Cool and moist weather conditions are favourable for the spreading of infection through the plant (Brauna-Morževska et al. 2019). In 2020 breeding lines 3637-2 (Lina DS), 3795-3 (Egle DS) and 3784-1 showed some resistance to grey mould, while Astronaute and Jūra DS were more sensitive to this disease. Jūra DS and 3795-3 (Egle DS) were less damaged by grey mould on pods, while 3637-2 (Lina DS) was more sensitive.

Pea grain yield was significantly affected by cultivar and breeding line, experiments year and growing conditions (2 backgrounds: natural disease infection and diseases under control) (Table 4). New breeding lines produced significantly higher yields than commercial cultivars, while dry weather conditions prevailed during the active pea growth period in 2018 and 2019. Meanwhile, when moisture during the active growing period of peas was sufficient, the new breeding lines and commercial cultivars gave similar grain yields with no differences. It is noted by other authors that a dry season resulted in a higher yield loss of field peas than at the wet season (Salam et al. 2011). Experiments year 2018 was not favourable for disease occurrence in pea; therefore, at low infection level in peas differences between yield at 2 different infection backgrounds was not established in tested cultivars. Meanwhile in 2020 when infection in peas was quite severe, a tangible effect of disease control during the season was established. Based on the results obtained in field trials over

### Table 3. Grey mould (*Botrytis cinerea*) severity (%) in field peas during 2018–2020.

| Pea cultivars/lines | Plants | Pods |
|---------------------|--------|------|
|                     | 2018   | 2019 | 2020 | 2018 | 2019 | 2020 |
| Untreated Astronaute | 0      | 0.36 | 9.06 | 0.00 | 0.02 | 5.31 |
| Jūra DS             | 0      | 0.13 | 10.11| 0.00 | 0.01 | 2.70 |
| Ingrid              | 0      | 0.16 | 7.47 | 0.00 | 0.03 | 5.04 |
| 3637-2 (Lina DS)    | 0      | 0.01 | 5.25 | 0.02 | 0.02 | 9.14 |
| 3784-1              | 0      | 0.06 | 5.63 | 0.00 | 0.03 | 4.39 |
| 3795-3 (Egle DS)    | 0      | 0.06 | 5.68 | 0.14 | 0.02 | 2.98 |
| LSD                 | 0.24   | 2.69 | 0.07 | 0.02 | 2.88 |
| Treated Astronaute  | 0      | 0.11 | 6.35 | 0.00 | 0.01 | 3.10 |
| Jūra DS             | 0      | 0.00 | 6.83 | 0.00 | 0.00 | 2.65 |
| Ingrid              | 0      | 0.16 | 5.71 | 0.01 | 0.00 | 3.09 |
| 3637-2 (Lina DS)    | 0      | 0.01 | 5.45 | 0.01 | 0.00 | 4.33 |
| 3784-1              | 0      | 0.05 | 5.46 | 0.00 | 0.00 | 4.25 |
| 3795-3 (Egle DS)    | 0      | 0.07 | 4.98 | 0.01 | 0.00 | 1.10 |
| LSD                 | 0.12   | 1.39 | 0.01 | 0.01 | 1.17 |

Note: LSD – least significant difference at *–* P < 0.05 and **–** P < 0.01.

### Table 4. Grain yield of field peas during 2018–2020.

| Pea cultivars/lines | Treatment | Grain yield (t ha⁻¹) | Average | Average grain yield increase. t ha⁻¹ |
|---------------------|-----------|----------------------|---------|-----------------------------------|
|                     | 2018      | 2019   | 2020   |                                   |
| Astronaute          | Untreated | 3.59   | 3.82   | 5.22 | 4.21 | – |
|                     | Treated   | 3.64   | 3.84   | 5.59 | 4.36 | 0.15 |
| Jūra DS             | Untreated | 3.97   | 3.77   | 4.64 | 4.13 | – |
|                     | Treated   | 4.13   | 3.78   | 4.83 | 4.25 | 0.12 |
| Ingrid              | Untreated | 3.44   | 3.49   | 4.72 | 3.88 | – |
|                     | Treated   | 3.59   | 4.08   | 5.12 | 4.26 | 0.38 |
| 3637-2 (Lina DS)    | Untreated | 4.44   | 4.35   | 4.71 | 4.50 | – |
|                     | Treated   | 4.47   | 4.67   | 5.40 | 4.85 | 0.35 |
| 3784-1              | Untreated | 4.78   | 4.39   | 5.00 | 4.72 | – |
|                     | Treated   | 4.78   | 4.49   | 5.29 | 4.85 | 0.13 |
| 3795-3 (Egle DS)    | Untreated | 4.75   | 5.09   | 4.70 | 4.85 | – |
|                     | Treated   | 4.79   | 5.15   | 5.46 | 5.13 | 0.28 |

A factor LSD = 0.199**, B factor LSD = 0.089**, C factor LSD = 0.126**, AxC Interaction LSD = 0.267**. Notes: Factor A – pea cultivar/line; Factor B – treatment; Factor C – investigation year; LSD – least significant difference at **–** P < 0.01.
three years all three breeding lines 3637-2, 3784-1 and 3795-3 showed significantly higher yield increases than grown commercial cultivars. Ascocytta complex was identified as dominating pathogenic fungi in field peas harvested grains in our experiments in all tested years, followed by *Fusarium* spp. and in the lowest amounts *Botrytis* spp. (Table 5).

In our study, from the Fusarium complex, *Fusarium poae* dominated in damaging harvested pea grains in all experimental years. The pathogenic fungi on harvested grains varied during the experimental year. A higher amount of precipitation during the vegetation period in 2020 (Figure 1) increased pathogenic fungi infection on harvested pea grains. According to Marcinikowska (2008) precipitations increased the frequency of infected seeds, especially in locations with higher precipitation and where lower temperatures dominated. The results of our analyses show a slight tendency that 3795-3 (Egle DS) harvested grains were less damaged by the Ascocytta complex, whereas Ingrid and 3637-2 (Lina DS) were more sensitive to this pathogen.

*Didymella pisi* was dominated the specie of the Ascocytta complex on harvested grain in all experimental years, while *Mycosphaerella pinodes* and *Phoma pinodella* in has higher amounts found in 2020 only (Table 6). Previous studies carried out in two locations in Lithuania showed differences in the prevalence of Ascocytta species on pea grains. *D. pisi* was more common in the middle of Lithuania (Dotnuva), while *M. pinodes* and *P. pinodella* in south part of Lithuania (Perloja) (Česnulevičienė et al. 2014). The infection level of *Ascocytta* species on pea grains was not high; therefore, the susceptibility of tested breeding lines and cultivars was not reflected during the study period. In Poland also no clear response was established of pea cultivars to Ascocytta blight fungi occurrence on seeds (Marcinkowska 2008). Distribution of these fungi can be caused not only by cultivar but also by weather conditions (Marcinkowska et al. 2009).

**According to the three-year results found in the present study, a few messages can be presented**

Seedling blight and foot rot occurred during research years. Dry and cool weather conditions at field peas sowing and germination increased the risk for seedling blight infection and seed treatment with plant protection product was targeted. When at sowing and crop germination wet and warm weather prevailed risk of seedling blight infection was low and seed treatment was insignificant. The footrot index before the harvest was high for all cultivars and breeding lines and no seed treatment efficacy was fixed.

The field peas during the season were damaged by Ascocytta blight at different intensities depending on the year cultivar/breeding line and diseases control efficacy. Ascocytta complex was identified as dominating pathogenic fungus on field peas harvested grains as well and *D. pisi* specie prevailed.

Pea grain yield was significantly affected by cultivar/breeding line, experiments year and growing conditions. When dry weather conditions prevailed during the active

| Table 5. Harvested grains infection in field pea during 2018–2020. |
|---------------------------------------------------------------|
| Pea cultivars/lines | **Fusarium pp.** | **Ascocytta species** | **Botrytis spp.** |
| | Untreated | Treated | Untreated | Treated | Untreated | Treated |
|---|---|---|---|---|---|---|
| 2018 | | | | | | |
| Astronave | 0 | 0 | 0.5 ± 0.6 | 0.3 ± 0.5 | 0.5 ± 0.6 | 0 |
| Jūra DS | 0.3 ± 0.5 | 0 | 1.3 ± 1.9 | 0 | 0 | 0.3 ± 0.5 |
| Ingrid | 0.3 ± 0.5 | 0 | 10.3 ± 3.3 | 0 | 0.3 ± 0.5 | 0 |
| 3637-2 (Lina DS) | 0.3 ± 0.5 | 0 | 0.3 ± 0.5 | 0 | 0.3 ± 0.5 | 0 |
| 3784-1 | 0 | 0 | 1.0 ± 1.2 | 0 | 0 | 0.5 ± 1.0 |
| 3795-3 (Egle DS) | 0.3 ± 0.5 | 0 | 0.5 ± 0.6 | 0 | 0 | 0.5 ± 0.6 |
| 2019 | | | | | | |
| Astronave | 0 | 0 | 3.5 ± 1.9 | 0 | 0 | 0 |
| Jūra DS | 0.3 ± 0.5 | 0 | 2.3 ± 1.3 | 0.3 ± 0.5 | 0 | 0.3 ± 0.5 |
| Ingrid | 0 | 0 | 3.5 ± 1.9 | 0.5 ± 0.6 | 0.3 ± 0.5 | 0 |
| 3637-2 (Lina DS) | 0.3 ± 0.5 | 0 | 1.5 ± 0.6 | 0 | 0 | 0 |
| 3784-1 | 0.2 ± 0.5 | 0 | 2.5 ± 1.3 | 0.3 ± 0.5 | 0.3 ± 0.5 | 0 |
| 3795-3 (Egle DS) | 0.2 ± 0.6 | 0 | 2.3 ± 1.7 | 0.2 ± 1.0 | 0 | 0 |
| 2020 | | | | | | |
| Astronave | 3.75 ± 2.8 | 2.75 ± 2.1 | 5.8 ± 3.8 | 2.3 ± 1.3 | 0.25 ± 0.5 | 1.0 ± 2.0 |
| Jūra DS | 5.0 ± 2.2 | 2.0 ± 2.2 | 3.0 ± 2.4 | 2.8 ± 1.7 | 0.25 ± 0.5 | 0 |
| Ingrid | 3.5 ± 1.9 | 3.75 ± 1.5 | 5.3 ± 0.5 | 3.5 ± 2.5 | 0 | 0 |
| 3637-2 (Lina DS) | 3.5 ± 1.3 | 3.75 ± 1.5 | 12.5 ± 1.7 | 3.5 ± 1.3 | 0 | 0.5 ± 0.6 |
| 3784-1 | 0.25 ± 0.5 | 0.25 ± 0.5 | 7.5 ± 2.4 | 5.8 ± 2.9 | 0.25 ± 0.5 | 0.75 ± 0.9 |
| 3795-3 (Egle DS) | 2.25 ± 1.7 | 1.75 ± 1.0 | 2.8 ± 1.3 | 1.0 ± 1.4 | 0.5 ± 0.6 | 0.25 ± 0.5 |

Note: ± Standard deviation.
pea growth period, new breeding lines produced a higher grain yield than commercial cultivars. Meanwhile, when moisture during the active growing period of peas was sufficient, the new breeding lines and commercial cultivars gave similar grain yields. This finding indicates higher drought stress tolerance of tested breeding lines. Seasonal challenges obligate more focus on stress-resistant cultivars in the North region as well.

The highest yield difference between growing conditions (natural field infection and under disease control) was recorded in 2020 when Ascochyta blight and Grey mould gave the most severe attack. This finding illustrates the importance of disease control during severe attacks, but for correct control time forecast about infection, risk is important.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This project has received funding from European Regional Development Fund under a grant agreement with the Research Council of Lithuania (LMT LT) through the high-level R&D project ‘Enhancement of the multifunctional properties of legumes in feed and food value chains’ (SmartLegume) [grant number 01.2.2-LMT-K-718-01-0068].

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**Kristyna Razbadauskienė** is a junior researcher at the Cereal Breeding Department in the Institute of Agriculture, of the Lithuanian Agricultural and Forestry Research Centre (LAMMC). With the co-authors, she developed 6 varieties of spring barley and 11 varieties of winter wheat. Also, with co-authors, she developed the pea varieties ‘Ingrid’ and ‘Jūra DS’, and she is the author of the pea cultivars ‘Lina DS’ and ‘Egle DS’. The main direction of work is the breeding and seed production of sown peas and the maintenance of bean breeder seeds.

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Table 6. Ascochyta species distribution on harvested grains of peas during 2018–2022.

| Pea cultivars/lines | Mycosphaerella pinodes | Didymella pinisi | Phoma pinodella |
|---------------------|------------------------|-----------------|-----------------|
|                     | Untreated | Treated | Untreated | Treated | Untreated | Treated |
| 2018                |
| Astronaute 0.0      | 0.0       | 0.0     | 0.5±0.6 | 0.3±0.5 | 0.0       | 0.0     |
| Jūra DS 0.0         | 0.0       | 0.0     | 1.3±1.9 | 0.0     | 0.0       | 0.0     |
| Ingrid 0.3±0.5      | 0.0       | 0.0     | 9.8±2.6 | 0.0     | 0.3±0.5 | 0.0     |
| 3637–2 (Lina DS)    | 0.0       | 0.0     | 0.3±0.5 | 0.0     | 0.0       | 0.0     |
| 3784–1              | 0.0       | 0.0     | 1.0±1.2 | 0.0     | 0.0       | 0.0     |
| 3795–3 (Egle DS)    | 0.0       | 0.0     | 0.5±0.6 | 0.0     | 0.0       | 0.0     |
| 2019                |
| Astronaute 0.0      | 0.0       | 0.0     | 3.5±1.9 | 0.0     | 0.0       | 0.0     |
| Jūra DS 0.0         | 0.0       | 0.0     | 2.3±1.3 | 0.3±0.5 | 0.0       | 0.0     |
| Ingrid 35±1.9       | 0.0       | 0.0     | 2.3±1.9 | 0.5±0.6 | 0.0       | 0.0     |
| 3637–2 (Lina DS)    | 0.0       | 0.0     | 1.5±1.6 | 0.0     | 0.0       | 0.0     |
| 3784–1              | 0.0       | 0.0     | 2.5±1.3 | 0.3±0.5 | 0.0       | 0.0     |
| 3795–3 (Egle DS)    | 0.0       | 0.0     | 2.3±1.7 | 0.5±1.0 | 0.0       | 0.0     |
| 2020                |
| Astronaute 0.5±1.0  | 0.0       | 0.0     | 1.5±1.3 | 1.0±0.8 | 3.8±2.9  | 1.3±0.9 |
| Jūra DS 0.8±0.6     | 0.0       | 0.0     | 1.5±1.3 | 0.3±0.5 | 0.8±1.5  | 2.5±1.9 |
| Ingrid 35±0.5       | 0.0       | 0.0     | 2.3±1.9 | 1.0±1.2 | 2.8±0.5  | 2.5±2.5 |
| 3637–2 (Lina DS)    | 35±0.5    | 0.3±0.5 | 10.2±2.5| 3.0±0.5 | 2.0±1.4  | 1.0±1.4 |
| 3784–1              | 0.0       | 0.3±0.5 | 4.3±2.2 | 2.0±2.2 | 3.3±4.5  | 3.5±2.4 |
| 3795–3 (Egle DS)    | 0.0       | 0.0     | 1.5±0.6 | 0.3±0.5 | 1.3±0.5  | 0.8±1.5 |

Note: ± Standard deviation.
management systems and the investigation of legumes, potato and sugar beet growing technology.

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Lina Šarūnaitė (Ph.D.) is a senior researcher at the Department of Plant Nutrition and Agroecology, in the Institute of Agriculture, of the Lithuanian Agricultural and Forestry Research Centre (LAMMC). Her research expertise includes the investigation of legume plants intended for multifunctional use, yield formation, biological nitrogen fixation and accumulation and the investigation of biodiversity formation and variation in grassland and field swards in agro-landscapes differing in genesis and sustainability. She conducts research in legume crop cultivation technologies, investigates biologically fixed nitrogen by legumes and N use efficiency to seek a cleaner environment and quality of production.

Žydrė Kadžiužienė (Ph.D.) is a chief researcher (since 2009) of the Lithuanian Agricultural and Forestry Research Centre (LAMMC), a member of the Lithuanian Academy of Sciences, a member of the Editorial Board in the scientific journal ‘Zemdirbystė-Agriculture’, Acta Agriculturae Scandinavica, Section B – Soil & Plant Science, referee in a number of the scientific journals in the area of agriculture, supervision and co-supervision of Ph.D. students. Research activities focus on agriculture in the context of climate change and bioeconomy, agronomy, agroeconomy and environmental fields. Last research projects: Horizon 2020 ‘EJP SOIL’, 2020–2024, Horizon 2020 ‘Fostering sustainable legume-based farming systems and agri-feed and food chains in the EU’ (LEGALVALUE), 2016–2017, participant and coordinator of LAMMC part, High-level R&D project (SMART) funded by the Lithuanian Research Council ‘Enhancement of the multifunctional properties of legumes in feed and food value chains’ (SmartLegume), 2017–2021, project leader. Publications with the most relevant contributions: during the last ten years, about 70, and 37 of them – with citation index journals, published in various popular publications and co-developed a number of technological recommendations for agricultural production, participated in many national and international conferences, where the presented oral and poster reports.

References

Brauna-Morževaska E, Bankina B, Kaneps J. 2019. Botrytis genus fungi as causal agents of legume diseases: a review. Res Rural Develop. 2:63–69. DOI: 10.22616/rzd.25.2019.050.

Bretag TW, Keane PJ, Price TV. 2006. The epidemiology and control of ascochyta blight in field peas: a review. Aust J Agric Res. 57(8):883–902. DOI: 10.1071/AR05222.

Česnulevičienė R, Gaurilkiškienė I, Ramanauskienė J. 2014. Control of ascochyta blight (Ascochyta complex) in pea under Lithuanian conditions. Zemdirb Agric. 101(1):101–108. DOI: 10.13080/z-a.2014.101.014.

Davidson JA, Hartley D, Priest M, Krysinska-Kaczmarek M, Herdina D, McKay A, Scott ES. 2009. A new species of Phomacaus ascochyta blight symptoms on field peas (Pisum sativum) in South Australia. Mycologia. 101(1):120–128. DOI: 10.3852/07-199.

Gaurilkiškienė I, Janušauskaitė D, Česnulevičienė R, Ramanauskienė J. 2008. The suppression of stem base and root rot diseases of pea as affected by fungicidal seed treatment. Zemdirb Agric. 95(3):50–57.

Gossen B, Conner R, Chang K, Pasche J, McLaren D, Henriquez M, Chatterton S, Hwang S. 2016. Identifying and managing root rot of pulses on the northern great plains. Plant Dis. 100:1965–1978. DOI: 10.1094/PDIS-02-16-0184-FE.

Khan TN, Meldrum A, Croser JS. 2016. Pea: overview. Encyclo Food Grain (Second Edition). 1:324–333. DOI: 10.1016/B978-0-12-394437-5.00037-1.

Lake L, Guillon L, French B, Sadras VO. 2021. Field pea. Crop Physiol Case Hist Major Crops. 9:320–341. DOI: 10.1016/B978-0-12-819194-1.00009-8.

Liu J, Cao T, Feng J, Chang K-F, Hwang S-F, Strelkov SE. 2013. Characterization of the fungi associated with ascochyta blight of field pea in Alberta, Canada. Crop Protect. 54:55–64. DOI: 10.1016/j.cropro.2013.07.016.

Marcinkowska J, Boros L, Wawer A. 2009. Response of pea (Pisum sativum L.) cultivars and lines to seed infection by Ascochyta blight fungi. Plant Seed Breed Sci. 59:75–86. DOI: 10.2478/v10129-009-0006-6.

Marcinkowska J. 2008. Fungi occurrence on seed of field pea. Acta Mycol. 43(1):77–89. DOI: 10.5586/am.2008.010.

Mathur SB, Kongsdal O. 2003. Common laboratory seed health testing methods for detecting fungi.

Modderman CT, Markell S, Wunsch M, Pasche JS. 2018. Efficacy of in-furrow fungicides for management of field pea root rot caused by Fusariumavenaceum and F. solani under greenhouse and field conditions. Plant Health Prog. 19(3):212–219. DOI: 10.1094/PHP-06-18-0030-RS.

Olle M, Sooväli P. 2020. The severity of field pea diseases depending on sowing rate and variety. Acta Agricul Scand Sec B — Soil Plant Sci. 70(7):556–563. DOI: 10.1080/09064710.2020.1803958.

Sainju UM, Lenssen AW, Allen BL, Jabro JD, Stevens WB. 2019. Pea growth, yield, and quality in different crop rotations and cultural practices. Agrosyst Geosci Environ. 2:180041. DOI: 10.2134/age2018.10.0041.

Salam MU, MacLeod WJ, Maling T, Prichard I, Seymour M, Barbetti MJ. 2011. A meta-analysis of severity and yield loss from ascochyta blight on field pea in Western Australia. Australasian Plant Pathol. 40:591–600. DOI: 10.1071/s13313-011-0034-1.

Skoglund LG, Harveson RM, Chen W, Dugan F, Schwartz HF, Markell SG, Porter L, Burrows ML, Goswami R. 2011. Ascochyta blight of peas. Online. Plant Health Prog. DOI: 10.1094/PHP-2011-0330-01-RS.