

SOIL SOLARIZATION IN THE CONTROL OF BEAN DISEASES CAUSED BY***Sclerotium rolfsii***

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ABSTRACT

This study aimed at assessing the effects of soil solarization on diseases caused by *Sclerotium rolfsii* in bean plants. Treatments consisted of solarization of a soil previously infested with *S. rolfsii* and a standard treatment (no solarization). A randomized block experimental design was adopted, with four replications. We assessed disease severity by measuring emergence, final stand, incidence, and severity of the disease. Soil microbial activity and number of viable sclerotia were evaluated after the second crop was grown in the first year of the experiment. In a two-year solarization period and under the temperatures achieved in this study it was not possible to control the diseases caused by the pathogen. However, the soil solarization decreases the incidence and severity of root collar rot caused by the fungus *S. rolfsii* in bean plants, as well as the pathogen's sclerotia viability.

Keywords: *Phaseolus vulgaris* L., sclerotia, temperature

**SOLARIZAÇÃO DO SOLO NO CONTROLE DAS DOENÇAS DO FEIJOEIRO
CAUSADAS POR *Sclerotium rolfsii*****RESUMO**

O objetivo deste trabalho foi avaliar os efeitos da solarização do solo sobre as doenças causadas por *Sclerotium rolfsii* em feijoeiro. Os tratamentos utilizados foram a solarização do solo previamente infestado com *S. rolfsii* e um tratamento padrão (ausência da solarização do solo). O

delineamento experimental foi de blocos ao acaso com quatro repetições. Avaliou-se a intensidade da doença pela emergência, estande final, incidência e severidade da doença. A atividade microbiana do solo e o número de escleródios viáveis foram avaliados após o segundo cultivo do primeiro ano de experimento. A solarização do solo reduziu a incidência e a severidade da podridão do colo causada pelo fungo *S. rolfsii* em feijoeiro, bem como a viabilidade de escleródios do patógeno, contudo, não é efetiva no controle total do patógeno. Em um período de solarização de dois anos e sob as temperaturas alcançadas neste estudo, não foi possível controlar as doenças causadas pelo patógeno. No entanto, a solarização do solo diminui a incidência e a severidade da podridão do colo da raiz causada pelo fungo *S. rolfsii* em plantas de feijão, bem como a viabilidade dos escleródios do patógeno.

Palavras-chave: *Phaseolus vulgaris* L., escleródios, temperatura

INTRODUCTION

Brazil is the world's largest producer of the common bean *Phaseolus vulgaris* L., with its production about 4.0 million tonnes/year. Bean is the basic protein food source in the nutrition of the Brazilian population. *Sclerotium* wilting or stem rot, caused by the fungus *Sclerotium rolfsii*, is among the most important bean diseases because it is hard to control. When infesting the soil, this pathogen causes great losses in productivity, which can reach 80% of production, mainly due to pre- and post-emergence damping-off (BIANCHINI et al. 1997; SOUZA & BUENO, 2003); its sclerotia may survive in the soil for several years (BUENO et al. 2004). Control strategies such as seed chemical treatment, genetic resistance, and crop rotation help reduce the amount of inoculum, but have little effectiveness. This calls for additional tests to find alternatives that would present higher control effectiveness.

Physical control through solarization may be a viable option for soil disinfestation, including areas under protected cultivation, where soil use is quite intensive; such treatment may be effective at 30 to 45 days in the field and at 20 to 30 days in protected environments (PATRÍCIO et al. 2007). The most important effect of solarization consists in increased temperature provided by a transparent plastic film applied to the soil, causing the death of a significant part of the microorganisms present in that soil (GHINI et al. 2002). This technique provides positive results in the control of several soil-borne pathogens that are difficult to control, such as nematodes

(BAPTISTA et al. 2006a) and sclerotia-forming fungi, such as *Rhizoctonia solani* (PATRÍCIO et al. 2007) and *S. rolfsii* (GAMLIEL & STAPLETON, 1993; SOUZA & BUENO, 2003). Control of these pathogens may occur due to soil heating (FERRAZ et al, 2003), since temperature is one of the main factors interfering with microorganism growth and survival (BAPTISTA et al. 2006b). Sustainable production models prioritize reductions in the use of chemical products. However, in order to achieve this, all variables associated with potential control alternatives must be known. Therefore, this investigation aimed at evaluating the effect of soil solarization on diseases caused by *S. rolfsii* in bean (*Phaseolus vulgaris* L.) plants, as well as its relation with soil microbial activity and sclerotia survival.

MATERIAL AND METHODS

The study was carried out at Universidade Federal de Tecnologia do Paraná (UTFPR) Southwest Unit's experimental field, Pato Branco Campus, Brazil, at 26°11'45.9"S latitude, 52°41'29.7"W longitude, and altitude of 700m.

The *S. rolfsii* isolate was obtained at UTFPR's Pato Branco plant pathology laboratory and was identified by optical microscopy. The pathogen was incubated for 10 days in Petri dishes containing PDA culture medium (potato-dextrose-agar, 39g/L) to obtain mycelial mass. The mycelium was then multiplied by placing 10 PDA disks (6 mm in diameter) containing the fungus at full development in 1-liter flasks, with substrates previously autoclaved for one hour during two consecutive days, containing: 100 g unhulled rice and 150 ml distilled water. The unhulled rice substrate was incubated for 10 days at 25±2°C. The soil was infested with 100 g/m² of that substrate 20 days before the treatments were applied.

Two treatments were evaluated: solarization and bare soil; a random block experimental design with four replicates was adopted. The experiment was repeated for two years, with two bean crops grown in the first year and one crop grown in the second year. A test crop was grown before the initial solarization to determine the presence and homogeneity of occurrence of the *S. rolfsii* fungus in the plots.

Solarized plots were covered with clear plastic (100 µm thickness), allowing 0.5-m borders on each side; the plastic borders were buried to hinder heat exchanges and moisture loss into the environment. Solarization was performed for two consecutive years, lasting 61 days in the first year (November and December) and 97 days in the second year (November, December, and

January). It was decided to increase the solarization time from 61 to 97 days to intensify the effects of solarization in the second crop. Soil temperature was monitored daily at 0900 h, 1100 h, 1300 h, and 1500 h, at a 5-cm depth, with a soil temperature sensor (multimeter-thermocouple model Teste Electronico DT-830B). Approximately 100 g of soil were collected at six points from each plot to evaluate microbial activity. These evaluations were carried out only after the second crop was grown in the first year of the experiment, via CO₂ release, according to the methodology described by Morales et al. (2007) adapted from Grisi (1978).

Seeding (80 bean seeds per plot, cultivar UTF-1, at 94% germination power), was performed one week after the solarization plastic tarps were removed. Disease intensity was evaluated based on plant emergence, final stand, incidence and severity of root collar rot.

Emergence evaluations were performed by counting the number of emerged plants 12 days after seeding; final stand was based on total plants remaining after 24 days, at which point the plants were collected to evaluate the incidence and severity of root collar rot. Incidence was calculated as the percentage of infected plants with visible symptoms of the disease in relation to healthy plants. Severity was evaluated based on the percentage of injured tissue at the plant root collar, based on a diagrammatic scale for bean root rots (SCHOONHOVEN & PASTOR-CORRALES, 1987). Identification and confirmation were performed under the optical microscope to ensure that the pathogen causing rot was indeed *S. rolfsii*.

After incidence and severity of the disease were evaluated, the plants were weighed and the results were divided by the final stand to obtain fresh matter mass per plant, in g/plant.

Another factor we evaluated was the number of sclerotia per plot, as well as their viability 15 days after the bean crop was harvested. To that effect, we collected dirt samples from six points at each plot (0 - 5 cm depth), totaling 500 g. After homogenizing, a 50-g aliquot was taken from each sample; the aliquots were sifted through a five-sieve set with 4.75 mm, 2.36 mm, 1.00 mm, 0.053 mm, and 0.037 mm meshes, submitted to pressure under tap water. The three sieves with the smaller meshes were dipped into a white basin containing water, for sclerotia removal and counting. A sample consisting of ten randomly-selected sclerotia from each plot was utilized. The sclerotia were submitted to surface disinfestation in sodium hypochlorite at 2% for three minutes and plated in Petri dishes containing agar-water medium (2%). Viability was evaluated after a 48-hour period in a growth room at 25±2°C, by counting germinated sclerotia. The 48-hour period was

determined in preliminary myceliogenic germination tests in which it was verified that viability was compromised when 100% germination would not occur within that period.

The data obtained were submitted to analysis of variance and the means were compared by Duncan's test at 5% probability. In the emergence, final stand, incidence, and severity analyses, the data were transformed to square root ($X + 0.5$).

RESULTS AND DISCUSSIONS

In both crops grown during the first year of the experiment, a reduction was observed in incidence and severity of root collar rot in plots submitted to solarization, as compared to plots without solarization. In the first crop grown, the mean incidence in non-solarized control plots was 67.30%, with 21.52% severity, whereas under solarization incidence was reduced to 41.06%, with 1.91% severity (Table 1).

Table 1. Effect of soil solarization on the incidence and severity of root collar rot caused by *Sclerotium rolfsii*, as well as on the emergence and final stand of bean plantlets (*Phaseolus vulgaris* L.) in crops grown after the plastic mulch was removed. Pato Branco, February 2005.

| 1 st Crop (1 st Year) | | | |
|---|-----------------|----------------|--------|
| Variable | No solarization | Solarized soil | CV (%) |
| Incidence (%) | 67.30 a | 41.06 b | 1.37 |
| Severity (%) | 21.52 a | 1.91 b | 11.71 |
| Emergence (%) | 76.41 a | 78.13 a | 17.72 |
| Final Stand (%) | 65.78 a | 71.56 a | 20.89 |
| 2 nd Crop (1 st Year) | | | |
| Incidence (%) | 52.83 a | 14.61 b | 3.54 |
| Severity (%) | 16.84 a | 1.57 b | 10.58 |
| Emergence (%) | 81.56 a | 81.48 a | 21.56 |
| Final Stand (%) | 79.77 a | 81.41 a | 25.33 |
| 1 st Crop (2 nd Year) | | | |
| Incidence (%) | 33.24 a | 27.57 b | 2.58 |
| Severity (%) | 6.89 a | 4.01 b | 17.96 |
| Emergence (%) | 73.52 a | 78.44 a | 12.45 |
| Final Stand (%) | 72.61 a | 76.79 a | 13.69 |

*Means followed by the same lower-case letter in the row do not differ significantly from each other by Duncan's test ($p \leq 0.05$).

In the second crop, incidence decreased from 52.83% to 14.61% and severity decreased from 16.84% to 1.57% between solarized and non-solarized plots, respectively. In the crop grown

after the second solarization, although there was a reduction in intensity of the disease between treatments, such reduction was less expressive. Incidence decreased from 33.24% to 27.57%, and severity decreased from 6.89% to 4.01% between non-solarized and solarized plots, respectively (Table 1).

Decreased incidence and severity with the use of solarization may be attributed to increased soil temperature, since, according to Katan & Devay (1991), phytopathogenic microorganisms are the most affected by high temperatures, while their antagonists have greater resistance. Thus, as solarization promotes greater biological balance, it may both reduce pathogen populations, making them less aggressive to plants, or completely eliminate them from the environment. In this case, their reintroduction into the soil will be made harder by the antagonists (FERRAZ et al. 2003).

The maximum temperature observed in solarized seedbeds was 51.00°C in the 1st year and 49.50°C in the 2nd year, while the maximum observed in bare soil was 35.00°C in both crops grown. Just as observed by Patrício et al. (2007), the highest temperatures observed in the present work were recorded at 1500 hours (Figure 1). The mean temperature was similar in both years evaluated, with values of 46.8°C in the 1st year in seedbeds submitted to solarization and 36.5°C in bare soil, i.e., a 10.3°C difference between them (Figure 1). In the second year the mean temperature in solarized plots was 43.15°C, with 35.5°C in bare soil, a 7.65°C difference. It can be seen that in the second year temperatures were in general lower, which may have had an influence on the lower control efficiency provided by the method.

The increase in temperature—between 7 and 10°C— can be sufficient to control some soil plant pathogens. A 10.4°C difference at a 5 cm depth in solarized soils reduced the incidence of bacterial wilt caused by *Ralstonia solanacearum* (BAPTISTA et al. 2006b). Baptista et al. (2006a) observed a mean difference of 5.2°C between solarized and non-solarized soils at a 5 cm depth in the months of September and October; that temperature difference was sufficient to reduce the incidence of nematodes in tomato plant roots.

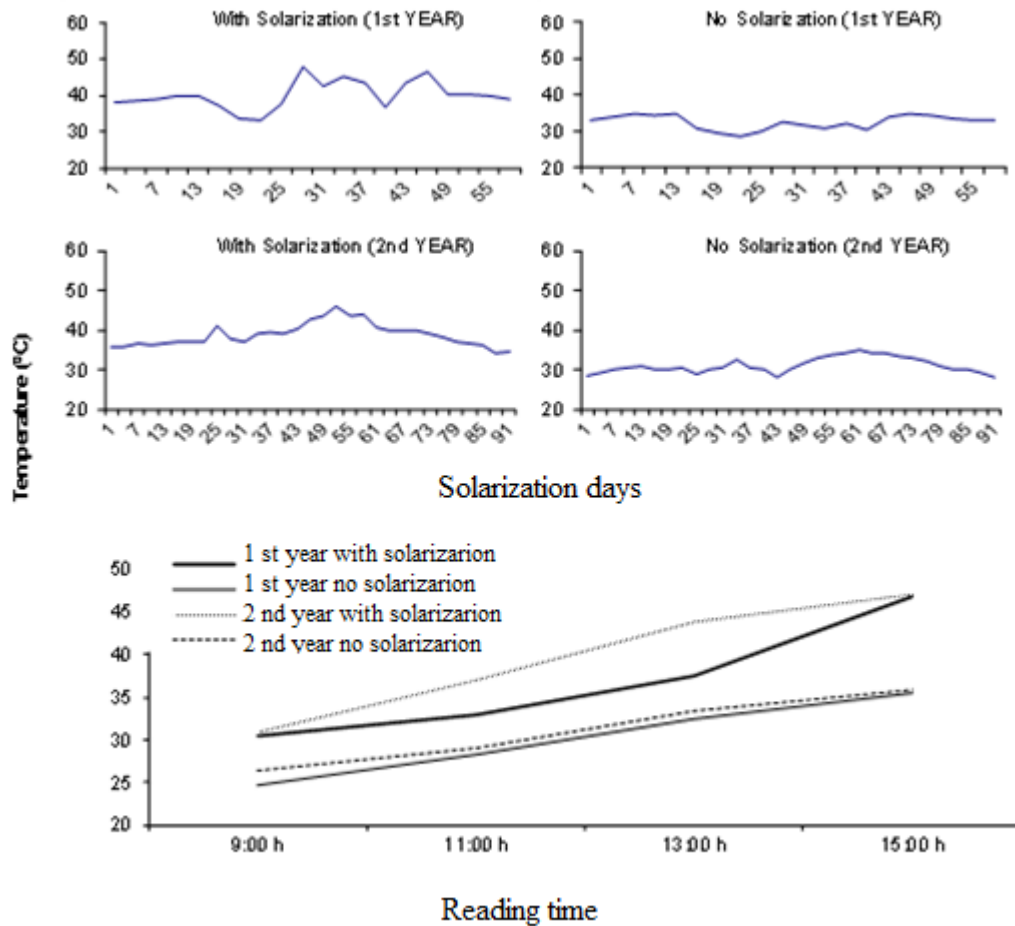


Figure 1. Mean daily temperature in soil under solarization and without solarization, during two years. Pato Branco, February 2005.

Plantlet emergence was not influenced by soil solarization in the three crops grown (Table 1). The lack of solarization effectiveness to control this disease at preemergence contradicts the results observed at postemergence; a more detailed investigation is required about this aspect. As to final stand and plant dry matter weight, the short period of time in which plants remained in the field (24 days after sowing) was decisive for the lack of damping off in plants with high severity. However, that 24-day period was enough for Morales et al. (2007) to evaluate the effect of incorporation of liquid swine manure on bean plantlet establishment in a soil infested with *S. rolfsii*. Tomazeli et al. (2011) also used the same period to evaluate the effect of organic residues in the control of bean plant diseases caused by *S. rolfsii*.

There was a reduction in the number of viable *S. rolf sii* sclerotia in the soil submitted to solarization. The reduction in number of sclerotia may be attributed to fissures in their protective rings, due to increased temperature, which may have facilitated the attack of antagonistic microorganisms such as bacteria attracted by the pathogen exudates (FERRAZ et al. 2003). Elad et al. (1980) observed that soils treated with plastic mulch stimulated sclerotia exudation in *S. rolf sii*, increasing their colonization and destruction by bacteria. Soil microbial activity, as evaluated by CO₂ release, did not decrease in solarized soils, which reinforces the idea that after the sclerotia had been damaged by high temperatures, antagonistic microorganisms present in the soil reduced sclerotia viability.

Table 2. Soil microbial activity and number of viable *Sclerotium rolf sii* sclerotia in soils with or without solarization, after growing the second crop in the first year of the experiment.

| Variable | No solarization | Solarized soil | CV (%) |
|---|-----------------|----------------|--------|
| Soil microbial activity (mg CO ₂ .100g soil ⁻¹) | 13.01 a | 12.11 a | 7.82 |
| Nº sclerotia (nº.50g soil ⁻¹) | 25.73 a | 10.19 b | 20.45 |

*Means followed by the same lower-case letter in the row do not differ significantly from each other by Duncan's test (p≤0.05).

CONCLUSIONS

In a two-year solarization period and under the temperatures achieved in this study it was not possible to control the diseases caused by the pathogen. However, the soil solarization decreases the incidence and severity of root collar rot caused by the fungus *S. rolf sii* in bean plants, as well as the pathogen's sclerotia viability.

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