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Damage to soybean caused by downy mildew

Danos na soja causada por míldio

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– NOTE –

ABSTRACT

Downy mildew is widespread throughout the world. However, the damage that it causes has not been studied in Brazil yet. The objective of this work was to evaluate which components of soybean yield are affected by downy mildew and to determine the coefficient of damage. Two field experiments were conducted in Castro (2006/07) and Ponta Grossa (2007/08) in the state of Parana, Brazil. The experimental design consisted of completely randomized blocks of (i) six treatments and five replications for the 2006/07 and (ii) eight treatments and four replications for the 2007/08 field experiments. Potassium phosphite (750g a.i. ha^{-1}), propamocarb + fenamidone (900g a.i. ha^{-1}) and mancozeb (2400g a.i. ha^{-1}) were applied. In all of the treatments, the maximum severity of downy mildew infection occurred at growth stage R5.3, and the percentage of severity ranged between 0 and 43%. The disease gradient was obtained only on the second season. Equations of damage were generated for the yield and grain weight. The number of grains per pod and the number of pods per plant were not affected by downy mildew but, the weight of 1000 seeds per plant was reduced linearly with increasing of mildew severity.

Key words: ***Peronospora manshurica*****,** ***Glycine max*****,** *oospore.*

RESUMO

O míldio da soja é disseminado em todo mundo. Entretanto, o dano que ele causa não tem sido estudado no Brasil. O objetivo deste trabalho foi avaliar quais componentes de rendimento da soja são afetados por essa doença e determinar o coeficiente de dano. Dois experimentos foram conduzidos, um em Castro (2006/07) e outro em Ponta Grossa (2007/08), no Estado do Paraná, Brasil. O delineamento experimental foi de blocos ao acaso com (i) seis tratamentos e cinco repetições para os experimentos de campo, safras 2006/07, e (ii) oito tratamentos e quatro repetições para 2007/08. Foram aplicados fosfito de potássio (750g ia ha^{-1}), propamocarb + fenamidona (900g ia ha^{-1}) e mancozeb (2,400g ia ha^{-1}). Em todos os tratamentos, a severidade máxima da infecção pelo míldio ocorreu no estádio R5.3 e a porcentagem de severidade variou entre 0 e 43%. O gradiente da doença foi obtido apenas na segunda safra. Equações de danos foram geradas para o peso de grãos e produtividade. O número de grãos por vagem e o número de vagens por planta não foram afetados pelo míldio mas o peso de 1000 sementes por planta foi reduzido linearmente com o aumento da severidade do míldio.

Palavras-chave: ***Peronospora manshurica*****,** ***Glycine max*****,** *oósporo.*

Soybean [***Glycine max*** (L.) Merill)] can be attacked by several diseases, among which downy mildew caused by ***Peronospora manshurica*** (Naumov) Syd.can cause 8 to 14% damage to U.S. susceptible genotypes (DUNLEAVY, 1987). Downy mildew is widespread throughout the major soybean-producing regions of the world (DUNLEAVY, 1987; LIM, 1989) and in Brazil (SILVA et al., 2011).

The main method for control ofthis disease involves resistant cultivars (LIM, 1989) by major genes.Susceptible cultivars of soybean are widely cultivated in Brazil and genetic resistance to downy mildew is not part of breeding programs in Brazil. This disease is known to cause low damage to the crop, therefore, specific control strategies for soybean downy mildew have been entirely neglected. Instead, an average of 2.3 applications of triazole, combined with strobilurinsis used to control Asian soybean rust (***Phakopsorapachyrhizi*** Syd. & P. Syd.) and other late season diseases (LSD) (***Cercoporakikuchii*** Mats.

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& Tomoy and ***Septoriaglycines*** Hemmi (GODOY et al., 2009). Several products are registered for the control of Oomycetes, however some authors also recommend phosphites (JACKSON et al., 2000; MCDONALD et al., 2001). SILVA et al. (2011) detected a linear reduction in the severity of downy mildew infections and a significant improvement in the leaf area index with an increase in the quantity of phosphite applied.

Models for quantifying the damage caused by downy mildew can be obtained by quantifying severity of the disease and correlating it with yield. The equation that correlates the severity of the disease with the amount of damage to the cropis called the damage coefficient (ZADOKS, 1985). The study of the damage caused by pathogens is essential to establish the strategy to disease control. (BAHATCHUKet al., 2008).

The present study aimed to investigate the damage caused by downy mildew infection under the components of the soybean yield in Brazil and to determine the damage coefficient equation via the disease gradient.

Two experiments were carried out in 2006/07 and 2007/08 seasons at ABC Foundation Field Station in Castro and the Ponta Grossa municipality, which are located in Parana State, Brazil. The coordinates are latitudes of 25º0'54" and 24º51'21"S and longitudes of 50º9'12" and 49º55'53"W for Ponta Grossa and the Castro municipality, respectively. The early season CD 215 cultivar, which is susceptible to downy mildew and soybean rust and moderately susceptible to powdery mildew and LSDs, was used. The soybean plants were sown in October, 2006 and November, 2007 under no-tillage system and a population density of 35 plant per m^2 of plot. In the 2006/07 season, a total of six treatments of 900g a.i. ha^{-1} of propamocarb hydrochloride + fenamidone (37.5% and 7.5%) was applied at V3 (2^{nd} trifoliate leaves have developed), V7 (6^{th} trifoliate leaves have developed), R2 (full bloom), R3 (2-4cm pods) and R5.1 (10% grain filling). In the 2007/08 crop year, 750g a.i. ha^{-1} of phosphite (30% P_2O_5 + 20% K_2O) was applied in treatments 1-6. For treatment 7, 900g a.i. ha^{-1} of propamocarb hydrochloride + fenamidone (37.5% and 7.5%) was applied, while 2400g a.i. ha^{-1} of mancozeb alternated with 1280g a.i. ha^{-1} of cymoxanil + mancozeb 160 was applied as treatment 8. The damage equationwas obtained by downy mildew severity gradient suggested by SAH & MACKENZIE (1987). The gradient was obtained bya sprays program of potassium phosphite and fungicides of six and eight treatments in 2006/07 and 2007/08, respectively. The treatments were appliedwith a backpack sprayer (MAEPower Equipment, Mission, TX, USA) at a constant pressure (maintained by compressed CO_2) of 131kPa. The sprayer was equipped with sixpointed "range" flat-fan nozzles (XR11002) spaced 0.5m apart and calibrated to deliver the equivalent of 135L ha^{-1} under weather conditions where the relative humidity is above 60% and temperatures are below 30°C.

Five fungicide applications were sprayedto prevent the occurrence of other leaf diseases: one application of cyproconazole (30g a.i. ha^{-1}), two applications of tebuconazole (100g a.i. ha^{-1}) and two applications of carbendazim (500g a.i. ha^{-1}) in V5 (four fully developed trifoliate leaves), R2 (full bloom) and R5 (reproductive stage) soybean stage. A randomized block design with (i) six treatments and four replications for the 2006/07 and, (ii) eight treatments and five replications for the 2007/08 field experiments, respectively, was utilized. Each plot was 2.8 x 5.0mbyseven rows spaced 0.40m (14m^2 and a total usable area of 6.4m^2). Five assessments of the severity of the downy mildew infection were conducted in the 2006/07 at V6 (five fully developed trifoliate leaves), V10 (nine trifoliate leaves), R2, R5.3 (26 to 50% grain filling) and R6 (100% grain filling and leaves were still green). In 2007/08 seven assessments of downy mildew severity were performed at the following growth stages: V6, V10, R1 (initial bloom), R2, R4 (2cm pods), R5.3 and R6. The severity of downy mildew was assessed in 20 trifoliate leaves, 10 leaves from the lower and 10 leaves from the upper part of canopy. The average of the disease severity was calculated by using bothsamples. The severity of the ***P. manshurica*** infection was quantified using the diagrammatic scale (KOWATA et al., 2008).

Plants were harvested in March of 2007 and 2008 to determine the yield and 1000 seed weight, and the seed moisture content was corrected to 13%. The yield componentswere calculated by number of pods per plant, the number of grains per pod and 1000 seed weight in 25 and 10 plants per plot in 2006/07 and 2007/08 respectively. When the F- test was significant at the 5% level, a regression analysis between the independent variable of the severity of downy mildew on leaves at the R5.3 stage and the dependent variables of yield and its components was performed to obtain the damage coefficient equations. The coefficientsof themodel usedwere tested by Student's t test (P<0.05). The equations were adjusted forthe 1000 seed weight and for kg per hectare of soybeans. The Statistical Analysis System software version 9.1 and JMP 8 (SAS Institute Inc., Cary, NC, USA) were applied in the analysis.

In both crop years and locations, the weather conditions were favored for downy mildew infection and its development but in 2006/07 the severity was lower than in 2007/08 (Figure 1A and

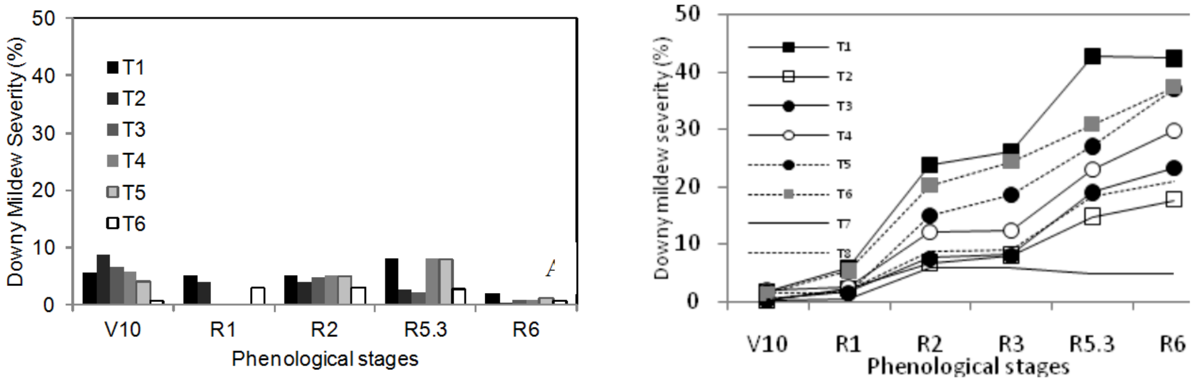

Figure 1 - Progress curve of soybean downy mildew (***Peronospora manshurica***), cv. 'CD 215' in Castro (2006/07) (A) and Ponta Grossa (2007/08) in Parana State, Brazil.

1B). The combination of phosphite and fungicide applications were used to generate the downy mildew severity gradient in soybean, resulting in a range of disease infection from zero to 8% in 2006/07 and from zero to 42.7% in the 2007/08. The first symptoms of the downy mildew occurred in the beginning of vegetative crop stage (V7 =6^{th} trifoliate leaves are open on the plants) with very low incidence, at 40 days after emergence (DAE) and the maximum severity occurred at the R5.3 reproductive stage (50% grain filling) at 90 DAE for both seasons. The data presented considered the disease from V10 to R5.3. The downy mildew severity was correlated with yield and its components and the negative correlation was obtained atthe R5.3 growth stage. The variables of the damage function were estimatedby using linear regression analysis. The equations were fittedto provide the damage coefficientsfor the 1000 seed weightand it was considered thatone on soybean for each 1% of ***P. manshurica*** disease severity when significant.

Among the four yield components evaluated the number of grains per pod and the number of pods per plant were not affected by downy mildew in both seasons (data not shown), which could be due to the duration of the disease and early occurrence in the season; besides that, to the low damage in general on the yield. The weight of 1000 seeds (P1000g) per plant was reduced linearly with increasing of mildew severity in the second season (Figures 2A). PANDEY & TORRIE (1973) found that in addition to genetic factors, environmental conditions and biotic agents influenced the average seed weight. The damage coefficient estimated for P1000 g was from 1.4g for each 1% of disease severity on the leaves at growth stage R5.3. DUNLEAVY (1987) also reported grain weight reductions from 3.9 to 7.2% in three cultivars when downy mildew incidence was up to 98%.The present study estimated yield reductions of 6.3% in 2007/08 using the damage coefficient of P1000g at 45% of disease severity.

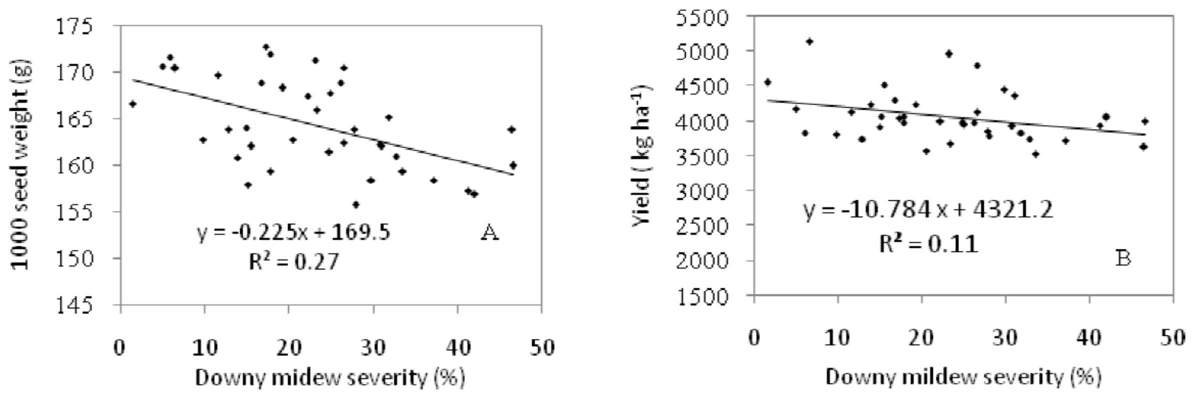

Figure 2 - Relationship between the 1000 seeds weight (A) and yield components (B) of soybean cv. CD 215 and the severity of the downy mildew infection at growth stage R5.3 when the plants were 50% filled with grain season 2007/08 in Ponta Grossa in Parana State, Brazil. Linear regression model: y=bx+a, where *a* is the intercept and *b* is the slope; R^2 is the coefficient of determination.

In 2007/08 the soybean yieldwas affected by ***P. manshurica*** and there was linear reduction of yield in relation to the increase in disease severity at growth stage R5.3 (Figure 2B). The damage coefficient estimated was 2.5kg for each 1% of disease severity assuming 1000kg ha^{-1} yield. Although downy mildew is considereda low-impact pathogen and reports of soybean damage by downy mildew are rare, DUNLEAVY (1987) reported damage of 11.8% in three susceptible cultivars when the disease incidence was higher than 95% in the USA for two seasons. The same 12% of damage reported by DUNLEAVY (1987) can be estimate dusing the damage coefficient of the present study at 45% of disease severity. The control of downy mildew on soybean leaves might be an important strategy to reduce crop damage and avoid seed transmission to new areas. In this study was confirmed the reduction of 1000 seed weight by the disease.

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