

EFFICIENCY OF FUNGICIDES FOR OIDIUM CONTROL IN SOYBEAN CROP

Matheus da Silva Maciel¹, Gabriel Fabiani¹, Jesiomar Delazeri¹, Douglas Mello Praetorius¹, Valter Pivotto Bussolotto¹, Rafael Goulart Machado², José de Alencar Lemos Vieira Junior², Leonita Beatriz Girardi², Katia Trevizan², Ronaldo Elias², Volmir Atilio Farina²

¹Academic of Agronomy, Instituto de Desenvolvimento Educacional de Passo Fundo Ltda, Passo Fundo, Brazil

²Professor of Agronomy, Instituto de Desenvolvimento Educacional de Passo Fundo Ltda, Passo Fundo, Brazil

* Author for correspondence: Rafael Goulart Machado, rgoulartmachado@gmail.com

ABSTRACT: One of the most relevant factors in soybean productivity is fungal diseases such as oidium (*Microsphaera diffusa*), which can be controlled through resistant cultivars or preventive control through the application of fungicides. The aim of the present study was to evaluate the efficiency of chemical fungicides for oidium control and their effects on yield and weight of one thousand seeds (WTS) of soybean crop. Seven treatments were conducted with fungicides for oidium control, and control treatment without fungicide (Treatment 8). Fungicides were effective in controlling oidium incidence and severity and also increased yield. Fungicides tested were: Picoxystrobin 100 gL⁻¹ + Benzovindiflupir 50 gL⁻¹ (Treatment 1), Trifloxystrobin 150 gL⁻¹ + Proticonazol 175 gL⁻¹ (Treatment 2), Fenpropimorph 750 gL⁻¹ (Treatment 3), Picoxystrobin 200 gL + Ciproconazol 80 gL⁻¹ (Treatment 4), Azoxystrobin 300 gL⁻¹ + Benzovindiflupir 150 gL⁻¹ (Treatment 5), Mancozeb 750 g.kg⁻¹ (Treatment 6), Metominostrobin 110 gL⁻¹ + Tebuconazol 165 gL⁻¹ (Treatment 7). A difference of 962 kg.ha⁻¹ (16 sc.ha⁻¹) was observed between the most efficient treatment (T3 - Fenpropimorph 750 g.L⁻¹) and the control treatment.

KEYWORDS: Glycine max, *Microsphaera diffusa*, oil seeds, grains, agribusiness.

EFICIÊNCIA DE FUNGICIDAS NO CONTROLE DE OÍDIO NA CULTURA DA SOJA

RESUMO: Um dos fatores mais impactantes na produtividade da cultura da soja são as doenças fúngicas como por exemplo o oídio (*Microsphaera diffusa*), a qual poderá ser controlada através de cultivares resistente ou controle preventivo por meio de aplicação de fungicidas. O objetivo do estudo foi avaliar a eficiência de fungicidas químicos no controle de oídio e seus respectivos efeitos na produtividade e peso de mil sementes (PMS) da cultura da soja. Foram conduzidos sete tratamentos compostos com fungicidas para o controle do oídio, bem como um tratamento testemunha sem utilização de defensivo (Tratamento 8). Os fungicidas testados foram: Picoxistrobina 100 g.L⁻¹ + Benzovindiflupir 50 g.L⁻¹ (Tratamento 1), Trifloxistrobina 150 g.L⁻¹ + Proticonazol 175 g.L⁻¹ (Tratamento 2), Fenpropimorfe 750 g.L⁻¹ (Tratamento 3), Picoxistrobina 200 g.L + Ciproconazole 80 g.L⁻¹ (Tratamento 4), Azoxistrobina 300 g.L + Benzovindiflupir 150 g.L⁻¹ (Tratamento 5), Mancozebe 750 g.kg⁻¹ (Tratamento 6), Metominostrobina 110 g.L⁻¹ + Tebuconazol 165 g.L⁻¹ (Tratamento 7). Foi verificada eficiência dos fungicidas no controle da incidência e da severidade do oídio na cultura da soja, bem como incremento da produtividade. Destaca-se uma diferença de 962 Kg.ha⁻¹ (16 sc. ha⁻¹) entre o tratamento mais eficiente (T3 - Fenpropimorfe 750 g.L⁻¹) em comparação à Testemunha. Observa-se que alguns fungicidas são mais eficientes que outros e isso impacta diretamente sobre parâmetros de produtividade.

PALAVRAS CHAVE: *Glycine max*, *Microsphaera diffusa*, oleaginosa, grãos, agronegócio.

INTRODUCTION

Soybean (*Glycine max*) is the oilseed most cultivated in Brazil, being of great importance for the generation of income, heat up the domestic economy and generation of surplus in the trade balance. According to CONAB (2018), a planted

area of 35.794 million hectares is estimated for the 2018/2019 crop season, reaching production of 118.019 million tonnes. Among Brazilian states, Rio Grande do Sul is the third largest soybean producer, reaching an estimated area of 5.777 million hectares and production about 18.690 million tonnes with

an average yield of 3.235 kg. ha⁻¹ (53.9 sc. ha⁻¹) (CONAB, 2018).

Oidium, caused by fungus *Microsphaera difusa*, stands out as one of the most economically important diseases in soybean crop (Barbosa, 2017). Mild temperatures favor its occurrence. According to Alves et al. (2009), temperature from 23 to 24°C associated with leaf wetting period of 8 h provided the maximum progress of its severity. Other factors such as medium to high air humidity (50 to 90%) and low incidence and intensity of precipitation at the beginning of flowering and seed formation are pointed out by Blum et al. (2002). Since 1996, from the Southern region to the Southeastern and Midwestern regions of Brazil, several outbreaks of this disease have been reported (Michel et al., 1998). In particular, when environmental conditions are favorable to disease development, the occurrence of oidium in soybeans may affect the crop and cause significant losses in grain yield (Toigo et al., 2008).

In leaves, the white color of the fungus turns to a grayish-brown color over time, giving the appearance of dirt covering both sides of the leaf. Under conditions of severe infection, mycelium development and fungus fruiting prevent photosynthesis and leaves dry and fall prematurely, giving the crop the appearance of soybean desiccated by herbicide, and color turns from grayish-brown to bronze (Yorinori, 1997).

Genetic resistance is considered the preferred method to control diseases, since it is a strategy of greater durability and does not impact production costs (Maciel and Danelli, 2018). On the other hand, several cultivars that were resistant to oidium became susceptible, demonstrating the fungi variability. In this case, one of the most efficient methods is chemical control, which until now is the main control method. Information on the efficiency of fungicides is increasingly essential and necessary to guide and select products with correct use and guidance in the field (Yorinori, 2002).

Due to the significant productivity losses that may be associated to the occurrence of oidium in soybean crops, as well as the costs related to the use of pesticides for disease control, investigating the efficiency of fungicides in the control of oidium is of great importance. The aim of the present study was to evaluate the efficiency of fungicides in the

control of oidium and its effects on yield and weight of one thousand seeds (WTS) of soybean crop.

MATERIAL AND METHODS

The experiment was conducted in a no-tillage area on oat straw in commercial soybean monoculture in the municipality of Estação - RS, in the "Alto Uruguai" region, with coordinates 27° 53 '53"S and 52° 15' 07'W and altitude of 754 m a.s.l. Oat desiccation was performed 21 days before sowing with the use of Paraquat herbicide at dose of 2.5 g. ha⁻¹ plus adjuvant recommended for the product at dose of 0.5 l.ha⁻¹. The cultivar used was Active BMX RR® of maturation group 5.6 with determined growth habit and medium size. Sowing was carried out on October 28, 2017, with Semeato® planter of 09 rows with mechanical seed distribution system and disk furrower and spacing of 0.45 meters pulled by a Massey Ferguson tractor model 292®, with sowing speed of 6 km.h⁻¹. Planter was regulated to deposit 16 seeds per linear meter, totaling approximately 300,000 plants/ha⁻¹. Seed treatment was carried out at dose of 1mL.L seed⁻¹ (pyraclostrobin-25 g.L⁻¹, methyl thiophanate 225 g.L⁻¹, fipronil 250 g.L⁻¹). Base fertilization was carried out with 400 kg. ha⁻¹ of NPK 02.23.23 fertilizer distributed in the sowing furrow according to soil analysis.

A completely randomized design (CRD) was used, consisting of 8 treatments and 4 replicates for each treatment. Each Experimental Unit (EU) presented total area of 12.5 m² (5.0 x 2.5m) and spacing between plots of 2.0m, totaling 32 experimental units (Figure 1).

Table 1 shows the treatments evaluated for the control of oidium in soybean crops, which were composed of different active ingredients and their respective doses recommended for the control of the disease. The first fungicide application was carried out at vegetative stage V6 (sixth node, sixth fully developed trifoliate leaf). At 21 days after the first application, the second application was performed at reproductive stage R1 (beginning of flowering); the third application was performed after 14 days at reproductive stage R4 (fully developed pod) and the fourth and last applications were performed 14 days after reproductive stage R5 (beginning of grain filling).

Figure 1. Experimental plots**Table 1.** Doses of fungicides sprayed on soybean plants.

Treatments	Recommended Dose	Active Ingredient (ha ¹)
T1	800 ml.ha ⁻¹	Picoxystrobin 100 g.L ⁻¹ + Benzovdiflupir 50 g.L ⁻¹
T2 *	400 ml.ha ¹	Trifloxystrobin 150 g.L ⁻¹ + Proticonazol 175 g.L ⁻¹
T3	700 ml.ha ¹	Fenpropimorph 750 g.L ⁻¹
T4 *	300 ml.ha ¹	Picoxystrobin 200g.L + Ciproconazol 80 g.L ⁻¹
T5 *	200 g.ha ¹	Azoxystrobin 300 g.L + Benzovdiflupir 150 g.L ⁻¹
T6 *	1.5 kg.ha ¹	Mancozeb 750 g.kg ⁻¹
T7 *	600 ml.ha ¹	Metominostrobin 110 g.L ⁻¹ + Tebuconazol 165 g.L ⁻¹
T8 (control)*	-----	-----

* Adjuvants used according to commercial product specification.

Applications were carried out with costal CO₂ sprayer, with application volume of 150L.ha⁻¹ and constant pressure of 3.5 bar. Application bar 2.5 meters long, with four spray tips ATR 80 full cone type with the purpose of applying 20 drops per cm² with spacing of 0.50 cm. Application height was 50 cm on the plant and displacement velocity used in fungicide application was 1 m.s⁻¹. Anti-drift and adjuvant were used in all applications at dose of 0.100 L. ha¹.

After 45 days of soybean sowing, post-emergence application with glyphosate herbicide (445g.L⁻¹) at dose of 2.5 L. ha¹ and physiological

insecticide Triflumurom (480 gL⁻¹) at dose of 100mL. ha¹ was performed. For control of caterpillars, clorantraniliprole insecticide (200 g.L⁻¹) at dose of 0.05 L.ha¹ and methoxyfenozide (240 g.L⁻¹) at dose of 0.300 L.ha¹ were used in all applications. For insect control, insecticide (Imidacloprid 250 g.L⁻¹ + Bifenthrin 50 g L⁻¹) at dose of 0.400 L. ha¹ was used.

In the present study, diagrammatic scales based on Polizel and Juliatti (2010) were developed to aid in the identification of oidium incidence and severity (Figures 2 and 3).

Figure 2. Leaves collected in T8 treatment (control), presenting oidium incidence in soybean crop.

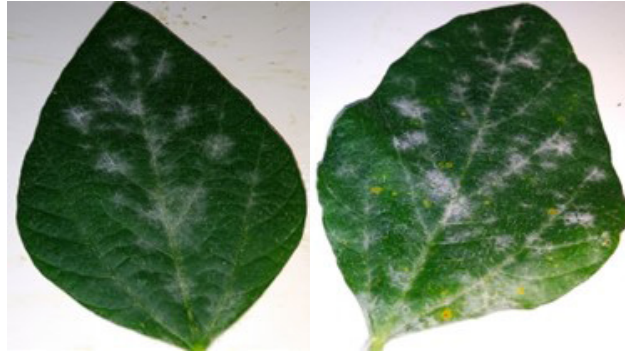
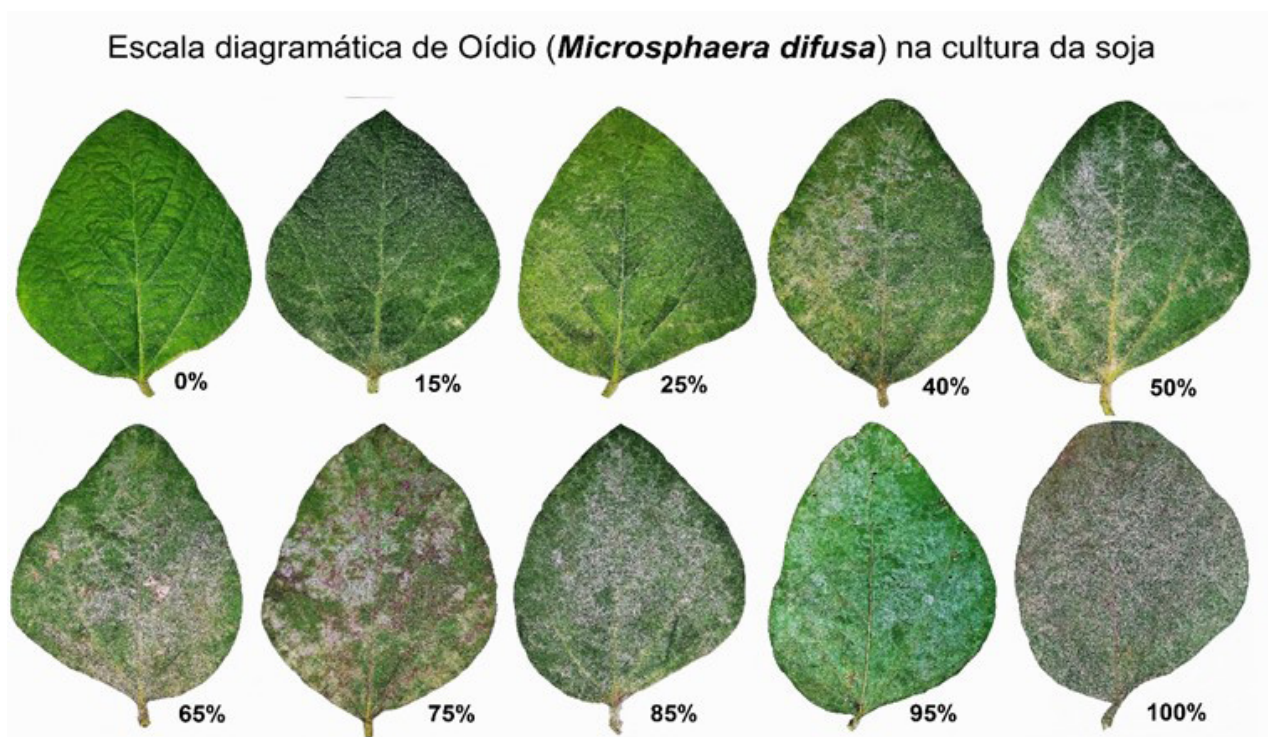


Figure 3. Diagrammatic scale for evaluating oidium severity under field conditions



Evaluations of oidium incidence and severity were carried out on the days of fungicide application at reproductive stages R5 (beginning of grain filling) and R6 (full grain). Three random evaluations were performed in the useful area of each replicate, and in each evaluation, 10 leaflets in the lower third, 10 leaflets in the middle third and 10 leaflets in the upper third of the plant were collected, totaling 30 leaflets within the plot. In each evaluation, 960 leaflets were evaluated.

Harvest was carried out on April 21, 2018, in the two central rows of each plot, contemplating the length of five linear meters, totaling an area of 4.5 m² per plot. Harvest was manually performed, and plants were manually husked and cleaned with the aid of a soybean-specific sieve, and after cleaning, grains were bagged

in paper bags and labeled according to the respective treatment and plot and taken to the IDEAU laboratory, Campus of Passo Fundo for moisture correction to 13% and weighed with the aid of a precision scale to determine the weight of one thousand seeds (WTS) and yield in Kg.ha⁻¹. Data obtained such as productivity, weight of one thousand seeds (WTS), oidium incidence and severity were submitted to analysis of variance with the Tukey test at 5% error probability, with the aid of the SISVAR statistical software (Ferreira, 2000).

RESULTS AND DISCUSSION

The mean oidium incidence and severity values obtained at reproductive stages R5 and R6 stages are presented in Table 2.

Table 2. Means of incidence and severity indexes observed in stages R5 and R6 of soybean crop.

Treatment	Active principle	Incidence (%)	Severity (%)
T3	Fenpropimorph 750 g.L ⁻¹	4.17 a	0.04 a
T2	Trifloxystrobin 150 g.L ⁻¹ + Proticonazol 175 g.L ⁻¹	5.83 a	9.29 b c
T5	Azoxystrobin 300 g.L ⁻¹ + Benzovindiflupir 150 g.L ⁻¹	13.33 a b	1.17 a
T4	Picoxystrobin 200 g.L ⁻¹ + Ciproconazol 80 g.L ⁻¹	24.17 b c	10.37 c
T1	Picoxystrobin 100 g.L ⁻¹ + Benzovindiflupir 50 g.L ⁻¹	28.33 c	1.78 a b
T7	Metominostrobin 110 g.L ⁻¹ + Tebuconazol 165 g.L ⁻¹	64.17 d	19.49 d
T6	Mancozeb 750 g.Kg ⁻¹	87.50 e	40.34 e
T8	Control	94.17 e	52.43 f
VC (%)		13.49	19.28

Means followed by the same letter in the column did not differ significantly from each other by the Tukey's test (P <0.05).

In T3 treatment (Fenpropimorph 750 g.L⁻¹), the lowest oidium incidence and severity values in soybean crops were observed, providing the best results, which combined the lowest incidence and severity values of the disease under study (Table 1). T5 treatment (Azoxystrobin 300 g.L⁻¹ + Benzovindiflupir 150 g.L⁻¹) provided results equivalent to those observed with T3 treatment for the incidence and severity indexes, but not differing from T4 treatment (Picoxystrobin 200 g.L⁻¹ + Ciproconazole 80 g.L⁻¹) for the incidence parameter.

Regarding parameter oidium incidence in soybean crop, T2 treatment (Trifloxystrobin 150 g.L⁻¹ + Proticonazole 175 g.L⁻¹) did not differ from T3 treatment (Fenpropimorph 750 g.L⁻¹), whereas for parameter oidium severity, only T5 (Azoxystrobin 300 g.L⁻¹ + Benzovindiflupir 150 g.L⁻¹) and T1 treatments (Picoxystrobin 100 g.L⁻¹ + Benzovindiflupir 50 g.L⁻¹) presented results equivalent to the low severity observed in T3 treatment (Fenpropimorph 750 g.L⁻¹).

Based on the excellent results observed with successive applications of T3 treatment (Fenpropimorph 750 g / L), it could be inferred that the formula is highly efficient for oidium control in soybean crops, presenting outstanding results in the control of disease incidence and severity. According to description published in 2006 by EPA, Fenpropimorph is a systemic morpholinic fungicide that provides protective and eradicating activity by inhibiting ergosterol biosynthesis. Currently in Brazil, the use of Fenpropimorph-based defensive agent for oidium control restricted to one application per soybean crop cycle is recommended (BASF®, 2018).

Despite the importance of controlling the incidence and severity of phytopathies for crop health, the use of chemical control of diseases through the application of fungicides is aimed at increasing grain yield (Cunha et al., 2008). Results regarding weight of one thousand seeds (WTS) and yield are presented in table 3.

Table 3. Average yield and weight of one thousand seeds (WTS) of soybean crop submitted to different treatments for oidium control.

Treatments	WTS (g)	Yield (Kg.ha ⁻¹)
T3 - Fenpropimorph 750 g.L ⁻¹	189.00 a	5488.39 a
T2 - Trifloxystrobin 150 g.L ⁻¹ + Proticonazol 175 g.L ⁻¹	172.63 b	5231.28 ab
T5 - Azoxystrobin 300 g.L ⁻¹ + Benzovindiflupir 150 g.L ⁻¹	163.50 c	4932.67 ab
T4 - Picoxystrobin 200 g.L ⁻¹ + Ciproconazol 80 g.L ⁻¹	160.00 c	4847.39 ab
T1 - Picoxystrobin 100 g.L ⁻¹ + Benzovindiflupir 50g.L ⁻¹	161.50 c	4824.10 ab
T7 - Metominostrobin 110 g.L ⁻¹ + Tebuconazo 165 g.L ⁻¹	159.38 c	4772.78 ab
T6 - Mancozeb 750 g.Kg ⁻¹	156.25 cd	4743.28 ab
T8 - Control	151.75 d	4526.17 b
VC (%)	1.94	7.67

Means followed by the same letter in the column did not differ significantly from each other by the Tukey's test (P <0.05).

T3 (Fenpropimorph 750 g.L⁻¹), in which the lowest incidence and severity indexes were observed, was the treatment with the best weight of

one thousand seeds (WTS) values, being superior to all other treatments for this parameter. In addition, with the exception of T6 treatment (Mancozebe 750

g kg⁻¹), all treatments provided better WTS than control.

Regarding grain yield, T3 treatment (Fenpropimorph 750 g.L⁻¹) was the only treatment superior to control, not differing from the other treatments. Grain yield is associated to greater photosynthetically active foliar area, due to the high sanity of leaves, which certainly favors the best use of solar radiation and consequently contributes in the best way to grain filling. On the other hand, in T8 treatment (control), in which the highest oidium incidence and severity were observed, the lowest grain yield and WTS values were also verified. In this sense, according to McGee (1992), the reduction of the photosynthetic layer of the leaf by the action of the fungus is associated with reduced grain yield.

It was observed that *Microsphaera difusa* fungus has a very great damage potential, as evaluated in the experiment, with difference of 962 kg ha⁻¹ (16 sc.ha⁻¹) between the most efficient treatment (T3 - Fenpropimorph 750 g.L⁻¹) and control treatment. It was concluded that even if the farmer has expenses with disease prevention, the simple fact of preventing the potential of disease damage will compensate in terms of greater profitability. In this sense, it is observed that treatments are efficient enough to cover prevention costs. Similar results were observed by Orso et al. (2018), regarding the increase in soybean crop productivity due to the chemical control of oidium incidence.

All treatments reduced oidium severity in soybean crops compared to control treatment, and all treatments except for T6 treatment (Mancozebe 750 g kg⁻¹) also reduced the oidium incidence in the crop. T3 treatment (Fenpropimorph 750 g.L⁻¹) stood out with the lowest incidence and severity indexes. T2 (Trifloxystrobin 150 g.L⁻¹ + Proticonazole 175 g.L⁻¹) and T5 treatments (Azoxystrobin 300 g.L⁻¹ + Benzovindiflupir 150 g.L⁻¹) were also highlighted as providing the lowest incidence and severity, respectively.

Regarding productive parameters, greater weight of one thousand seeds (WTS) was observed for T3 treatment (Fenpropimorph 750 g.L⁻¹) compared to the other treatments, being also efficient to increase grain yield.

REFERENCES

- Alves, M.C.; Pozza, E.A.; Costa, J.C.B.; Ferreira, J.B.; Araújo, D.V. Intensidade do oídio *Microsphaera diffusa* CKE. & PK. em cultivares de soja [*Glycine max* (L.) Merr.] sob diferentes temperaturas e períodos de molhamento foliar. *Ciência e Agrotecnologia*, **2009**, 33, 1926-1930.
- Barbosa, R.M. Associação genômica para resistência de soja à pústula-bacteriana. Dissertação (Mestrado). Viçosa: Programa de Pós-Graduação em Fitotecnia, Universidade Federal de Viçosa, **2017**. 34.
- Basf ®. Bula Versalitis ®. URL (https://agriculture.basf.com/br/pt/Protec%CC%A7a%CC%83o-de_Cultivos/Versalitis.html) (Acesso em 30/12/2018)
- Blum, L.E.B.; Reis, E.F.; Prade, A.G.; Tavela, V.J. Fungicidas e mistura de fungicidas no controle do oídio da soja. *Fitopatologia Brasileira*, **2002**, 27, 216-218.
- CONAB – COMPANHIA NACIONAL DE ABASTECIMENTO – Observatório Agrícola, acompanhamento da safra brasileira, grãos. 6, n. 3 – Terceiro levantamento; Brasília: Conab, **2018**.
- Cunha, J.P.A.R.; Moura, E.A.C.; Silva Júnior, J.L.; Zago, F.A.; Juliatti, F.C. Efeito de pontas de pulverização no controle químico da ferrugem da soja. *Engenharia Agrícola*, **2008**, 28, 283-291.
- EPA (United States Environmental Protection Agency) – Pesticide Fact Sheet, Name of Chemical: Fenpropimorph. Washington D.C., USA, **2006**.
- Ferreira, D.F. Sistemas de análise estatística para dados balanceados. Lavras: UFLA/DEX/SISVAR **2000**. 145.
- McGee, D.C. Soybean diseases: a reference source for seed technologists. St. Paul: American Phytopathological Society, **1992**. 151.
- Maciel, J.L.N.; Danelli, A.L.D. Resistência genética de plantas a fungos. In. Resistência genética de plantas a patógenos, edição n. 1, Dallagnol, L.J., Org.; Pelotas: UFPel, **2018**, 359-393.

Michel, C.A.; Reis, E.M.; Vieira, R. Controle químico do oídio na cultura da soja. *Fitopatologia Brasileira*, **1998**, 23, 259.

Orso, L.; Walendorff, R.; Casassola, A.; Machado, R.G.; Mambrin, R.B. Aplicação de diferentes fungicidas para o controle de *Microsphaera diffusa* na cultura de soja. In: I Mostra de Iniciação Científica, Mostra de Criação e Inovação, 1; Instituto de Desenvolvimento Educacional de Passo Fundo: Passo Fundo, RS, **2018**; 1-14.

Polizel, A.C.; Juliatti, F.C. Quantificação de doenças foliares da soja por escalas diagramáticas. *Enciclopédia Biosfera*, **2010**, 6, 1-9.

Toigo, S.; Santos, I.; Carnieletto, C.E.; Mazaro, S.M. Controle químico do oídio na cultura da soja. *Scientia Agraria*, **2008**, 9, 491-496.

Yorinori, J.T. Oídio da Soja. Comunicado Técnico 59. Londrina: Embrapa-CNPSO, **1997**. 5.

Yorinori, J.T. Ferrugem asiática da soja (*Phakopsora pachyrhizi*): ocorrência no Brasil e estratégias de manejo. In: Reunião de pesquisa de soja da região central do Brasil, 24; Embrapa Soja: Londrina, PR, **2002**; 73-83.

