Discrimination of leaf diseases affecting faba bean (Vicia faba)

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Abstract

Faba bean is susceptible to several leaf diseases caused by pathogenic fungi. With the increasing importance of faba bean in northern European cropping systems, the importance of its leaf diseases is likely to increase. The aim of this study was to discriminate the diseases and to test agronomic strategies for limiting their spread in a five-year experiment. Chocolate spot disease caused by *Botrytis* spp. and leaf blotches caused by an *Alternaria/Stemphylium* complex dominated, the severity of rust was lower, and downy mildew occurred in only one year. The severity of the diseases depended on weather conditions and cultivar, but not on sowing rate. Application of fungicides significantly decreased the severity of chocolate spot, leaf blotch and rust, but not downy mildew, and in no case was the disease progress stopped. None of the cultivars showed strong resistance to a disease. The *Alternaria/Stemphylium* leaf blotch is an emerging disease of faba bean in northern Europe. Work continues on the identification of the responsible species in the chocolate spot and leaf blotch complexes and determination of their relative importance in causing disease.

Introduction

Faba bean (*Vicia faba* L.) is one of the most important grain legumes, with the highest global average grain yield after soybean (FAOstat, 2020). Its importance in Europe is increasing (Eurostat, 2020), partly as a result of efforts to reduce reliance on imported soy protein for feed use (Watson et al., 2017).

Faba bean is affected by a wide range of leaf diseases (Stoddard et al., 2010; Plūduma-Pauniņa et al., 2018). Of these, chocolate spot (caused by *Botrytis* spp.) is the most widely written about (Stoddard et al., 2010). According to bibliometric analysis, Ascochyta blight (caused by *Didymella fabae*) and rust (caused by *Uromyces viciae-fabae*) are of approximately equal importance. Leaf blights (caused by *Alternaria* spp. and *Stemphylium* spp.), Cercospora leaf spot (caused by *Cercospora zonata*) and downy mildew (caused by *Peronospora viciae* f. sp. *fabae*) are also found. Each disease has its environmental optima (Stoddard et al., 2010), so the dominant disease varies across regions and years.

Chocolate spot is attributable to at least three species of *Botrytis*: *B. fabae*, *B. cinerea* and *B. fabiopsis* (Zhang et al., 2010), and possibly others (Bankina et al., 2017). In some conditions, grey mould caused by *B. cinerea* has been described as a separate disease (Boligłowa et al., 2016), but it is challenging to distinguish these pathogens under field conditions. Leaf blights caused by *Alternaria* spp. and *Stemphylium* spp.

have become more widely observed in recent years, suggesting an increase in distribution and destructiveness (Sheikh et al., 2015; Vasić et al., 2019) and they are well established in the Baltic region (Plūduma-Pauniņa et al., 2019). *Alternaria alternata* and *A. tenuissima* are considered the main causal agents of Alternaria leaf blight, but other species have been found (Rahman et al., 2002; Coca-Morante & Mamani-Álvarez, 2012). Similarly, several species of *Stemphylium* are associated with the disease on faba bean, including *S. botryosum*, *S. eturmiunum* and *S. vesicarium* (Sheikh et al., 2015; Caudillo-Ruiz et al., 2017; Vaghefi et al., 2020).

Meteorological conditions are one of the main limiting factors that affect disease development. In general, temperatures around 20°C, free moisture on the leaves and high (< 90%) relative humidity are optimal conditions for the development of most leaf blotch diseases (Harrison, 1988; Stoddard et al., 2010; Salam et al., 2016; Watson et al., 2017). Disease development depends also on agronomic practices, with high crop density increasing the spread of disease by reducing transmission distances and increasing canopy humidity, while intercropping can reduce the spread by intercepting propagules on non-susceptible species (Stoddard et al., 2010). Genetic resistance to diseases is the ideal way to control them, but few sources of strong or long-lasting resistance to any disease have been found in faba bean (Stoddard et al., 2010; Ijaz et al., 2018; Sudheesh et al., 2019). Hence, fungicide application is often the only available tool for controlling disease development and azoles, strobilurins and dithiocarbamates are considered effective against several leaf diseases of faba bean (Ahmed et al., 2016).

With the increasing importance of faba bean in northern European cropping systems, the importance of its leaf diseases is likely to increase. Hence, we set out to discriminate the diseases from each other, to evaluate their relative importance and to test agronomic strategies for limiting their spread in a five-year experiment.

Materials and Methods

Field trials were conducted from 2015 to 2019 at the Pēterlauki Research and Study Farm of the Latvia University of Life Sciences and Technologies (56.54°N, 23.71°E). The prevailing soil type is silty loam characterized as an Endocalcaric Abruptic Luvisol. Disease assessment was part of a larger experiment investigating agronomic strategies for optimizing yield of faba bean. Data about disease development were obtained from a three-factor experiment: cultivar ('Isabell'; 'Boxer' and 'Laura'), sowing rate (30, 40 and 50 germinable seeds m^{-2}) and fungicide (combined boscalid, 267 g kg^{-1} and pyraclostrobin, 67 g kg^{-1} application or without fungicide), with four replicates in a full factorial, randomized split block. Sowing dates were 26 March 2015, 5 April 2016, 4 April 2017, 29 April 2018 and 15 April 2019. Harvest dates were 27 August 2015, 29 August 2016, 24 September 2017, 13 August 2018, and 29 August 2019. Detailed descriptions of the trial site and agronomic practices have been published (Pluduma-Paunina et al., 2018; Pluduma-Paunina et al., 2019).

Diseases were identified by visual evaluation when symptoms were typical and by microscopic evaluation of spores obtained from infected tissues.

Development of diseases were evaluated on a 10-point scale (0: no disease symptoms, 1: 1 – 3 spots on the whole plant; 2: 4 – 6 spots on the plant; 3: up to 10% of the whole

plant covered by spots; 4: 11 – 25% of the whole plant covered by spots; 5: 26 – 50% of the whole plant covered by spots; 6: 51 – 75% of the whole plant covered by spots; 7: > 75% of the whole plant covered by spots; 8: all leaves covered with spots; 9: plant is dead) every two weeks from the time of appearance of first symptoms until crop maturity. Areas under the disease progress curves (AUDPC) were calculated (Simko & Piepho, 2012).

Temperature and amount of precipitation were recorded daily by an automatic weather station near the experimental field (Table 1) and the hydrothermal coefficient (HTC) was calculated (Vlăduţ et al., 2017) when the daily average temperature was above 10°C (Table 1). Values of HTC close to 1.0 are considered as optimal conditions, values above 1.1 as wet, and those below 0.9 as dry.

Multifactorial analysis of variance (ANOVA) was used to evaluate the influence of year, cultivar, sowing rate and fungicide use on the development of faba bean diseases using R software. The differences among factor groups were compared using Bonferroni test with alpha level of 0.05.

Results

Symptoms and disease identification

Chocolate spot disease was detected every year. Typical small reddish-brown spots and/or large necrotic blotches with reddish margins were observed on the leaves, stems and pods. In some cases, small black sclerotia were found, mostly on the pods. In wet conditions, blotches were covered with powdery grey mould that consisted of conidiophores and conidia (Fig. 1.)

Large, grey to black, necrotic and fused blotches were also observed on leaves every year. The symptoms were typical of either *Alternaria* or *Stemphylium*, so diagnosis via microscopy was necessary. Spores typical of both genera *Alternaria* and *Stemphylium* were found, indicating that they were the causal agents (Fig. 2, Fig. 3). It was not possible to distinguish the blotches caused by one or the other pathogen under field conditions, and both pathogens were isolated from the same plants and same blotches, so this disease appears to have been caused by a complex of the two pathogens and was called *Alternaria/Stemphylium* leaf blotch.

Rust infected plants every year, and was identified by its distinctive and bright orange uredo-pustules.

Downy mildew formed blotches with reddish tint on the underside of leaves in 2017 and conidiophores typical of genus *Peronospora* were found (Fig. 4).

Seasonal progress of diseases

The first symptoms of both chocolate spot and leaf blotch were observed in early June, before the start of flowering. In most years, rapid disease development started in July (end of flowering to development of pods), except in 2016, when progress of disease started earlier (Fig. 5, Fig. 6); in this season, the faba beans developed earlier and ended flowering at the end of June.

Rust appeared during pod development and its scores remained low, failing to reach 1 point until August. Downy mildew was found only in 2017 and the first symptoms were

seen in the third decade of July (development of pods). During pod ripening, disease severity ranged from 1.2–2.4 points.

The AUDPC differed widely between years (p<0.0001) (Fig. 7). The highest values for chocolate spot, leaf blotch and rust were observed in 2016. The lowest severity of chocolate spot was in 2015, only traces of leaf blotch were observed in 2017, and rust was not detected in 2018.

Cultivars showed differences in AUDPC averaged across years (p < 0.001 for leaf blotch and p < 0.0001 for the other diseases), but none could be classified as resistant (Fig. 8). Cultivar 'Laura' was the most sensitive to all observed diseases, whereas 'Boxer' was least sensitive to downy mildew but equal to 'Laura' in sensitivity to *Alternaria*/*Stemphylium* leaf blotch and chocolate spot. 'Isabell' was least sensitive to chocolate spot.

Fungicide application decreased the AUDPC of all diseases (p < 0.0001), except downy mildew, p > 0.05) (Fig. 9). Seed rate did not influence the development of any of the diseases. Treatment interactions were not statistically significant.

Discussion.

During the course of this experiment, chocolate spot was the most prevalent disease, followed by Alternaria/Stemphylium leaf blotch, while rust was minor and downy mildew was found in only one year. In two of the five years, leaf blotch symptoms were more severe than those of any other disease, indicating the need for improved knowledge about this parasite complex and how it may be controlled.

The ubiquity of chocolate spot disease was according to expectations, as was its moderate impact in three of the five years. It was most severe, with the disease index approaching 6 (> 50% of leaf area covered with spots), in 2016 and 2017. This was associated with a high HTC and heavy rainfall in early July of both years, confirming the importance of leaf wetness for the spread of this disease (Stoddard et al., 2010). Furthermore, the cool weather in July and August 2017 was associated with prolonged growth of the crop and availability of green leaves for the disease to spread, as shown by the prolonged disease score curve for that year (Figure 4). In contrast, the cool and dry weather of 2015 was associated with a low incidence of this disease.

Leaf blotch caused by *Alternaria* and *Stemphylium* spp. was observed in every year except 2017. Symptoms of *Alternaria* infection have been described as slowly increasing brown spots with concentric rings, often water-soaked (Rahman et al., 2002; Abd El-Hai, 2015) while those of *Stemphylium* infection are large, grey to black spots growing from the leaf margins (Vaghefi et al., 2020). In the present work, the leaf spots were large, dark and shapeless as the result of coalescence of smaller spots, thus showing some of the symptoms of both pathogens. Furthermore, both genera were recovered from the spots. In Australia, although two species of *Stemphylium* were recovered from leaf spots on faba bean, only some isolates of one (*S. eturmiunum*) were pathogenic in subsequent tests, and the same may be true here. In Bolivia, several species of *Alternaria* were mentioned as causal agents of leaf blotch (Coca-Morante & Mamani-Álvarez, 2012). Both genera have been found to cause significant crop damage, with more than 90% of plants affected by *Alternaria* in some fields in Japan (Rahman et al., 2002) and lethal damage attributed to *S. eturmiunum* in Australia (Vaghefi et al., 2020). Neither genus is identifiable to species level by morphological tools alone, and DNA sequence data has been used for species identification in both *Alternaria* (Woudenberg et al., 2013) and *Stemphylium* (Vaghefi et al., 2020).

In the present study, the leaf blotches were found before flowering, similar to the timing of *Stemphylium* leaf blotch in Australia (Vaghefi et al., 2020) and *Alternaria* leaf spot in Japan (Rahman et al., 2002). Although the maximum severity of *Alternaria*/*Stemphylium* leaf blotch was only 3.7 points, in contrast to 6.0 for chocolate spot, the AUDPC of leaf blotch exceeded that of chocolate spot in both 2015 and 2019. In both these years, the mean summer temperature was slightly lower and the rainfall was much lower than in 2016, the year that was particularly favourable for chocolate spot. The absence of leaf blotch in 2017 was associated with the strong presence of downy mildew and it is not possible to determine whether the absence was due to poor conditions or to the presence of the other disease. Taken together with results from several countries in different climatic zones, our results indicate that this disease complex is important and tools for its control need to be developed.

Rust disease was found every year, but only after flowering and its severity did not exceed one point. Rust is not considered a devasting disease in northern Europe, but it is an important problem in dry and warm climates (Sillero et al., 2006; Ijaz et al., 2018).

Downy mildew was found only in 2017, so it is difficult to make any conclusions about occurrence and harmfulness of this disease in the Baltic region. The 2017 growing season had the lowest mean temperature of the five years of experiments, particularly in early July temperature when the rainfall was also plentiful, leading to a combination of relatively low temperature and high humidity that is favourable for the development of this disease (Stegmark, 1995; Stoddard et al., 2010). Downy mildew is a common problem on spring-sown faba bean in the United Kingdom (Thomas et al., 1999).

There were only small differences between cultivars in response to the various diseases. Genetic resistance to chocolate spot disease is partial at best (Bouhassan et al., 2004; Kora et al., 2017) and knowledge about cultivar differences in response to *Alternaria* / *Stemphylium* leaf blotch is still very limited (Sheikh et al., 2015). The fact that both chocolate spot and leaf blotch are caused by several related pathogens with possibly different modes of infection is likely to impede breeding for resistance until more is known about both the pathogens and the host responses.

Seed rate did not influence development of any diseases in our investigations. Optimal seed rate is often considered as an important tool to reduce development of leaf diseases, because high density promotes high air humidity and leaf wetness (Stoddard et al., 2010), although Doussoulin et al. (2015) did not find correlation between density of plants and severity of diseases. Nevertheless, the relatively low seed rates in the current experiment (30 to 50 m^{-2}) may not have been enough to cause problems.

The fungicide combination (boscalid and pyraclostrobin) provided partial protection against chocolate spot, *Alternaria*/*Stemphylium* leaf blotch and rust on average, but efficacy depended on year and cultivar, with greater effectiveness in years when pathogen pressure was greater. These fungicides are not considered effective against oomycetes, so their lack of effect on downy mildew was expected.

In conclusion, these experiments have shown that *Alternaria*/*Stemphylium* leaf blotch is an emerging disease of increasing importance on faba bean in northern Europe, as also demonstrated in other countries, and that it is comparable in impact to chocolate spot disease. Each disease complex has its optima of temperature and moisture, so it should be possible to develop forecasts for the timing of disease control interventions such as the use of fungicides. The diseases are easily distinguished by their typical

symptoms. Lowering crop density was not an effective tool to reduce disease incidence and fungicide application was only partly successful. Better sources of resistance are needed if the diseases are to be controlled by genetic means. Work continues on the identification of the responsible species in the chocolate spot and leaf blotch complexes and determination of their relative importance in causing disease.

References

1. Abd El-Hai, K. M. (2015). Controlling of Alternaria leaf spot disease on faba bean using some growth substances. *Asian Journal of Plant Pathology*, *9*, 123–134. https://doi.org/10.3923/ajppaj.2015.124.134

2. Abd El-Hai, K. M., Ghoniem, A. A., El-Khateeb, A. Y., & EL-Ghamry, A. (2019). Mitigation of salinity stress and alternaria leaf spot disease in faba bean by nicotinamide. *Plant Archives*, *19*, 823–839.

3. Ahmed, S., Abang, M. M., & Maalouf, F. (2016). Integrated management of Ascochyta blight (*Didymella fabae*) on faba bean under Mediterranean conditions. *Crop Protection*, *81*, 65–69. https://doi.org/10.1016/j.cropro.2015.12.013

4. Bankina, B., Bimšteine, G., Neusa-Luca, I., Roga, A., & Fridmanis, D. (2017). Less known species of *Botrytis* spp. – the causal agents of faba bean chocolate spot. In M. Kukwa (Ed.), *Book of abstracts*. *XX Symposium of Baltic Mycologists and Lichenologists* (p. 27).

5. Boligłowa, E., Gleń-Karolczyk, K., & Gospodarek, J. (2016). Effect of intensity of broad bean protection with biopreparations against fungal diseases. *Journal of Research and Applications in Agricultural Engineering*, *61*(3), 38–42.

6. Bouhassan, A., Sadiki, M., & Tivoli, B. (2004). Evaluation of a collection of faba bean (*Vicia faba* L.) genotypes originating from the Maghreb for resistance to chocolate spot (*Botrytis fabae*) by assessment in the field and laboratory. *Euphytica*, *135*, 55–62. https://doi.org/10.1023/B:EUPH.0000009540.98531.4d

7. Caudillo-Ruiz, K. B., Bhadauria, V., & Banniza, S. (2017). Aetiology of stemphylium blight on lentil in Canada. *Canadian Journal of Plant Pathology*, *39*, 422–432. https://doi.org/10.1080/07060661.2017.1378728

8. Coca-Morante, M., & Mamani-Álvarez, F. (2012). Control of leaf spot diseases on ecotypes of faba bean (*Vicia faba* L.) produced in the Andean region of Bolivia. *American Journal of Plant Sciences*, *03*, 1150–1158. https://doi.org/10.4236/ajps.2012.38139

9. Doussoulin, H., Andrade, N., & Acuña, R. (2015). Influencia de la fecha y densidad de siembra sobre el desarrollo de patógenos presentes en cultivares de haba (*Vicia faba* L.) de crecimiento determinado. *Agro Sur*, *43*, 25–30. https://doi.org/10.4206/agrosur.2015.v43n1-04

10. Eurostat. (2020). *Agriculture database* [database]. Retrieved from: https://ec.europa.eu/eurostat/data/database, visited 24 November 2020

11. FAOstat. (2020) Crops database [database] Retrieved from: http://www.fao.org/faostat/en/#data, visited 24 November 2020

12. Harrison, J. G. (1988). The biology of *Botrytis* spp. on *Vicia* beans and chocolate spot disease - a review. *Plant Pathology 37*, 168 - 201. https://doi.org/10.1111/j.1365-3059.1988.tb02064.x.

13. Ijaz, U., Adhikari, K.N., Stoddard, F.L. & Trethowan, R.M. 2018. Rust resistance in faba bean (*Vicia faba* L.): status and strategies for improvement. *Australasian Plant Pathology, 47*, 71-81. https://doi.org/10.1007/s13313-017-0528-6

14. Karkanis, A., Ntatsi, G., Lepse, L., Fernández, J. A., Vågen, I. M., Rewald, B., Alsiņa, I., Kronberga, A., Balliu, A., Olle, M., Bodner, G., Dubova, L., Rosa, E., & Savvas, D. (2018). Faba bean cultivation – revealing novel managing practices for more sustainable and competitive European cropping systems. *Frontiers in Plant Science 9*, 1115. https://doi.org/10.3389/fpls.2018.01115

15. Plūduma-Pauniņa, I., Gaile, Z., Bankina, B., & Balodis, R. (2018). Field bean (*Vicia faba* L.) yield and quality depending on some agrotechnical aspects. *Agronomy Research*, *16*, 212–220. https://doi.org/10.15159/AR.18.035

16. Plūduma-Pauniņa, I., Gaile, Z., Bankina, B., & Balodis, R. (2019). Variety, seeding rate and disease control affect faba bean yield components. *Agronomy Research*, *17*, 621–634. https://doi.org/10.15159/AR.19.079

17. Rahman, M. Z., Honda, Y., Islam, S. Z., Muroguchi, N., & Arase, S. (2002). Leaf spot disease of broad bean (*Vicia faba* L.) caused by *Alternaria tenuissima* — A new disease in Japan. *Journal of General Plant Pathology*, *68*, 31–37. https://doi.org/10.1007/PL00013049

18. Salam, M. U., Day, T. K., Ahmed, A. U., Nessa, B., Haque, A. H. M. M., Subedi, S., Malik, A. I., Rahman, M. M., & Erskine, W. (2016). Stempedia: a weather-based model to explore and manage the risk of lentil Stemphylium blight disease. *Australasian Plant Pathology*, *45*, 499–507. https://doi.org/10.1007/s13313-016-0434-3

19. Sheikh, F., Dehghani, H., & Aghajani, M. A. (2015). Screening faba bean (*Vicia faba* L.) genotypes for resistance to Stemphylium blight in Iran. *European Journal of Plant Pathology*, *143*, 677–689. https://doi.org/10.1007/s10658-015-0718-4

20. Sillero, J. C., Fondevilla, S., Davidson, J., Vaz Patto, M. C., Warkentin, T. D., Thomas, J., & Rubiales, D. (2006). Screening techniques and sources of resistance to rusts and mildews in grain legumes. *Euphytica*, *147*, 255–272. https://doi.org/10.1007/s10681-006-6544-1

21. Simko, I., & Piepho, H. P. (2012). The area under the disease progress stairs: Calculation, advantage, and application. *Phytopathology*, *102*, 381–389. https://doi.org/10.1094/PHYTO-07-11-0216

22. Stegmark, R. (1994) Downy mildew on peas (*Peronospora viciae* f.sp. *pisi*). *Agronomie, 14*, 641-647.

23. Stoddard, F. L., Nicholas, A. H., Rubiales, D., Thomas, J., & Villegas-Fernández, A. M. (2010). Integrated pest management in faba bean. *Field Crops Research 115*, 308–318. https://doi.org/10.1016/j.fcr.2009.07.002

24. Sudheesh, S., Kimber, R.B.E., Braich, S., Forster, J W., Paull, J.G. & Kaur, S. 2019. Construction of an integrated genetic linkage map and detection of quantitative trait loci for ascochyta blight resistance in faba bean (*Vicia faba* L.). *Euphytica 215*, 42.

25. Thomas, J.E., Kenyon, D.M. & Kightley, S.P.J. (1999). Progress in the exploitation of disease resistance in oilseed rape, field peas and field beans. *Aspects of Applied Biology* 56, 67-74.

26. Vaghefi, N., Thompson, S.M., Kimber, R.B.E., Thomas, G.J., Kant, P., Barbetti, M.J. & van Leur, J.A.G. 2020. Multilocus phylogeny and pathogenicity of *Stemphylium* species associated with legumes in Australia. *Mycological Progress 19*, 381 – 396. https://doi.org/10.1007/s11557-020-01566-8

27. Vasić, T., Živković, J., Marković, J., Stanojević, I., Filipović, S., & Terzić, D. (2019). Phytopathogenic fungi causers fungal diseases of the faba bean (*Vicia faba* L.) in Serbia. *Biologica Nyssana 10*, 17–21. https://doi.org/10.5281/zenodo.3463990

28. Vlăduţ, A., Nikolova, N., & Licurici, M. (2017). Aridity assessment within southern Romania and northern Bulgaria. *Hrvatski Geografski Glasnik/Croatian Geographical Bulletin*, *79*, 5–26. https://doi.org/10.21861/HGG.2017.79.02.01

29. Watson, C. A., Reckling, M., Preissel, S., Bachinger, J., Bergkvist, G., Kuhlman, T., Lindström, K., Nemecek, T., Topp, C. F. E., Vanhatalo, A., Zander, P., Murphy-Bokern, D., & Stoddard, F. L. (2017). Grain Legume Production and Use in European Agricultural Systems. *Advances in Agronomy* 144, 235–303. https://doi.org/10.1016/bs.agron.2017.03.003

30. Woudenberg, J.H.C., Groenewald, J.Z., Binder, M. & Crous, P.W. (2013). *Alternaria* redefined. *Studies in Mycology* 75, 171 – 212. https://doi.org/10.3114/sim0015

31. Zhang, J., Wu, M.-D., Li, G.-Q., Yang, L., Yu, L., Jiang, D.-H., Huang, H.-C., & Zhuang, W.-Y. (2010). *Botrytis fabiopsis*, a new species causing chocolate spot of broad bean in central China. *Mycologia*, *102*, 1114–1126. https://doi.org/10.3852/09-217

Table 1. Average temperature (°C), amount of precipitation (mm) and hydrothermal coefficient (HTC) during the growing season at the Pēterlauki Research and Study farm of the Latvia University of Life Sciences and Technologies.

Month	Decade	2015			2016			2017			2018			2019		
		°C	mm	HTC	°C	mm	HTC	°C	mm	HTC	°C	mm	HTC	°C	mm	HTC
April	I	4.3	16.0	3.8	7.2	9.0	1.3	7.6	2.5	0.3	6.4	35.5	5.6	5.2	0.0	0.0
	II	6.2	16.5	2.7	7.0	21.5	3.1	2.0	11.0	5.5	10.5	14.0	1.3	5.7	0.0	0.0
	III	9.5	24.6	2.6	5.7	32.5	5.7	4.8	25.0	5.2	10.1	20.0	2.0	13.4	0.0	0.0
May	I	10.6	11.4	1.1	14.0	0.2	0.0	7.7	1.0	0.1	13.8	8.0	0.6	8.1	5.2	0.6
	II	9.8	25.4	2.6	12.2	20.5	1.7	12.4	6.5	0.5	16.4	4.0	0.2	14.2	10.0	0.7
	III	12.2	17.7	1.3	17.0	15.0	0.8	14.4	16.0	1.0	17.9	0.0	0.0	14.7	5.8	0.4
June	I	14.5	1.0	0.1	14.0	18.0	1.3	13.7	24.0	1.8	16.3	2.0	0.1	19.3	3.0	0.2
	II	15.2	4.7	0.3	15.4	22.5	1.5	16.5	13.5	0.8	18.2	1.0	0.1	20.6	3.2	0.2
	III	14.6	10.0	0.7	21.0	47.0	2.2	15.0	12.0	0.8	15.9	12.6	0.8	18.4	4.6	0.3
July	I	18.5	27.2	1.5	18.0	80.0	4.4	14.8	43.0	2.9	16.7	16.4	1.0	14.9	29.0	2.0
	II	15.6	27.5	1.8	17.8	20.0	1.1	15.9	23.0	1.4	22.2	16.2	0.7	16.0	48.2	3.0
	III	16.5	19.3	1.1	20.1	45.0	2.0	19.1	17.0	0.8	23.7	1.0	0.0	19.4	23.8	1.1
August	I	20.4	1.0	0.0	17.4	66.1	3.8	18.2	22.2	1.2	23.4	6.0	0.3	15.5	31.6	2.0
	II	17.6	1.8	0.1	16.9	45.5	2.7	17.1	4.8	0.3	18.5	13.2	0.7	18.5	1.4	0.1
	III	18.5	2.9	0.2	17.2	17.0	1.0	15.0	4.0	0.3	16.7	9.2	0.6	18.5	4.8	0.3

Figures

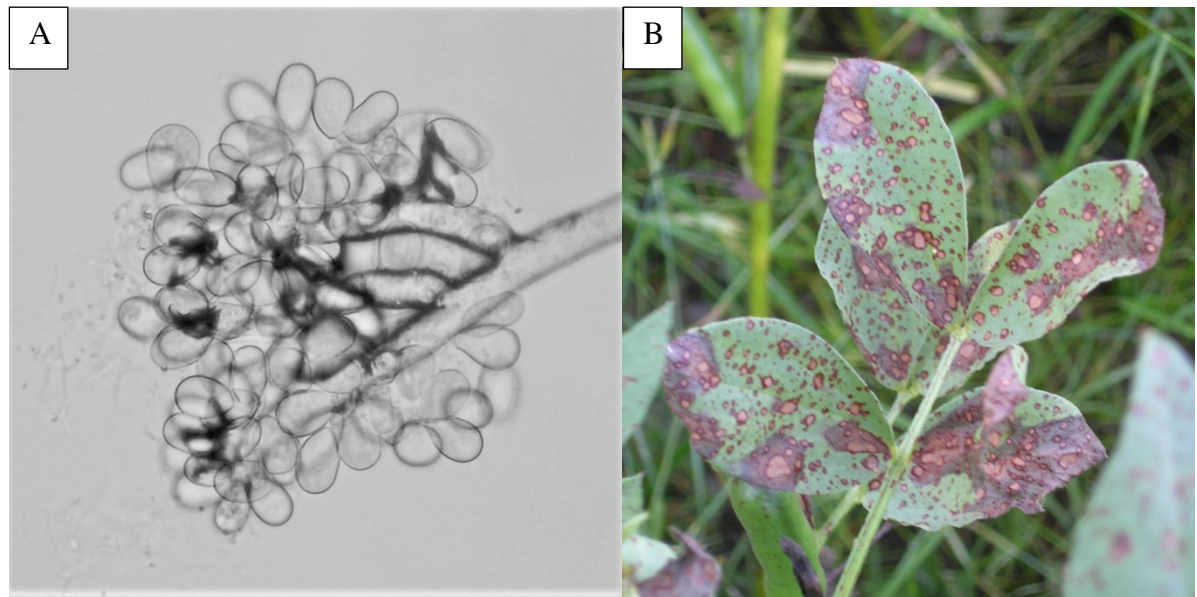Fig. 1. *Botrytis* spp., (A) conidiophores and conidia (magnification ×40) and (B) symptoms of chocolate spot disease on a leaf.

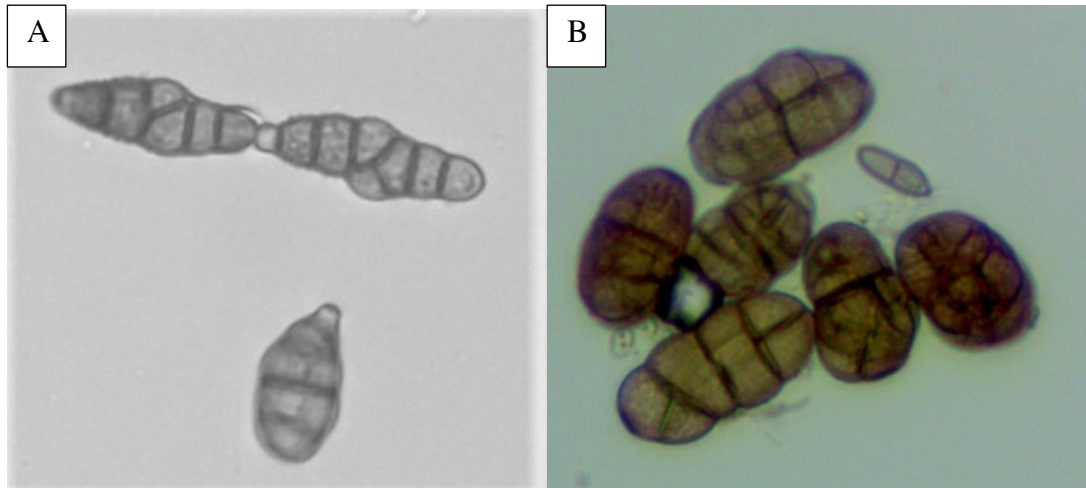Fig. 2. Symptoms of the leaf blotch, caused by *Alternaria*/*Stemphylium* complex.

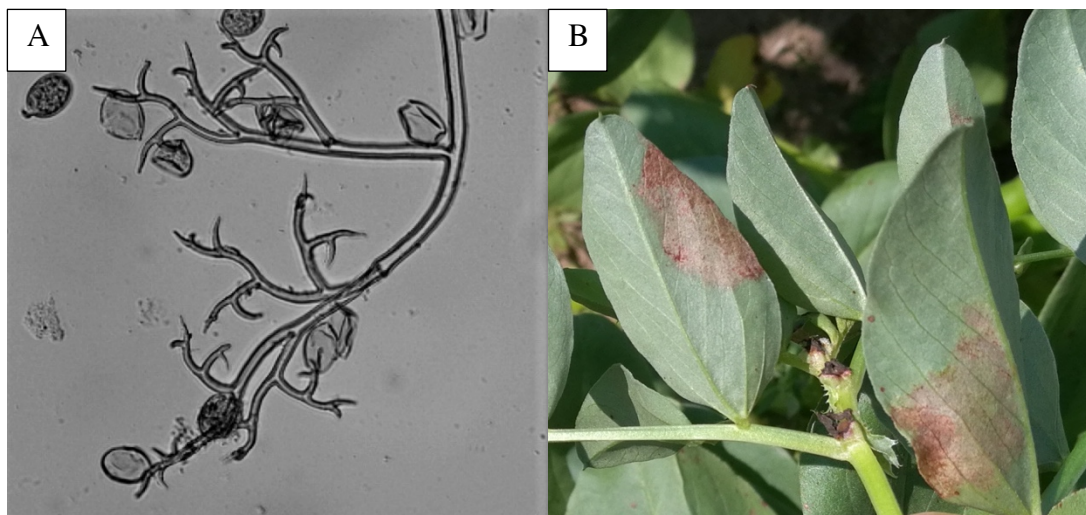Fig. 3. Conidia of (A) *Alternaria* sp. and (B) *Stemphylium* sp. (magnification ×40).

Fig. 4. *Peronospora viciae*, (A) sporophores with sporangia (magnification ×40) and (B) symptoms of downy mildew disease on a leaf.
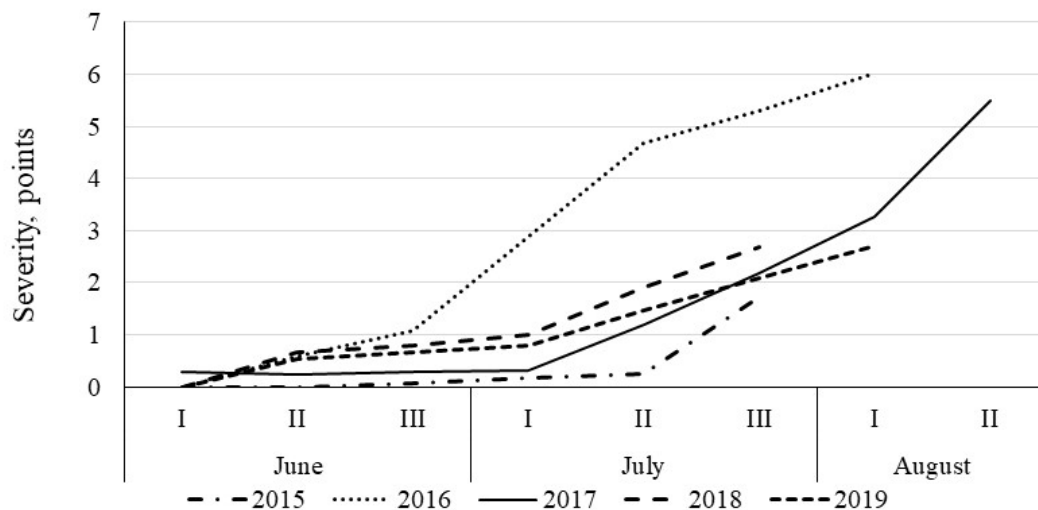
Fig. 5. Dynamics of development of chocolate spot, caused by *Botrytis* spp. in untreated plots. Data show means across cultivars and plant densities.
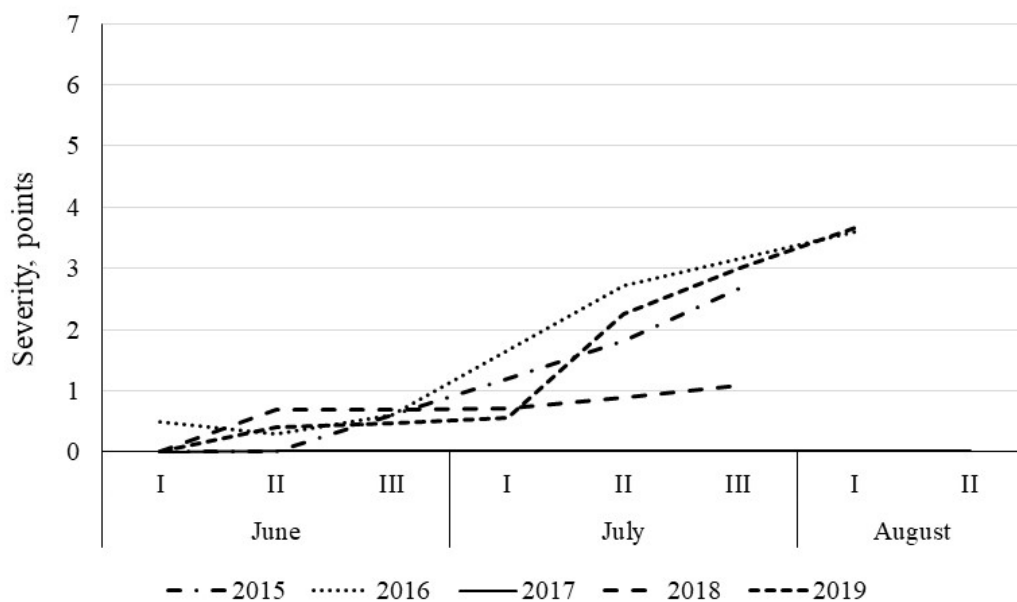
Fig. 6. Dynamics of development of leaf blotch (caused by *Alternaria*/*Stemphylium* complex) in untreated plots. Data show means across cultivars and plant densities.
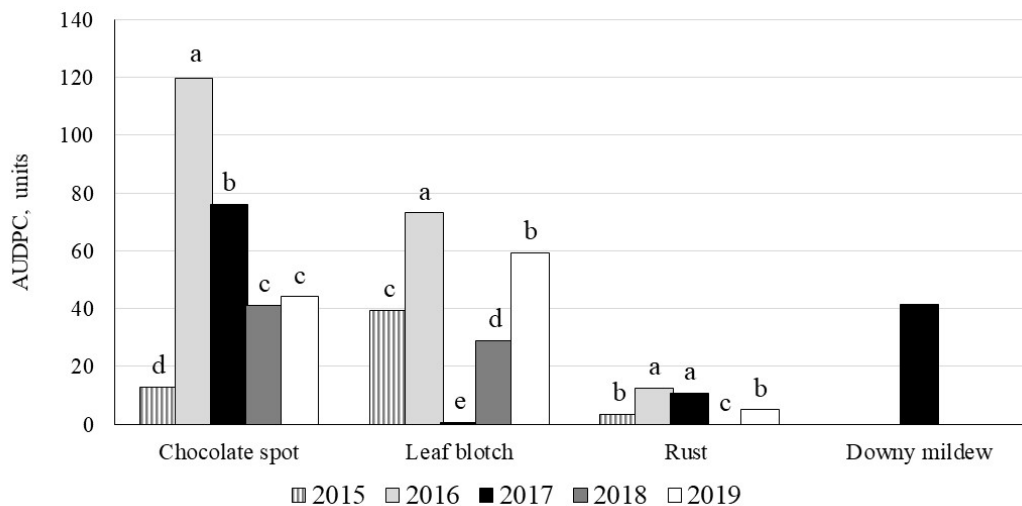
Fig. 7. Development of faba bean leaf diseases as AUDPC, depending on year (2015-2019) in untreated plots. Data show means across cultivars and crop densities. Significantly (p<0.001) different means within a year are labelled with different letters.
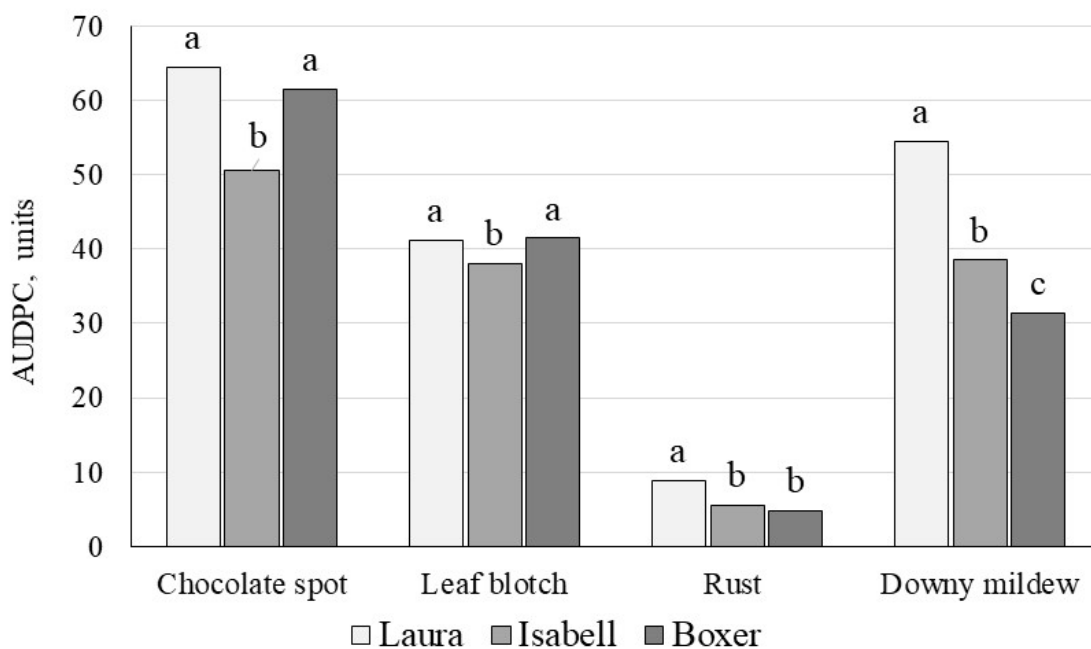

Fig. 8. Development of faba bean leaf diseases as AUDPC, depending on cultivar in untreated plots. Data show means across years and crop densities. Significantly (p < 0.001) different means within a disease are labelled with different letters.
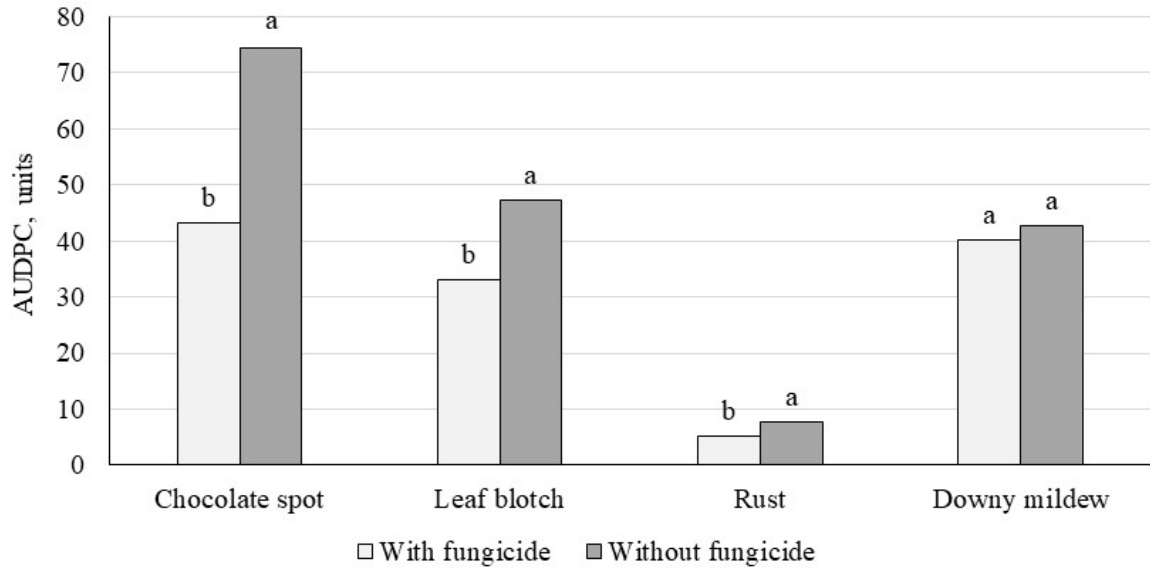
Fig. 9. Development of faba bean leaf diseases depending on fungicide application. Data show means across years, crop densities and cultivars (p > 0.05 for downy mildew; p < 0.0001 for other diseases). Different letters indicate significance of difference between treatments within a disease.