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EFFECT OF SOLAR HEATING BY POLYETHYLENE MULCHING ON SCLEROTIAL VIABILITY AND PATHOGENICITY OF *SCLEROTIUM ROLFSII* ON MUNGBEAN AND SUNFLOWER

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Abstract

Soil solarization by polyethylene mulching significantly enhanced soil temperatures in mulched soils. A difference of 16°C was recorded in mulched and non-mulched soils at 5cm depth. Effect of mulching was more profound on upper soil surface since higher temperatures in mulched soils were recorded at 5 cm depth as compared to 10 cm depth. Sclerotial viability of *S. rolfsii* and RCI were negatively correlated with depth of mulched soils. Maximum sclerotial mortality occurred at 5cm followed by 10 cm in mulched soils. Similarly, minimum disease infection and better plant growth was recorded in plants grown in soil removed from 5 cm depth in mulched plots. Maximum sclerotial mortality and minimum pathogen infection was noted after 15 days of mulching.

Introduction

Plant diseases play a direct role in the destruction of natural resources in agriculture. Fungal phytopathogens are widely spread in the global ecosystem. Some of the soil-borne plant pathogenic fungi in order to survive for long periods of unfavorable conditions produce different types of resting structures like sclerotia which show high resistance to chemicals and biological degradation (Coley-Smith & Cooke, 1971).

Sclerotium rolfsii Sacc., is a soil borne plant pathogen that causes disease in over 500 plant species throughout the world specially in tropics and subtropics (Punja, 1988; Mukherjee & Rajhu, 1997; Harlton *et al* ., 1995; Cilliers *et al*., 2000). The large number of sclerotia produced by *S. rolfsii* and their ability to persist in soil for several years, as well as the prolific growth rate of the fungus make it a well suited facultative saprophyte and a pathogen of major importance throughout the world (Punja, 1988).

Chemical compounds have been used to control plant diseases, but abuse in their application has favored the development of pathogens resistant to fungicides. Unfortunately, the more specific the effect of a chemical on an organism, the greater the probability of decreasing the effect through genetic shifts in the population, whereas fungicides of broad spectrum produce undesirable consequences on non-target organism (Tjamos *et al*., 1992). Soil solarization has proved as an effective and environmentally safe alternate to chemicals that is applicable to various agricultural situations for the control of various soil-borne pests, including phytopathogens and weeds (deVay *et al*., 1990; Stapleton *et al*., 1987). Experiments were carried out to study the effect of solar heating by polyethyelene mulching on the pathogenecity and viability of sclerotia of *Sclerotium rolfsii* on mungbean and sunflower.

Materials and Methods

Production of sclerotia: Wheat straw was cut into 2-3cm long pieces and soaked in water for 2 hrs. The straw was pressed between hands to remove excess moisture, transferred into 250ml conical flasks and sterilized for 20min at 15psi. A 5mm diam., inoculum disc from an actively growing culture of *S. rolfsii,* isolated from sugar beet seed on potato sucrose agar (PSA) was transferred into each flask. This isolate was found to be pathogenic on mungbean and sunflower (Fouzia & Shahzad, 2005).The flask was incubated at room temperature for one month for production and maturation of sclerotia. The straw were then spread on a sterilized blotter paper sheet, allowed to air dry and sclerotia collected in sterile glass vials and stored in a refrigerator for future use.

Polyethylene mulching: Soil samples artificially infested with 200 sclerotia per 200g soil were distributed in 15x15cm nylon net (100 mesh), tied with nylon strings into small bags and buried in soil at 5 cm and 10 cm depths. Moisture of the soil was brought to field capacity and transparent polyethylene sheets were spread over the soil. Margins of the sheets were buried in soil to prevent loss of moisture. A comparable set of non-mulched plots was kept as control. Soil samples were collected after 7 and 15 days intervals. Plastic pipes (12mm diam) were inserted into soil to 5 and 10 cm depth in both the mulched and non mulched soil to place the thermometer. Soil temperature was recorded from 10 am to 4 pm at 2 hours intervals. After recovering samples at 7 days interval, the soil was again irrigated to field capacity before covering with polyethylene sheets. There were three replicates for each treatment. The experiment was carried out in completely randomized design.

Sclerotial viability: In another set 10 sclerotia kept in nylon net were buried in soil at 5cm and 10cm depths in mulched and non-mulched soils. At 7 and 15-days intervals the polyethylene sheets were removed and three bags of each treatment containing sclerotia were recovered from 5 and 10cm depths. Viability of the sclerotia was assessed on PSA amended with penicillin (@ 100,000 units L^{-1}) and streptomycin (@ 0.2g L^{-1}), where sclerotia were surfaced sterilized with 1% Sodium hypochlorite solution for 2-3 minutes and 5 sclerotia were plated in each Petri plate.

Effect on pathogenicity: Soil samples removed from 5 and 10 cm depths from mulched and non mulched soils after 7 and 15 days intervals were transferred into 8cm diam., thermopol pots @ 200g per pot. Set of 3 pots of each treatment were used for mungbeen and sunflower separately. Seeds were sown @ 10 seed per pot. Soil moisture was adjusted to 50% MHC and the amount of water lost was restored daily. Plant was uprooted after 30 days growth, length and weight of plants were recorded. Roots were washed under running tap water to remove the soil, cut into 1cm long pieces and 10 randomly selected root pieces from each root system were plated on PSA amended with penicillin (100,000 units L^{-1}) and streptomycin (0.2g L^{-1}). The data on root colonization were converted to root colonization index (RCI) according to the following 0-5 scale of Shahzad & Ghaffar (1992) where 0=0, 1=1-10, 2=11-25, 3=26-50, 4=51-75 and 5=76-100% root colonized.

Results

Effect of mulching on temperature: Polyethylene mulching greatly influenced the daily temperature during the experiment. In mulched soils temperature increased to 52ºC as compared to 36ºC in non-mulched soils (Fig. 1). Maximum temperature was recorded at 2 O'clock. Soil heating by polyethylene mulching was also affected by the soil depth, as in our experiment significantly higher soil temperatures were recorded at the 5cm depth as compared to 10 cm depth. However, at both 5 and 10 cm depths, polythelene mulching produced significantly higher temperatures than non-mulched soils at the same depth (Fig. 1).

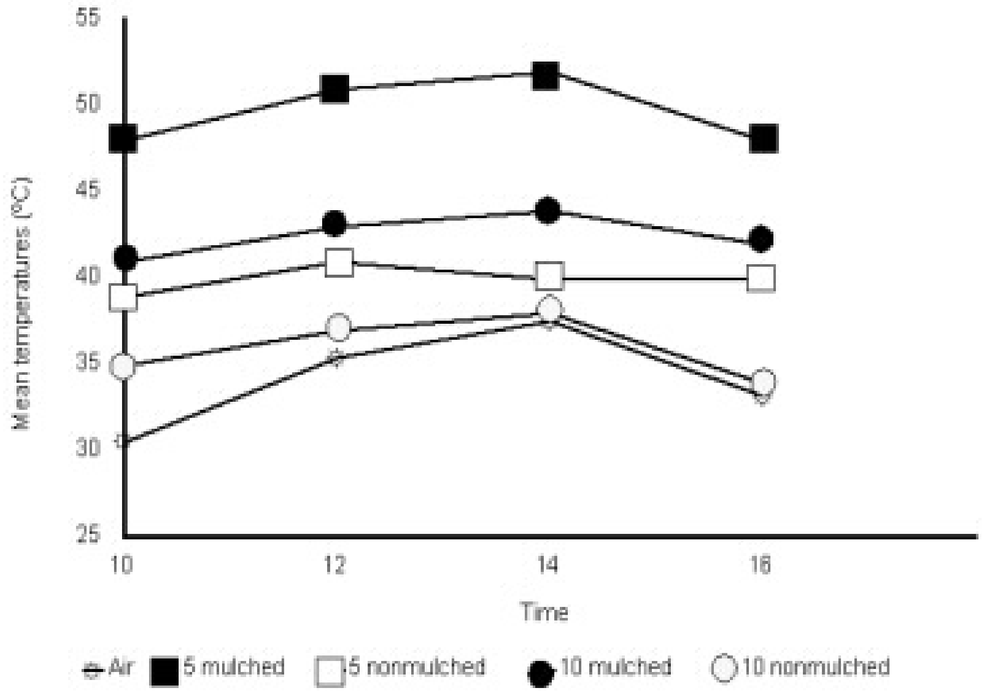

Fig. 1. Average daily temperatures at 10am, 12am, 2pm and 4pm during the experiment in different treatments.

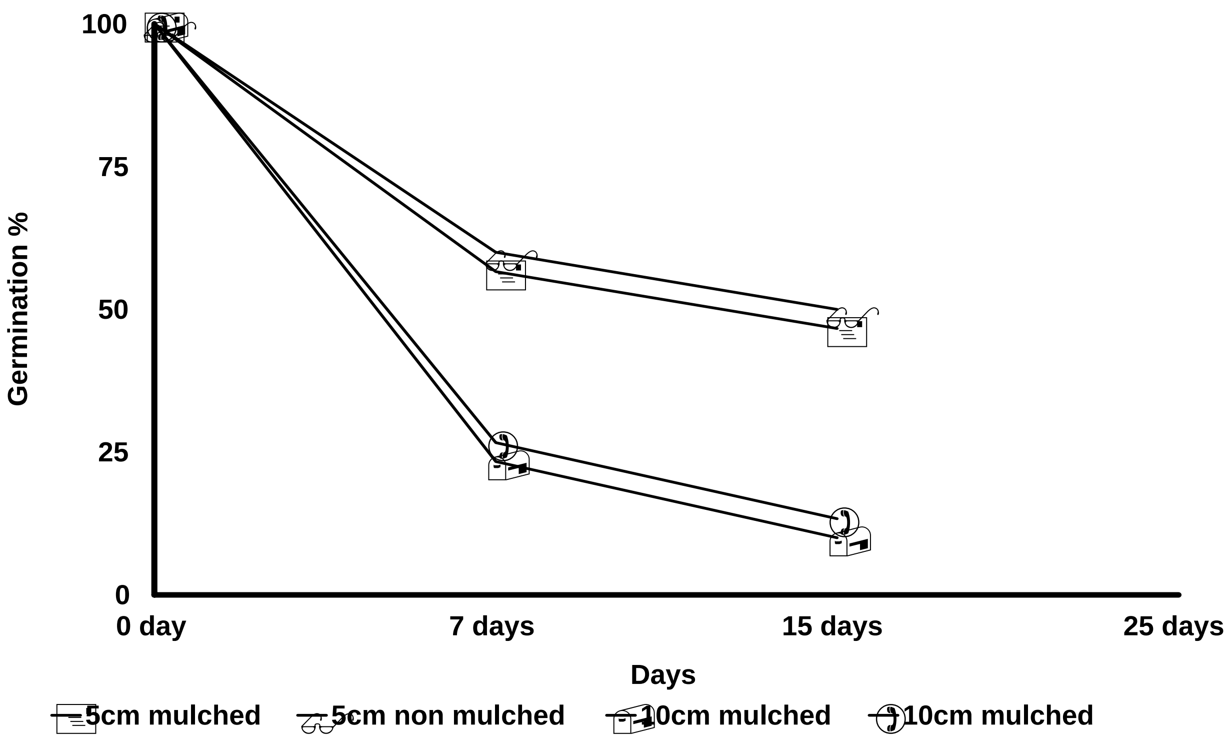

Fig. 2. Effect of polyethylene mulching on sclerotial viability of *Sclerotium rolfsii.*

Effect of mulching on sclerotial viability: Soil mulching with polyethylene sheet for 2 weeks in hot summer was highly effective in reducing soil population densities of sclerotia of *S. rolfsii* and in bringing about significant control of pathogen infection on mung bean and sunflower. The effect was more pronounced at upper 5cm soil layer (Fig. 2). After 7 days reduction in sclerotial viability in mulched soil was 77 and 73% at 5 and 10 cm depths, these increased to 90 and 87%, respectively, after 15 days. In non-mulched soil, reduction in viability after 7 days was 43 and 40% at 5 and 10 cm depths whereas reduction in viability was 53 and 50% respectively at 5 and 10 cm depths after 15 days (Fig. 2).

Effect of mulching on the pathogenicity of *S. rolfsii*: Root colonization index (RCI) on mungbean and sunflower in mulched soil was less as compared to non-mulched soil at each depth. Greater reduction in RCI was observed after 15 days interval (Fig. 3). Similarly, plant weight and length were also greater in mulched soils as compared to non-mulched soil (Fig. 3). RCI appeared to be directly correlated with the population of *S. rolfsii* in soil, whereas, plant growth showed an inverse correlation with the population of *S. rolfsii* in soil (Fig. 4).

Discussion

Mulching with polyethylene sheets proved highly effective in raising the soil temperatures as compared to non-mulched soils. However, mulching heated the soils more at the depth of 5 cm than at 10 cm. Singh *et al.*, (1990) also recorded maximum temperature of 53ºC in a tarped plot at 1 cm depth. Similar results have also been recorded by Shahzad & Ghaffar (1991), Usmani & Ghaffar (1982) and Sheikh & Ghaffar, (1984) who evaluated the effect of mulching on *R. solani*, *Sclerotium oryzae* and *Macrophomina phaseolina*, respectively.

Soil solarization by polyethylene mulching significantly reduced the sclerotial viability. The mulching at both depths produced more or less similar results in terms of sclerotial mortality, however, more sclerotial mortality was observed after 15days than 7 days. The heat generated in soil by solar radiation and the resultant death of pathogens encompasses the major principles of soil solarization. Stevens *et al.*, (2003) reported that IPM plus soil solarization effectively reduced the numbers of sclerotia of *S. rolfsii* as compared to non-solarized bare soil. Singh *et al.*, (1990) observed that after 45 days of soil solarization at 1 cm depth, only 10% sclerotia of *S. rolfsii* germinated while in our experiment similar sclerotial mortality was achieved after 15 days at 5 cm depth. Similar results were also reported by Elad *et al*., (1980) and Mihail & Alcorn (1984). About 50% reduction in sclerotial viability in non-mulched soils was recorded in the present investigation. Same as in mulched treatments, more reduction in sclerotial viability were recorded at 5 cm than 10 cm depth and after 15 days than 7 days interval in non-mulched soil. The mechanisms of inactivation of fungi by soil heating is not clear, however fungal inactivation may involve enzyme inactivation, changes in fatty acids and membrane components (Crisan, 1973). Although, the possible effects of thermophilic, thermotolarant and anaerobic soil-borne biological agents on sclerotial mortality cannot be neglected and they may be one of the factors alongwith the soil temperature in reduction of sclerotial viability in both mulched and non-mulched soils (Ghaffar, 1987; Usmani & Ghaffar, 1982).

Soil solarization by mulching also affected the RCI and plant growth of mungbean and sunflower. The infection was more reduced in mulched soils after 15 days than in 7 days. It means that by the passage of time the effects of mulching become more profound. The minimum RCI was recorded in soils removed from 5cm depth after 15 days mulch treatment. Consequently, less infection results in the better plant growth and maximum plant height and weight were recorded in plants grown in soils removed from 5cm depth from mulched plots. Our results are in confirmation to those reported by Ristaino *et al.*, (1996) who observed that solarization of fallow soil in bell pepper raised beds significantly reduced incidence of *S. rolfsii.* Stevens *et al*., (2003) also observed that IPM plus soil solarization reduced the plants mortality by southern blight caused by *S. rolfsii*. Our results are also in accordance with the findings of Ristanio *et al*., (1991), Stevens *et al*., (1990), Jenkins & Avere (1986) and Grinstein *et al*., (1979) who observed that soil solarization effectively reduced the infection of *S. rolfsii* in crop plants. The results of the present study suggest that a three week mulching period could provide almost 100% reductions in population of *S. rolfsii* in soil.

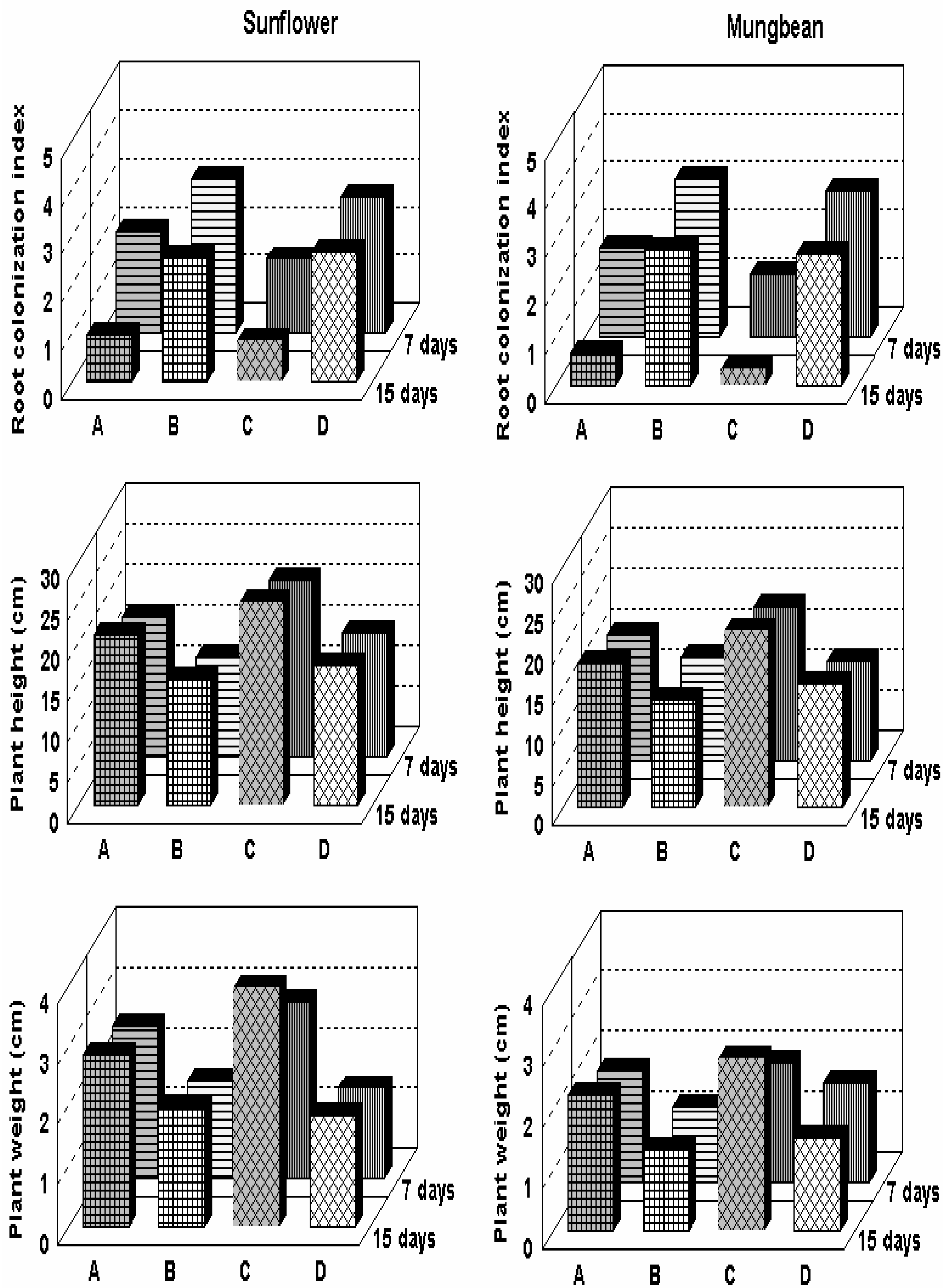

Fig. 3. Effect of mulching on disease infection and plant growth on sunflower and mungbean. A=10cm mulched; B=10cm non-mulched; C=5cm mulched; D=5 cm non-mulched.

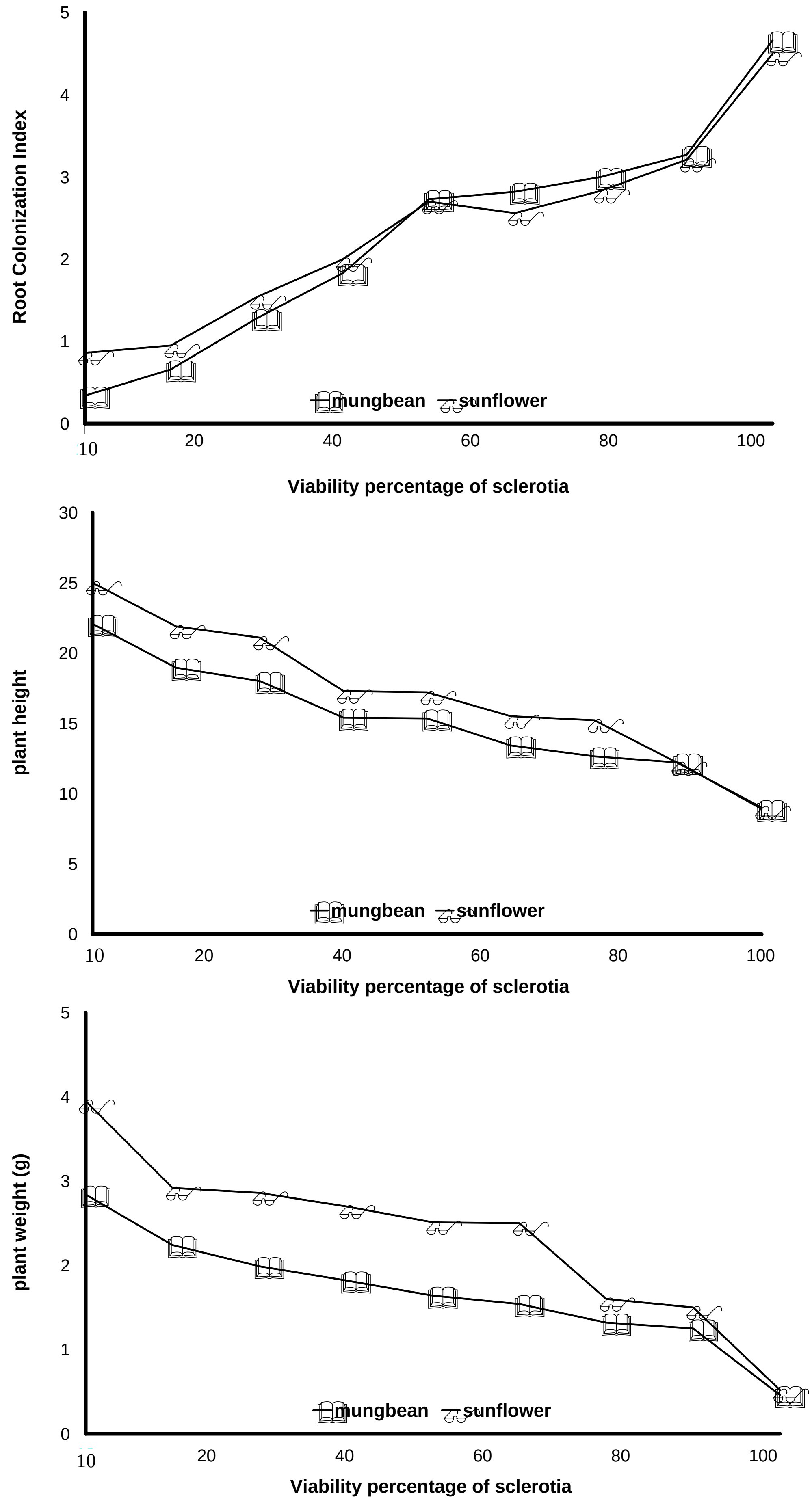

Fig. 4. Effect of sclerotial viability on RCI, plant height and plant growth.

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