MANAGEMENT OF RHIZOME ROT DISEASE OF GINGER (*ZINGIBER OFFICINALE* Rosc.) BY SOIL SOLARISATION

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ABSTRACT

Rhizome rot caused by *Pythium aphanidermatum* (Edson) Fitz. is the main production constraint in all ginger growing tracts. As a disease management practice, soil solarisation technique was adopted. This was further integrated with seed treatment and soil drenches with Mancozeb, Captafol, Chlorothalonil and Ridomil-Mancozeb. For comparison, the whole experiment was also conducted under nonsolarised conditions in *Pythium* sick soil. Soil temperature and pathogen population were monitored in solarised and non-solarised plots. Soil solarisation effectively suppressed *P. aphanidermatum* in soil and as a consequence germination was increased and the incidence of rhizome rot reduced. This in turn reflected in increased yield of rhizomes in solarised plots.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is one of the most important spice crops grown in India. It is cultivated over an area of 53,020 ha producing 1,53,890 tonnes. Kerala alone contributes 25.14% of area and 30.34% of production. Rhizome rot disease caused by *Pythium aphanidermatum* (Edson) Fitz. is the main production constraint in all ginger growing tracts (Sarma, 1994). It is a soil-borne pathogen and inoculum present in soil as well as contaminated seed rhizomes would serve as the primary sources of infection (Iyer, 1987; Sarma, 1994). Use of disease free seed rhizomes (Shahare & Asthana, 1962), soil application of neem cake (Sadanandan & Iyer, 1986), crop rotation, (Rajan & Agnihotri, 1989), fungicidal seed treatment (Thomas, 1940; Mishra & Iyer, 1981, Dake *et. al.* 1989, Koshy *et. al.* 1988b) and soil drenches (Shahare & Asthana, 1962; Sarma *et. al.* 1979; Koshy *et. al.* 1988a see: Sarma, 1994) are the recommended practices to check the disease.

The utilisation of solar energy for the management of soil borne diseases (soil solarisation) is a recent innovation (Katan, 1976). It is commercially used for management of diseases of various crops in Israel, United States and Japan and actively investigated in many other countries. It is a method of hydrothermal disinfestations accomplished by covering the moist soil with transparent polythene sheets under appropriate climatic conditions (Kiatan 1987). This paper reports the results of field experiments conducted during three crop seasons from 1991-93 for investigating the effects of soil solarisation and fungicides on rhizome rot of ginger.

MATERIALS AND METHODS

Seed rhizomes: Healthy seed rhizome of variety Maran was used in this study. Seed rhizomes after harvest were given a seed dip treatment with monocrotophos (1.5 ml/l) and were stored in saw-dust under room temperature for three months before planting.

Fungicidal seed treatment and soil application

For seed-rhizome treatment, solutions of Mancozeb (0.3%) Captafol (0.3%), Chlorothalonil (0.3%) and Ridomil-Mancozeb (500 ppm for seed treatment and 100 ppm for soil drenching) were prepared. Seed rhizomes were soaked in the respective fungicide solutions for 30 minutes, drained and dried in shade for a day.

Soil drenching with the above fungicides was done in respective plots 30 days after sowing (time at which sprouting occur) using 10 *l* of fungicidal solution in each $3m^2$ bed. Phorate was applied in the respective plots (30 $gm/3m^2$ bed) at the time of planting.

Solarisation: All the field experiments were conducted in *Pythium* sick plots. The fields were ploughed to a fine tilth after the receipt of an early monsoon shower.

Beds of size $3m^2$ were prepared after the pre-monsoon shower in the first week of May. The beds in the plot meant for solarisation were immediately covered with transparent polythene sheets of thickness 200 gauge and the sides were sealed. The non-solarised plots were maintained at distance of 5m away from solarised plots and were kept as such without polythene tarping. Soil temperature in each plot was recorded daily at 3 different depths viz. 5 cm, 15 cm and 30 cms.

Monitoring *Pythium* population

Pathogen population in both the plots were analysed before the commencement of soil solarisation and after it. Pathogen population was studied for two years (1992, 1993) using direct soil plating on CMA medium supplemented with P10VP, a selective medium for *Pythium* (Tsao and Ocana, 1969). Eight soil samples were taken from each plot at 30 cms depth using a soil sampling tube of diameter 3 cm. The eight samples were mixed together to form a composite sample. Three such composite samples from each plot were separately analysed. After air-drying for 24 hrs. soil samples were sieved using a 2 mm mesh sieve. Twenty mg of sieved soil was taken in sterilised petri plates and 15 ml of the medium was poured in each petri plate, swirled to ensure uniform spread of soil and incubated at room temperature (28°C) in dark. Number of colonies in each plate was counted after 72 hours. The population was estimated as colony forming units (CFU) per gram of soil.

The field trial consisted of the following eight treatments in split plot design with two main plot treatments i.e. solarised and non-solarised. Each treatment was replicated three times with plot size of four beds each having

	Treatment	Conc.	Mode of application
1.	Mancozeb	0.3%	Seed treatment + soil drench
2.	Captafol	0.3%	Seed treatment + soil drench
3.	Chlorothalonil	0.3%	Seed treatment + soil drench
4.	Ridomil-Mancozeb	500 ppm 100 ppm	Seed treatment Soil drench
5.	Phorate	$30g/3m^2$ bed	
6.	1+5	1+5	
7.	4+5	4+5	
8.	Control	— —	

Planting

Polythene tarp was removed after 30 days in the month of June. Seed rhizome pieces of weight 20-25 g were planted in shallow pits immediately after the removal of polythene sheets. Seed rhizomes were planted in rows (4 rows/bed, each row having 10 plants). Standard cultural practices were followed in both the plots which consisted of basal application of 10 kg cowdung and 1 kg neem cake in each bed. NPK fertilizers were added in three split doses.

Analysis of weed growth

Weeds from an area of 50m^2 were uprooted and biomass estimated. Three such areas were randomly selected from solarised and non-solarised plots for comparison of weed biomass in both the plots.

Observations and analysis of data

Percentage germination of rhizomes was recorded 45 days after planting. Diseases incidence, i.e., number of clumps infected out of total number of clumps germinated, was monitored periodically. Yield was taken as fresh weight of rhizomes after harvest i.e., eight months after planting. The data were analysed statistically. Effect of solarisation, treatments and interaction effects on germination, disease incidence and yield were separately analysed.

RESULTS

Temperature build up in solarised plot

Increase in soil temperature in solarised plot was observed at all the three depths studied. Soil temperature in solarised plot at 5 cm depth was increased by 8.53°C over non-solarised during the first year (1991), 5.61°C during the second year (1992) and 6.57°C during the third year (1993). Increase in soil temperature was observed up to 30 cm depth. Soil temperature (monthly average) in solarised and non solarised plots at three different depths viz., 5 cms., 15 cms. and 30 cms, range of daily soil temperature during the solarisation period and difference of average temperature in both the plots for 3 years studied are given in Table 1.

Table 1. Comparison between soil temperature in solarised and non-solarised plots

Sl. No.	Depth cm	Year	Solarised		Non-solarised		Difference of temperature °C Mean
			Mean°C	Range°C	Mean°C	Range°C	
1.		1991	44.36	39.5 - 48.5	35.83	31 - 39.5	8.53
2.	5	1992	40.52	35 - 46.5	34.91	31 - 40.5	5.61
3.		1993	42.68	28 - 47	36.11	29.5 - 39.5	6.57
4.		1991	41.62	38 - 44	34.12	31 - 37.5	7.50
5.	15	1992	37.12	33 - 42	31.72	29.5 - 35.5	5.40
6.		1993	38.10	30 - 42	33.78	30.5 - 39.5	4.32
7.		1991	38.50	35 - 41	33.30	31 - 36	5.20
8.	30	1992	34.70	31 - 38	31.22	29.5 - 33.5	3.48
9.		1993	36.52	33 - 38.5	32.91	30.5 - 37	3.61

studied are given in Table I.

Pathogen population

Pathogen population in solarised and non-solarised plots was monitored during the second and third year. Significant reduction in pathogen population could be noticed in solarised plots. Pathogen population in both the plots before the commencement of soil solarisation was 100 CFU/gm of air-dried soil during the second year (1992). Gradual build up of pathogen population in non-solarised plot was noticed from May onwards. Fifteen days after solarisation *Pythium* population in solarised plot decreased from 100 CFU/gm to 28 CFU/gm of air-dried soil whereas in non-solarised plot, it increased to 122. Thirty days after solarisation, pathogen population in solarised plot was 85 CFU/gm of soil while in nonsolarised it was 183. During the third year, pathogen population in both the plots before solarisation was 130 CFU/gm of air dried soil. Significant reduction of pathogen occurred in solarised plot by the end of solarisation period (Table II).

Effect of solarisation on rhizome rot

a) Germination: Germination was significantly higher in solarised plot (84-78%) than the non-solarised (79.29%, Table III)

b) Disease incidence: Significant reduction of rhizome rot could be recorded in solarised plot. It was 29.25% in solarised plot when compared to 39.93% in non-solarised (Table III).

c) Yield: The yield in solarised plot was significantly higher (2.909 kg/bed) compared to non-solarised plot (0.946 kg/bed) (Table III).

Effect of treatments

a) Germination: Among the various fungicides/ combination used, Captafol, Ridomil-Mancozeb Ridomil-Mancozeb+Phorate and Mancozeb increased germination significantly over others (Table IV)

b) Disease incidence: Captafol, Ridomil-Mancozeb, Mancozeb, Mancozeb+Phorate and Ridomil-Mancozeb+Phorate significantly reduced incidence of rhizome rot (Table IV).

c) Yield: Yield was more in Ridomil-Mancoeb, Captafol and Mancozeb treatments but they did not differ among themselves or from other treatments significantly (Table IV). Interaction effect: There was no significant interaction effect between the treatments in solarised and non-solarised fields in terms of germination, disease incidence or yield (Table V).

Table II. Effect of soil solarisation on population * of *P. aphanidermatum*

Sl. No.	Days	Solarised		Non-solarised	
		1992	1993	1992	1993
1.	0	100	130	100	130
2.	15	28	44	122	214
3.	30	85	29	183	133

* As CFU/g of soil

Table III. Effect of soil solarisation on rhizome rot of ginger

Sl. No.	Treatment	Germination (%)	Disease incidence (%)	Yield (kg)
1.	Solarised	84.78	29.25	2.909
2.	Non-solarised	79.29	39.83	0.946
	CD (5%)	4.42	6.31	1.054

Table IV. Effect of fungicides/nematicides/combinations on rhizome rot of ginger

Sl. No.	Treatment	Germination (%)	Disease incidence (%)	Yield (kg)
1.	Mancozeb	83.055	33.404	2.117
2.	Captafol	85.189	26.671	2.175
3.	Chlorothalonil	80.895	36.089	1.709
4.	Ridomil-Mancozeb	84.238	31.852	2.288
5.	Phorate	79.504	37.444	1.618
6.	Mancozeb+Phorate	80.129	34.939	2.065
7.	RMZ+Phorate	82.938	35.459	1.897
8.	Control	80.346	40.521	1.549
	CD 5%	2.21	3.47	N.S.

Table V. Biomass of weeds in solarised and non-solarised plots in 1993

Sl. No.	Solarised		Non-solarised		Reduction %
	30 days	90 days (g)	30 days	90 days (g)	
1.	0	8200	1600	14800	44.59
2.	0	8400	1700	14500	42.06
3.	0	9500	1900	15000	36.66
Mean	0	8700	1733	14766	41.10

In solarised plot weed growth was suppressed to the extent of 41.1% (Table V), when estimated on 90th day after solarisation. The solarised plots were free of weeds up to 30 days after solarisation.

DISCUSSION

The efficacy of soil solarisation on the overall management of rhizome rot disease of ginger has been brought out in the present investigation. Rise in soil temperature to the tune of 10°C in solarised field has been reported (Katan, 1987, Cartia, 1989). In the present study, soil solarisation raised the temperature by 8.5°C in the year 1991, 5.61°C in 1992 and 6.57° in 1993. The variations observed were mainly due to prevailing climatic condition during the period of solarisation. Significant reduction in pathogen population in solarised field was reported by many workers (Katan, 1987; De Vay, 1991). The efficacy of soil solarisation over other soil disinfestation methods for the suppression of *Pythium aphanidermatum* in cucumber culture under green house conditions was also demonstrated (Al-Samarria *et. al.* 1988). The present investigation further confirmed these results under open field conditions. Slight increase in population of the pathogen in solarised plot after 15 days of solarisation during the year 1992 was unexpected. That might have occurred due to favourable climatic conditions for multiplication of the pathogen during that period.

As a consequence of suppression of pathogen population in solarised soil, germination, vigour of plants and yield were improved as reported by other workers investigating similar situations (See: Katan and De-Vay, 1991). Disease incidence was also reduced significantly. Complete elimination of

Table VI. Effect of soil solarisation and fungicides/nematicides/combinations on rhizome rot of ginger (Interaction effect)

Sl. No.	Treatment	Germination (%)		Disease Incidence %		Yield (kg)	
		S	N	S	N	S	N
1	Mancozeb	84.144	81.966	27.994	38.813	3.482	0.752
2.	Captafol	86.758	83.261	20.714	32.627	2.879	1.470
3.	Chlorothalonil	84.231	77.559	26.959	45.221	2.598	0.820
4.	Ridomil-Mancozeb	87.767	80.709	30.503	33.201	3.375	1.201
5.	Phorate	82.568	76.440	31.417	43.471	2.335	0.902
6.	Mancozeb+Phorate	84.584	75.673	28.094	41.784	3.372	0.758
7.	RMZ+Phorate	84.644	81.212	31.990	38.918	2.855	0.329
8.	Control	83.526	77.167	36.406	44.639	2.374	0.723
	CD (5%)	NS	NS	NS	NS	NS	NS

S = solarised N = non solarised

disease from solarised field was not feasible partly because of residual inoculum in soil and partly because of seed borne infections which might have functioned as the source of inoculum. The efficacy of fungicides viz., Captafol, Mancozeb and Ridomil-mancozeb in management of rhizome rot has already been reported (See: Sarma, 1994). Interaction between solarisation and soil-applied fungicides leading to synergistic effect on suppression of soil-borne pathogens was demonstrated (Aharonson and Katan, 1991). But analysis of the present data shows that there is no interaction between solarisation and fungicides, though the fungicides were effective in reducing rhizome rot infection. Further investigations might be required to confirm this aspect. Suppression of weed growth is another noticeable phenomenon in solarised field. This is one of the advantages of solarisation as it reduces the cost of weeding.

CONCLUSION

Soil solarisation effectively suppressed population of *Pythium* in soil and as a consequence germination was increased and the incidence of rhizome rot reduced. This in turn is reflected in increased yield of rhizomes in solarised soil over non-solarised. Among the fungicides/combinations Captafol, Mancozeb and Ridomil-Mancozeb increased germination and reduced disease incidence significantly over other treatments. Significant interaction effect of solarisation and fungicides could not be observed. Suppression of weed growth is another advantage of soil solarisation as it reduces the cost of cultivation.

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BIOLOGICAL SUPPRESSION OF PLANT DISEASES, PHYTOPARASITIC NEMATODES AND WEEDS

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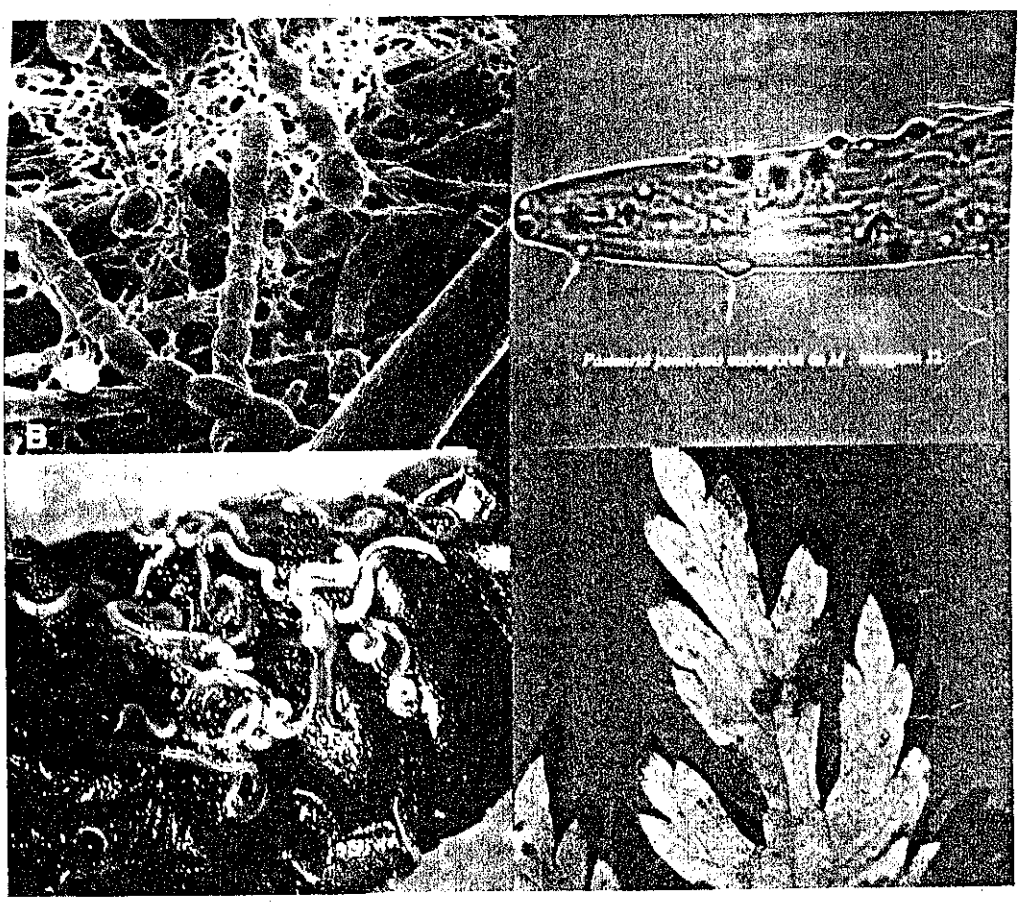

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