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# SUPPRESSION OF FUSARIUM ROOT ROT AND SOUTHERN BLIGHT ON PEANUT BY SOIL SOLARIZATION

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## ABSTRACT

Both southern blight (*Sclerotium rolfsii*) and Fusarium root rot (*Fusarium solani*) are the important soil-borne diseases found in peanut (*Arachis hypogaea*) in the Bogor area, including the Seed Technology Experimental Station of Bogor Agricultural University (IPB). Solar heating by means of clear polyethylene sheets to control these two soil-borne diseases was performed in naturally infested soil in the experimental station. The temperature in the moistened field soil covered with transparent polyethylene sheets increased dramatically by solarization particularly in the upper 5 cm layer. Soil solarization suppressed incidence of both diseases and enhanced crop yields significantly. Soil solarization for 1, 2, and 3 weeks suppressed southern blight by 75.3, 79.3, and 91.0 percent, and Fusarium root rot disease by 74.5, 81.2. and 83.9 percent, respectively. The average dry weight of fulfilled pod yields increased by 43.9, 48.8, and 80.5 percent in soils solarized for 1, 2 and 3 weeks, respectively. A higher population of the total bacteria, actinomycetes, and fungi were found in solarized soils. Changes in microbial populations induced by soil solarization might contribute in the diseases suppression beyond the physical effects. The phenomenon of increased growth response (IGR) also occurred in this study besides disease suppression.

**Key words:** *Arachis hypogaea*, soil-borne diseases, transparent polyethylene sheets, IGR

## INTRODUCTION

Peanut is one of the important protein resources in daily diet in Indonesia. Average annual production of this crop in Indonesia, 702,861 ton can not covered the average annual consumption, 836,560 ton. Though many peanut varieties have the potential to produce between 2.5 – 3.3 ton/ha based on research activity, only about a half (1.08 ton/ha) of the potency has been performed in practically (Manurung, 2002). One of the limiting factors causing the decrease in productivity is plant pathogens. As the peanut pods produced on the tip of the flower pegs initially grow downward into the soil to mature, these are exposed to many soil microorganisms including fungal pathogens. Several soil fungal plant pathogens, such as *Fusarium, Sclerotium, Rhizoctonia, Rhizopus, Pythium, Verticillium, Sclerotinia, Cylindrocladium, Penicilium*¸and *Aspergillus* species have been reported as causal agents of peanut diseases throughout the growing areas in the world (Kokalis-Burelle et al., 1997). Among these soil-inhabiting fungal plant pathogens, *S. rolfsii* and *F. solani* are the most devastating and economically important in many peanut growing areas in Indonesia (Semangun, 1993). Since 1987, these two fungi have caused devastating diseases which affect adversely many kinds of field experiments, not only phytopathological but also the other aspects in the Seed Technology Experimental Station-Bogor Agricultural University (IPB).

In ecological views, the management of soil-borne plant pathogens should be emphasized in the promotion of soil health as it provides an environment that allows maximum yields with reduced risks of loss and minimal environmental contamination. Since 1976, when the first publication appeared on solarization involving the use of polyethylene sheets (Katan et al. 1976), many studies have explored its uses and effectiveness under different environmental conditions (Greenberger et al., 1987; Lopez-Herrrera et al., 1994; Chellemi et al. 1997; Mc Govern et al. 2000). The use of this method to control soil-borne diseases as well as weeds and arthropod pests seems to have a promising approach since the phase out of methyl bromide in developing countries was implemented in 2005. Many investigations seemed to show that soil solarization raised the equilibrium of many physical, chemical and biological factors that promoted soil health (DeVay and Katan, 1991).

## MATERIALS AND METHODS

### Soil solarization

Field experiments were carried out in naturally severely infested soil in the Seed Technology Experimental Station-Bogor Agricultural University (IPB), where peanut has been grown frequently, from November 2001 to April 2002. Individual plots, 5 x 5 $m^2$, were arranged in a randomized complete block design (RCBD) consisting of four treatments each with three replications. Solarization was carried out on soils amended with chicken manure (200 ton /ha) and moistened by irrigated one day before mulching. Plots were mulched with 0.05 mm transparent polyethylene plastic sheets for one, two, and three weeks during November and December. Non-mulched plots were weeded once a week to let solar heat reach the soil surface optimally as treated plots. Soil temperatures were measured daily and recorded for solarized and non-solarized treatments at 5 and 15 cm depths. Soil temperatures were recorded daily every three hours from 06 am to 06 pm using a soil thermometer at three points in each representative treatment.

### Planting and maintenance

After solarization, the peanut seeds (cv. Gajah) were sown at a 25 cm distance in rows and 50 cm in between rows. Cultural practices were done as needed to maintain good plant growth, including fertilization of TSP, urea, KCl, (each 600 kg/ha), weeding (2 times), and irrigation during the vegetative phase when needed.

### Disease development and yields

Disease development was recorded once a week by observing percentage of wilted plants from one to nine weeks after planting. At each observation, all wilted plants were uprooted to determine the causal agents, whether *Fusarium* or *Sclerotium*. The data of disease incidence was expressed as cumulative number with previous observation weekly. To measure the effect of soil solarization on yields, pods were harvested from all plants without two furrows from the edge of each plot. Pods were exposed to full sunny days in a cemented drying area for 5 days. Crop production was estimated as the dry weight (ton) of fulfilled pods per hectare.

### Soil microbial count

Soil samples were taken from of each experimental plot (5 – 15 cm depth) at the end of soil solarization. Composite samples (five sub samples from each plot) were taken to determine total microbial population, including fungi, bacteria and actinomycetes, using serial dilution methods. Composite soil samples were mixed well from each replicate plot, and 10 g soil were taken; 100 ml sterilized distilled water was than added, shaken for 20 minutes using rotary shaker, allowed to settle and diluted with blank sterilized water. At the proper dilution for colony counting, 0.1 ml of soil suspension was transferred into the various media in Petri dishes, spread with L-shaped glass rod and incubated at $28^0$C. The media used in this experiment were Martin Agar, Chitin Agar, and Tryptic Soy Agar 1/10 strength, to determine the population of fungi, actinomycetes, and bacteria, respectively. Bacterial, fungal and actinomycetes colonies which appeared on the plates were counted 48 - 72 hours, and 7 – 9 days after incubation, respectively.

## RESULTS

The highest soil temperature reached 50$^o$C or higher in mulched and solarized plots during November (Fig. 1). Overall, daily maximum temperatures reached at 5 and 15 cm depth in the solarized soil were higher than non-solarized controls, especially in two and three weeks treatments. The mulching of moist soils raised the soil temperature and the highest temperature was in the upper layer at 5 cm depth (Fig. 1). Maximum soil temperatures in the other deeper layer (15 cm) also increased in mulched soils compared to the non mulched soil. The differences in the maximum temperatures between mulched and non mulched soils after three weeks were 17 $^o$ and 15 $^o$ C at the 5 and 15 cm depth, respectively.

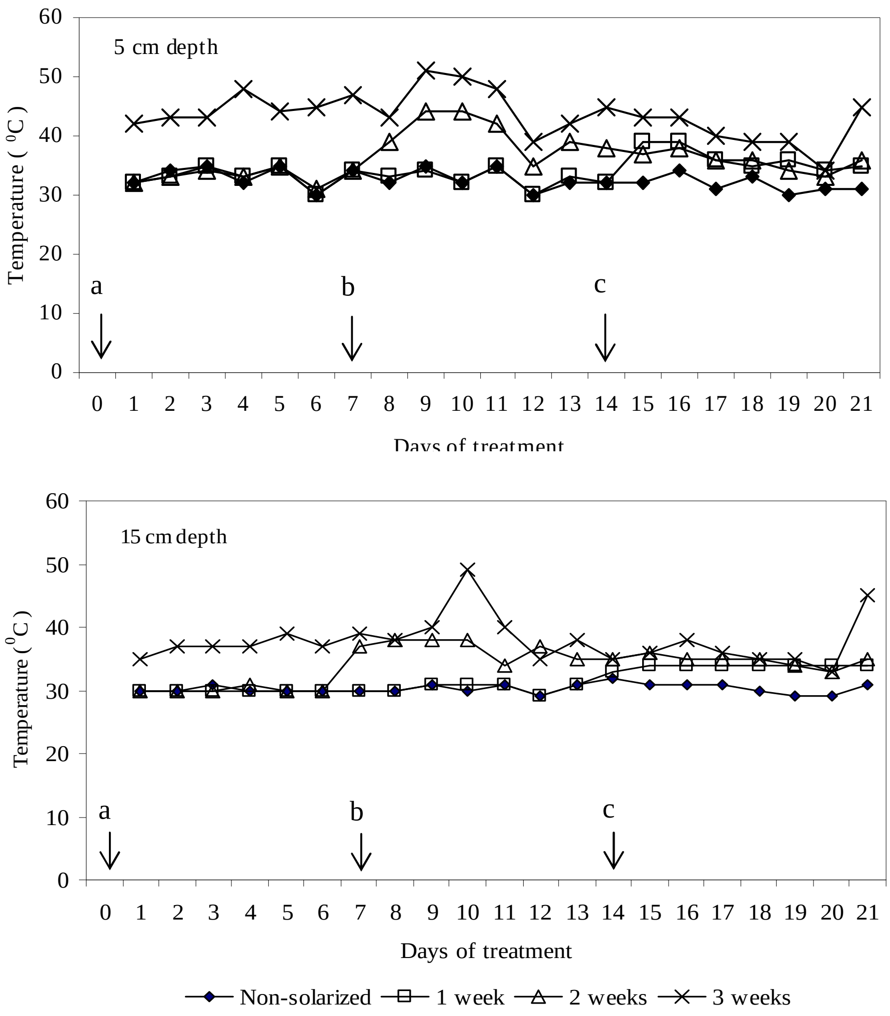


**Fig. 1.** Daily maximum soil temperatures in solarized and non-solarized soils at depths of 5 and 15 cm. Letters a, b, c mean starting days of 3 weeks, 2 weeks, and 1week solarization treatments, respectively.

The development of two diseases, Southern blight and Fusarium root rot disease in peanut, were suppressed by soil solarization for 1, 2 or 3 weeks (Fig. 2). This treatment also reduced significantly the disease incidence in nine weeks after planting compared to non-solarized (Table 1). The highest reduction in disease incidence was seen in the 3-weeks solarization plot although there was no statistical significance among treated plots. Solarization for 1, 2, and 3 weeks reduced the Fusarium (*F. solani*) disease incidence by 74.6 %, 81.7 %, and 83.9 %, respectively, as compared with the non-solarized. The reduction of stem rot (*S. rolfsii*) disease incidence was up to 75.3 %, 79.1 %, and 91.0 % in plots solarized for 1, 2 and 3 weeks, respectively (Table 1).

The disease suppression development was reflected in the better peanut growth performance and the significant increase in pod yields dry weight when compared with the non-solarized. Target disease was not seen in the solarized field one month after planting and the greener canopies were still seen in the treated plots even at harvest compared with the non-solarized. Conversely, wilted plants caused by the two targeted diseases were present in the untreated plots, and leaves almost fell down on the day of harvest (figures not shown). Solarizing the soil for 3 weeks showed the highest pod yield, and significantly different compared with one week treatment and non-solarized. Plots with solarization treatments increased the dry weight of fulfilled pods yield by 43.9 to 80.5 % relative to untreated (Table 2). Although not statistically significant, soil solarization tended to give the best result in the percentage of fulfilled, and reduced the empty pods (Table 2).

**Table 1**. Influence of soil solarization on the disease incidence of stem blight and Fusarium disease.

| **Treatments** | **Disease incidence [v]** | | | |
|---|---|---|---|---|
| | **Southern blight (%)** | **Reduction over non-solarized (%)** | **Fusarium disease (%)** | **Reduction over non-solarized (%)** |
| Non-solarized | 12.89 a | - | 23.34 a | - |
| 1 week solarization | 3.19 b | 75.2 | 5.93 b | 74.8 |
| 2 weeks solarization | 2.69 b | 79.1 | 4.26 b | 81.7 |
| 3 weeks solarization | 1.16 b | 91.0 | 3.76 b | 83.9 |

[v] Data of nine weeks after planting; Values followed by different letters in the same column are significantly different according to Duncan Multiple Range Test ($p = 0.05$)

**Table 2**. Influence of soil solarization on yield and pods quality of peanut.

| **Treatments** | **Dry Yield** | | **Pods quality** | |
|---|---|---|---|---|
| | **Full filled pods (ton/ha)[w]** | **Increase over non-solarized (%)** | **Full filled pods (%)[w]** | **Empty pods (%)[w]** |
| Non-solarized | 0.41 c | - | 89.20 a | 10,78 a |
| 1 week solarization | 0.59 b | 43.9 | 91.80 a | 8.19 a |
| 2 weeks solarization | 0.61 ab | 48.8 | 91.24 a | 8.74 a |
| 3 weeks solarization | 0.74 a | 80.5 | 93.07 a | 6.93 a |

[w] Values followed by different letters in the same column are significantly different according to Duncan Multiple Range Test ($p = 0.05$)

The results also showed a significant increase in the total population of microorganisms, especially bacteria and fungi, in soil after solarization, but the actinomycetes was not significantly affected by the treatments (Table 3). The most recorded fungi were the genera of *Trichoderma, Aspergillus, Cladosporium,* and *Fusarium*.

**Table 3.** Effect of soil solarization on microorganisms population.

| Treatments | Total microorganisms population (log cfu / g soil)[x] | | |
|---|---|---|---|
| | **Bacteria** | **Actinomycetes** | **Fungi** |
| Non-solarization | 8.29 b | 5.51 a | 3.81 c |
| 1 week solarization | 8.66 a | 5.56 a | 4.05 b |
| 2 weeks solarization | 8.53 ab | 5.76 a | 4.06 b |
| 3 weeks solarization | 8.51 ab | 5.97 a | 4.32 a |

[x] Values followed by different letters are significantly different according to Duncan Multiple Range Test ($p = 0.05$)

## DISCUSSION

The diseases caused by *F. solani* and *S. rolfsii* were considerably suppressed by soil solarization (Figure 2) and the disease incidences were reduced up to 83.9% and 91.0 % compared with the non-solarized, respectively (Table 1). In this study, the average solarized soil temperature at 5 and 15cm depth increased 3.5 to 10.3$^0$C and 1.2 to 6.6$^0$C compared with the non-solarized, respectively (data not shown). A lower soil temperature increase in another study showed significant reduction in *F. oxysporum* populations in southern Spain (Rafael et al., 1991). These results suggest that the suppression of *Fusarium* disease in this study was affected physically by the increase of soil temperatures. Although the difference in the solarization periods did not significantly affect incidences of both diseases, the disease suppression effects increased with the extension of the solarization period (Table 1). The extension of the solarization period enables control of the pathogens that inhabit in deeper soil layers and/or less sensitive to heat. The extended period of solarization was required to achieve 90 to 100 % mortality of *Verticillium dahliae* sclerotia in deeper soil layers (Katan, 1987).

Another field experiment also showed that suppression of club root disease incidence on cabbage was higher when the solarization period was extended up to 7 weeks (Widodo and Suheri, 1995). Significant control effect in various regions in the world, with different pathogens, were obtained usually within 20 to 60 days of solarization (DeVay and Katan, 1991). Longer soil exposure to higher temperatures achieved during solarization caused of cracking *S. rolfsii* sclerotia and increased its vulnerability to antagonistic microorganisms (Kartini and Widodo, 2000). Increasing of soil temperatures during solarization suppressed average population of weeds and several groups of pathogen, including fungi, bacteria and nematode in Western Oregon (Pinkerton et al., 2000).

This result suggests that microbial processes induced by soil solarization might contribute to suppression of the two targeted diseases beyond the physical effect as showed in the increase in total microbial population, especially fungi (Table 3). The most frequently obtained fungi in this experiment, that may potentially be antagonistic to microorganisms, were *Aspergillus, Trichoderma,* and *Cladosporium. Aspergillus* appeared most frequently as colonies on sclerotia buried in the solarized soil (data not shown). In another study, the population of actinomycetes was significantly higher in solarized than untreated soils and may contribute in club root suppression (Widodo and Suheri, 1995).

More vigorous growth of peanut in 30 days after sowing was shown in solarized plots and disease symptoms were not obtained. More plants survived and a greener canopy found several days before harvesting in solarized plots indicated that this treatment may promote plant growth and increase their productivity (Table 3). Beyond the disease control, the phenomenon of increased growth response (IGR) was frequently seen in solarized soils (Katan, 1981; Gamliel and Katan, 1991; Stapleton and DeVay, 1984; Chen and Katan, 1980; Widodo and Suheri, 1995; Pinkerton et al., 2000). The manifestation of IGR in solarized soils has been indicated as the involvement of physical, chemical, and microbial changes. However, the changes which result in a new microbial balance in the soil are apparently related to the long-term effect of IGR, and might be as one of an economically approach in soil borne plant diseases control and increasing the genetic potential of cultivated crops.

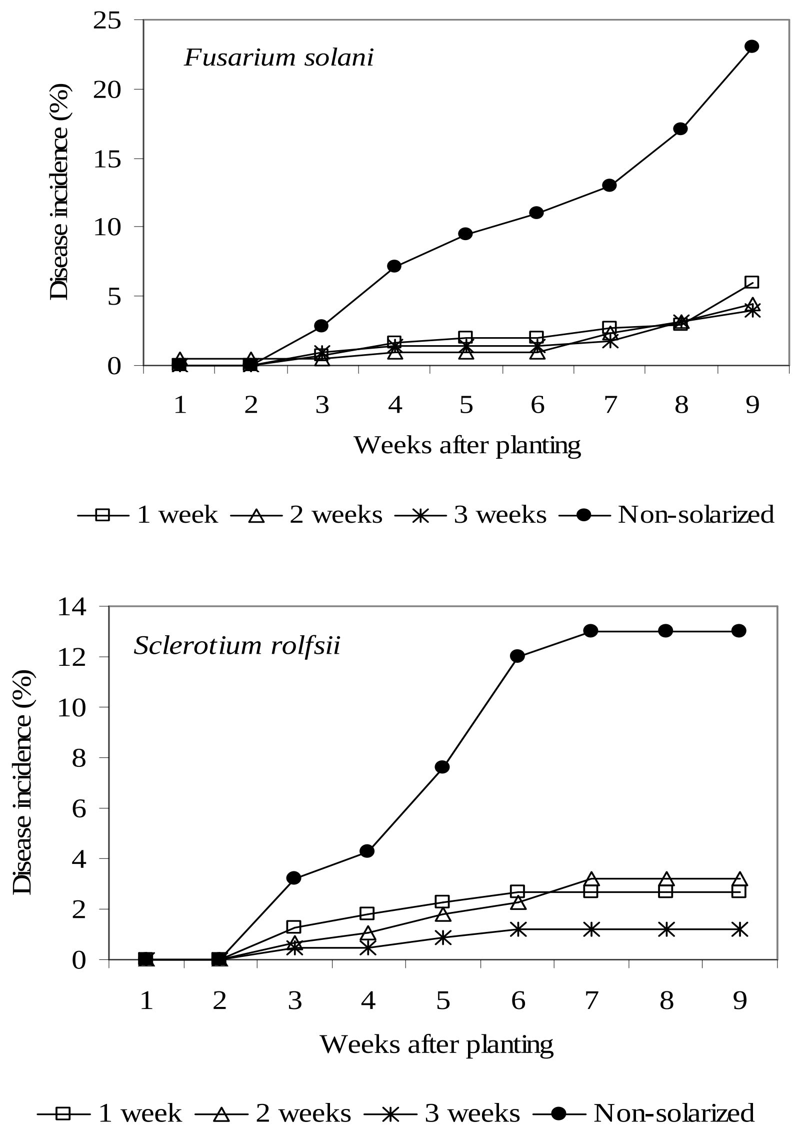


**Fig. 2**. Effect of soil solarization on the development of Southern blight (*S. rolfsii*) and Fusarium root rot disease (*F. solani*) in peanut.

## CONCLUSION

Soil solarization using transparent plastic for 1, 2, and 3 weeks significantly suppressed the two soil borne diseases, *Fusarium* root rot and Southern blight, on peanut and increased yield potency. The extension of the solarization period resulted in higher disease suppression and yield increase which might be induced by some microbial processes during soil solarization.

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