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Effect of soil solarization on viability, disease incidence and incubation period of stem rot of chrysanthemum caused by *R. solani*

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Abstract

A study conducted during 2016 at Nauni to find out the effect of soil solarization with transparent polyethylene mulch (25µm thick) was recorded on soil temperature in the earthen pots and pathogenic potential of the stem rot pathogen mixed in the soil of the earthen pots. Soil solarization increased average maximum soil temperature to 45.9 °C, in the year 2016 with an increase of 7.8 °C at 5 cm soil depth over unsolarized pots. Soil solarization for 40 days resulted in significant reduction in the potential of the pathogen to cause the disease. Soil solarization was observed on disease causing capability of the stem rot pathogen. Sclerotia of *Rhizoctonia* stem rot pathogen subjected to soil solarization with transparent polyethylene sheet which were put at 5 cm soil depth for 40 days lost the viability of by 88.7 per cent in comparison to unsolarized soil in the pots. Sclerotia of the stem rot pathogen subjected to soil solarization with transparent polyethylene sheet at 5 cm soil depth for 40 days increased the incubation period of the disease by 21.2 per cent i.e. symptoms were delayed and reduced the disease incidence by 46.1 per cent in comparison to unsolarized pots.

Keywords: soil solarization, viability, incubation period, stem rot, chrysanthemum caused, *R. solani*

Introduction

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one of the five important commercial ornamental crops grow in India. There are number of factors which affect the yield and quality of flowers and diseases are one of the most important limiting factors. Chrysanthemum is also attacked by a number of fungal, bacterial and viral diseases which results in huge losses to the planting material and also affect the quality of the flowers. Among fungal diseases, *Rhizoctonia* stem rot (*Rhizoctonia solani*), Septoria leaf spot (*Septoria chrysanthemi*, *Alternaria* leaf spot (*Alternaria* spp.), Fusarium wilt (*Fusarium oxysporum* f. sp. *chrysanthemi*), rust (*Puccinia chrysanthemi*) and Powdery mildew (*Erysiphe cichoracearum*) are important. Amongst different diseases of chrysanthemum, *Rhizoctonia* stem rot caused by *Rhizoctonia solani* Kühn (teleomorph: *Thanatephorus cucumeris* [Frank] Donk.) is one of the most important fungal disease which mainly cause damping off, stem rot, stem girdling and root rot (Parmeter, 1970) [1]. *Rhizoctonia solani* is a soil-borne fungus that causes diseases on many economically important crop plants worldwide. The pathogen overwinters as soil-borne sclerotia and mycelium in plant debris and these constitute the primary inoculum. Soil solarization involves the use of transparent polyethylene mulch for capturing solar energy for heating the soil for controlling pest in the soil (Katan, 1981) [2, 3, 4, 12, 21, 22, 25, 29]. Soil solarization has significant potential for control of soil-borne pathogens (Polizzi *et al.*, 2002) [7]. Of late, clear polyethylene sheet is being used for soil solarization in many countries for controlling soil-borne plant pathogens and weed effectively. Therefore, study was undertaken to find out the effect of solarization on incubation period take for the symptoms to appear, sclerotia viability and disease incidence for management of *Rhizoctonia* stem rot of chrysanthemum.

Materials and Methods

The experiment was laid out at the experimental farm of the Department of Plant Pathology in the year 2016. Experimental design was completely randomized design with 4 replication of each treatment.

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Effect of soil solarization on the viability of sclerotia of *Rhizoctonia solani*

Effect of soil solarization with transparent polyethylene mulch on the viability of the sclerotia buried in the soil. Effect of soil solarization were observed on the viability of the sclerotia of pathogen by burying 50 sclerotia put in nylon sieve bags at 5 and 15cm soil depths. Soil solarization was done by covering plots with transparent polyethylene sheet (25µm thick) for 40 days in the month of May-June. These nylon sieve bags containing sclerotia were retrieved after 20, 30 and 40 days of solarization and brought to the laboratory to find out the viability of the sclerotia of the pathogen. The sclerotia withdrawn were dipped in Sodium hypochlorite (1%) for one minute and then sclerotia were washed thrice with sterilized distilled water in Petri plates. Sclerotia were dried by keeping them in sterilized filter papers. Then, sclerotia were inoculated and embedded aseptically in the potato dextrose agar medium in the Petri plates. These Petri plates were incubated at 25±1°C temperature and count on viability of the sclerotia was taken for next 20 days till all the sclerotia in the control plates are germinated.

Effect of soil solarization on potential of sclerotia of *Rhizoctonia solani* to cause the stem rot disease

Effect of soil solarization on the potential of the sclerotia to cause disease. Fifty sclerotia of the pathogen (*R. solani*) were

placed in nylon sieve bags at 5 and 15 cm soil depths. Soil solarization was done by covering plots with transparent polyethylene sheet (25µm thick) for 40 days during the months of May-June. These nylon sieve bags containing culture were retrieved after 20, 30 and 40 days of solarization. The effect of sub-lethal heat on pathogenic potential of the test pathogen was observed in the earthen pots filled with solarized soil by mixing the retrieved sclerotia of the test pathogen from the nylon sieve bags which were buried at from different depths and were taken out after 20, 30, and 40 days durations of soil solarization. After mixing the sclerotia in the sterilized soil of the earthen pots, light irrigation was given to make the soil of the pots wet. Three weeks after mixing of the sclerotia in soil, five chrysanthemum cutting were raised in each earthen pot and disease incidence was recorded in each treatment. Each treatment was replicated four times.

Result and Discussion

Effect of soil solarization on soil temperature in earthen pots

Soil solarization with transparent polyethylene sheet (25 µm thick) was done for 40 days from 15th May to 23rd June during 2016 in earthen pots. Soil solarization with transparent polyethylene sheet resulted in increase in the maximum soil temperature (Table-1).

Table 1: Effect of soil solarization with transparent polyethylene sheet (25 µm thick) on maximum soil temperature in the earthen pots

Treatments	Soil depth (cm)	Maximum soil temperature (°C) during May-June 2016	
		Average	Range
		Soil covered with transparent polyethylene mulch (25 µm thick)	5
	15	41.60	38 - 46
Unsolarized	5	38.08	40 - 44
	15	34.69	33 - 38

Average maximum soil temperature in the solarized soil of the pots was 45.9 °C during 2016, respectively at 5 cm depth in comparison to 38.0 °C in unsolarized pots. During 2016, soil solarization with transparent polyethylene sheet at 5 cm resulted in 7.8 °C increase in average maximum soil temperature with range of 42-49 °C during the period of solarization. However, average maximum soil temperature in the solarized soil at 15 cm depth, was 41.6 °C during 2016, respectively in comparison to 34.6 °C in unsolarized pots.

There are no specific reports of soil solarization in pots but the principle of soil solarization remains the same. Raj *et al.* (1997) [8, 14, 15, 28] reported that mulching with polyethylene resulted in 13.5 °C higher temperature at 8 cm soil depth with average maximum temperature of 49.7 °C. Negi (2009) [9] recorded an increase of 5.6 °C in average maximum soil temperature at 5 cm soil depth during soil solarization with transparent polyethylene sheet in the polyhouse. Mulching with transparent polyethylene mulch resulted in 11, 8, 7 and 5 °C increase in average maximum soil temperature in comparison to non-solarized fields, at 5, 10, 20 and 30 cm soil depth, respectively (Cimen *et al.* 2010) [10]. Hermanto (2012) [11] also reported that solarization with polyethylene sheet

increased the mean maximum soil temperature by 10.2 °C in comparison to control. Similar type of findings have been reported from different parts of the world where soil solarization is reported to cause increase in the average maximum soil temperature (Jacobson *et al.* 1980; Katan, 1981; Chauhan *et al.*, 1988; Raj and Gupta, 1996; Raj and Upmanyu, 2006) [2, 3, 4, 8, 12, 14, 15, 21, 22, 25, 28, 29].

Effect of different durations of soil solarization on viability of sclerotia of the *R. solani*

In general, soil solarization with transparent polyethylene sheet reduced the viability of the sclerotia of stem rot pathogen. Soil solarization for 40 days was found most effective with average 9.0 per cent viability of the sclerotia in comparison to 88.0 per cent viability in control. Duration of soil solarization also significantly affected the average viability of the stem rot pathogen. Increase in duration of soil solarization, from 20 to 40 days with significantly reduced the viability of the sclerotia from 25.0 to 9.0 percent, respectively at 5 cm soil depth. Soil solarization was found more effective at upper soil layers (5 cm) soil depth than at lower (15 cm) soil depth (Table-2).

Table 2: Effect of different durations of soil solarization on viability of sclerotia of the *R. solani*

Treatment	Percent viability of the sclerotia						Over all mean
	20 days		30 days		40 days		
	5 cm	15 cm	5 cm	15 cm	5 cm	15 cm	
Solarized	25.00 (29.75)	48.00 (43.83)	19.00 (25.55)	41.00 (39.73)	9.00 (17.09)	25.00 (29.75)	27.83 (30.95)

Unsolarized	100.00 (89.96)	100.00 (89.96)	92.00 (75.45)	99.00 (87.38)	80.00 (66.21)	88.00 (71.86)	93.17 (80.14)
Mean	62.50 (59.86)	74.00 (66.90)	55.50 (50.50)	70.00 (63.56)	44.50 (41.65)	56.50 (50.81)	

*Figures in parentheses are arc since transformed

CD_(0.05)

Days	(4.34)
Solarized	(3.55)
Depth	(3.53)
Solarization × Depth	(5.01)
Days × Solarization	(NS)
Days × Depth	(NS)
Days × Solarization × Depth	(NS)

Stapleton *et al.* (1989) [19] also observed that soil solarization for 30 days with transparent polyethylene mulch was effective in reducing the viability of artificially infested sclerotia of *Sclerotinia sclerotiorum* at different soil depths. In addition, the mechanism for reduction in viability of sclerotia has also been attributed to colonization by bacteria and streptomycetes resulting in the reduction of their pathogenic capacity (Lifshitz, 1979) [20]. Research findings from different parts of the world corroborates the present findings with similar results. In these findings soil artificial inoculated with sclerotia of *Sclerotium rolfsii* at different depths following solarization, had decreased viability of sclerotia under open field conditions (Grinstein *et al.*, 1979a; Horowitz and Ragev, 1980; Jacobshon *et al.*, 1980; Elad *et al.*, 1981; Stevens *et al.*, 2003) [3, 21-24, 26]. Ferraz *et al.* (2003) [27] also reported that solarization killed sclerotia of *Sclerotinia sclerotiorum* at 5, 10 and 30 cm soil depths. Raj and Bharadwaj (2000) [8, 14, 15, 28] and Minuto *et al.* (2000) [29] reported that increase in temperature due to soil solarization was lethal to mycelia, spores and resting structures of soil-borne plant pathogens. Gupta *et al.* (2017) [14, 16] reported that solar heating with polythene mulches reduced the propagules of *Sclerotinia sclerotiorum* significantly when compared to non-solarized soil at 10 and 20 cm depth.

Effect of different durations of soil solarization on potential of the pathogen to cause the disease

In general, treatment of soil solarization with transparent polyethylene sheet had a significant effect on the stem rot incidence. Soil solarization had a significant effect on the disease incidence even after 20 days and incidence of the stem rot was reduced to 36.6 per cent in the pots containing the sclerotia of the pathogen which were retrieved from 5 cm soil depth after 20 days of soil solarization in comparison to incidence of 60.0 per cent in the pots containing sclerotia retrieved from the same depth after 20 days without solarization. With the increase in duration of soil solarization, from 20-40 days at 5 cm soil depth, the potential of the stem rot pathogen reduced significantly as the incidence of the stem rot reduced from 36.0 to 23.3 per cent. Potential of the stem rot pathogen reduced at lower depths because at lower depth, more heat is generated which has sub-lethal effects and also different fungal antagonists affects the potential and viability of the pathogen. Over all, the treatment of soil solarization with transparent polyethylene sheet resulted in marked reduction in the pathogenic potential of the pathogen and thus significantly decreased the diseased the disease incidence in comparison to sclerotia of the stem rot pathogen retrieved from unsolarized pots (Table-3).

Table 3: Effect of different durations of soil solarization on potential of the pathogen (*R. solani*) to cause the disease

Treatment	Disease incidence (%)						Over all mean
	20 days		30 days		40 days		
	5 cm	15 cm	5 cm	15 cm	5 cm	15 cm	
Solarized	36.66 (36.91)	46.67 (43.04)	26.66 (30.49)	40.00 (39.14)	23.33 (28.55)	36.66 (37.23)	35.00 (35.89)
Unsolarized	60.00 (50.82)	66.66 (54.71)	53.33 (46.93)	63.33 (52.76)	43.33 (41.09)	60.00 (50.77)	57.78 (49.51)
Mean	48.33 (43.87)	56.67 (48.88)	40.00 (38.71)	51.67 (45.95)	33.33 (34.82)	48.33 (44.00)	

*Figures in parentheses are arc since transformed

CD	(0.05)
Days	(3.46)
Solarized	(2.83)
Depth	(2.82)
Days × Solarization	(NS)
Days × Depth	(NS)
Solarization × Depth	(NS)
Days × Solarization × Depth	(NS)

Mulching of soil with transparent polyethylene mulch has been reported to bring marked reduction in the population of the sclerotia of different fungi thus resulting in the reduction of disease incidence (Merriman, 1976; Grinsten *et al.*, 1979; Merriman *et al.*, 1981; Usmani and Ghaffar, 1981; Porter and Merriman, 1983) [17, 18, 30, 31]. Soil solarization is an effective method of disease management of soil borne pathogens and efficacy has been reported by different workers from different

parts of the world in a comprehensive review by Katan (1981) [2, 3, 4, 12, 21, 22, 25, 29]. Soil solarization has been reported to reduce the incidence of *Verticillium dahliae* by 65 per cent in tomato (Katan *et al.*, 1976) [2, 3, 4, 12, 21, 22, 25, 29] and by 95 per cent in potato (Grinstein *et al.*, 1979b) [3]. Likewise, the incidence of *Pyrenochaeton terrestris* in onion was reduced by 90 per cent (Katan *et al.*, 1980) [2, 3, 4, 12, 21, 22, 25, 29] and

incidence of *Sclerotium rolfsii* root rot was reduced by 90 per cent in peanuts.

Effect of soil solarization on incubation period (time take for development of symptoms)

Effect of soil solarization was observed on disease causing capability of the stem rot pathogen. Pathogenic potential of the sclerotia of the pathogen retrieved after different durations of soil solarization was observed by recording the appearance of the symptoms in different treatments i.e. incubation period taken for the symptoms to develop. In general, treatment of soil solarization with transparent polyethylene sheet delayed the average incubation period, which was delayed to 77.1 days, in comparison to 59.9 days in the pots containing sclerotia of the pathogen retrieved from unsolarized pots. Sclerotia of the stem rot pathogen subjected to the treatment

of soil solarization for 40 days at 5 cm soil depth delayed the incubation period up to 85.6 days, in comparison to incubation period of 75.2 days after 20 days of soil solarization at the same depth. Sclerotia of the stem rot pathogen subjected to the treatment of soil solarization for 40 days at 15 cm soil depth also delayed the incubation period up to 79.6 days in comparison to incubation period of 58.8 days after 40 days of soil solarization at the same depth. This indicates that soil solarization affected the potential of the pathogen at all the depths on different durations in causing the disease. It is clear from the data that as the duration of the solarization increased from 20 to 40 days; the incubation period taken for the appearance of the symptoms has also increased. Thus, duration of the soil solarization also played a significant role in the incubation period of the disease (Table-4).

Table 4: Effect of different durations of soil solarization on potential of the pathogen (*R. solani*) in relation to incubation period taken for the symptoms to appear

Treatment	Incubation period						Over all mean
	20 days		30 days		40 days		
	5 cm	15 cm	5 cm	15 cm	5 cm	15 cm	
Solarized	75.20	71.40	77.60	73.20	85.60	79.60	77.10
Unsolarized	60.40	52.80	64.20	55.80	67.60	58.80	59.93
Mean	67.80	62.10	70.90	64.50	76.60	69.20	

CD_(0.05)

Days	(1.05)
Solarized	(0.86)
Depth	(0.85)
Days × Solarization	(1.49)
Solarization × Depth	(1.22)
Days × Depth	(NS)
Days × Solarization × Depth	(NS)

Soil solarization has been reported to reduce the population of many soil-borne pathogens in different crops as soil solarization resulted in increase in soil temperature which is either lethal to the pathogens or had other adverse effects on its potential and viability (Katan, 1981 and Patel, 2001) [2, 3, 4, 12, 21, 22, 25, 29]. Kumar (2005) [5] reported that as the duration of solarization of the culture of *Fusarium oxysporum* f. sp. *gladioli* with transparent polyethylene mulch increased from 20, 30 to 40 days the incubation period of *Fusarium* yellows of gladiolus was also increased by 15.4, 27.5 and 36.2 per cent, respectively at 5 cm soil depth in comparison to the culture of the pathogen retrieved from unsolarized plots. However, at 20 cm soil depth increase in the incubation period was lesser i.e. 15.1, 24.5 and 27.6 per cent due to less heat generated at 20 cm soil depth by soil solarization. Negi (2009) [9] reported that as the duration of the soil solarization with transparent polythene sheet at 5 cm soil depth of the culture of *Fusarium oxysporum* f. sp. *dianthi* increased from 20, 30 to 40 days the incubation period was increased by 27.17, 42.86 and 47.10 per cent in comparison to the culture of the pathogen retrieved from unsolarized plots. Verma (2012) [32] also reported that as the duration of the soil solarization at 5 cm soil depth increased to 40 days, the incubation period taken for *Fusarium* wilt of carnation was increased by 43.6 per cent in comparison to the culture of the pathogen retrieved from unsolarized plots.

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