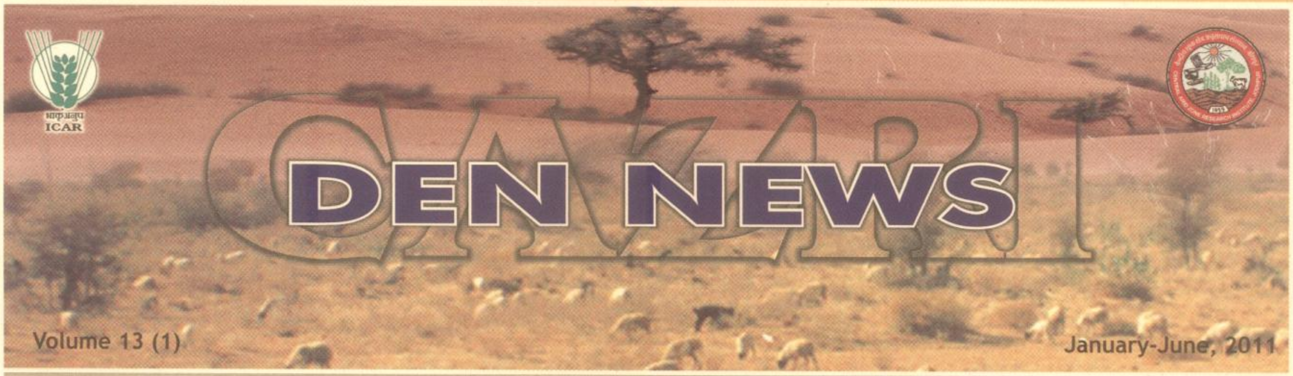

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SOIL SOLARIZATION : AN ECO-FRIENDLY APPROACH TO MANAGE SOIL BORNE PLANT PATHOGENS

Soil solarization is a technique used primarily for the disinfestations of soil. It was described over three decades ago by a team of Israeli scientists. This technique quickly became of intense interest because it was non-chemical, eco-friendly and an effective approach for integrated pest management (Table 1). At present this technique is used in at least 120 countries world-wide particularly in protected agriculture. Two international conferences, in 1990 at Jordan and in 1997 at Syria were exclusively held to review advance made by scientists world-over. In this method, a transparent polyethylene sheet is mulched on moist infested soil during period of high ambient temperature. The plastic film allows the sun's radiant energy to be trapped in the soil, resulting in elevated soil temperatures. These elevated temperature reach in those ranges, which are found lethal for the resting structures of soil borne plant pathogens, nematodes and weed seed and seedlings. Depending on soil type, plastic film, prevailing ambient temperature, an increase between 5-14°C has been achieved under polyethylene sheet. Thus, a sizeable proportion of viable pathogenic propagules are eradicated due to sub-lethal and lethal dosages of temperature. This technique is especially effective in the regions where climatic conditions favour adequate heating during crop-free period. Incidently, hot arid regions of India are characterized by high ambient temperature (42-48°C) during summer months (April-June). Therefore, this technique has been found very effective in managing certain stubborn soil-borne plant pathogens, weeds and nematodes in this region.

Table 1. Pathogens and pests controlled by soil solarization

Pest	Disease	Crop/Plants
Fungi		
Macrophomina phaseolina	Dry root rot	Legumes and oil seeds
Fusarium solani	Root rot	Jojoba, Gayule, Eucalyptus
Cylindrocarpon lichenicola	Dry root rot	Jojoba
Fusarium oxysporum f. sp. *lycopersici*	Wilt	Tomato
Fusarium oxysporum f. sp. *vasinfecum*	Wilt	Cotton
Phytophthora cinnamomi	Phytophthora root rot	Many crops
Pythium ultimum	Seed rot	Many crops
Rhizoctonia solani	Seed rot	Many crops
Sclerotium rolfsii	Southern blight	Many crops
Verticillium dahliae	Wilt	Many crops
Nematodes	**Common Name**	
Ditylenchus dipsaci	Stem and bulb nematodes	
Heterodera schachtii	Sugarbeet cyst nematode	
Meliodogyne javanica	Javanese root knot nematode	
Pratylenchus penetrans	Lesion nematode	
Tylenchulus semipenetrans	Citrus nematode	
Weeds		
Cenchrus biflorus	*Gisekia pharnacides*	*Cynodon dactylon*
Prosopis juliflora	*Amaranthus retroflexus*	*Convolvulus arvensis*
Heliotropium subulatum	*Brassica nigra*	*Orobanche ramose*
Cyperus rotundus	*Chenopodium album*	*Cynodon dactylon*
Boerhaavia diffusa		

HOW TO SOLARIZE SOIL

Soil preparation

Solarization is most effective when the plastic film is laid as close as possible to a smooth soil surface (Fig. 1). Stones, weeds or any other debris that may puncture the plastic sheet or allow air should be removed

Fig.1. Mulching the soil with transparent polyethylene sheet

Laying the plastic film

Plastic film may be laid by hand since in our country operational machines are not available. The open edges of the plastic film should be anchored to the soil by burying the edges in a shallow trench around the treated areas.

Irrigation

Wet soil conducts heat better than dry soil and makes soil organisms more sensitive to heat. The soil under the plastic film must be saturated to at least 70 per cent of the field capacity. In cases, where only one irrigation is given then complete saturation at field capacity in the top 45 cm of the soil layer is recommended. The plastic must be applied as soon as possible after irrigation to avoid water loss. Usually second irrigation is not required but if duration of mulching has to be extended beyond 2-3 weeks, it may be necessary to irrigate second time. In the fields where drip system of irrigation is available laterals are laid beneath the plastic sheet to facilitate second or third irrigation without lifting the plastic sheet.

Duration of treatment

In hot arid regions mulching with polyethylene sheet is quite effective even in 15 days if prevailing ambient temperature are above 41°C. However, if there is a fall in temperature than mulching period has to be extended for few more days depending on thermal tolerance of resting structures of pathogen and their distribution in lower soil depths etc.

Type of plastic

A transparent or clear plastic is more effective for solarization. Thinner the plastic, greater will be the heating. Polyethylene (PE) plastic 25µ thick is efficient and economical but not very resistant to tearing by wind or puncture by animals. In windy areas plastic sheet of 38-50µ is recommended. If holes or tears do occurs in the plastic sheet, they should be patched with clear patching tape. Plastic sheets laid by hand can often be used more than once for solarization although if the plastic is dirty or dusty reuse is less effective.

Factors influencing success of solarization

The most important factor that can influence success of technique is the existence of the problem. It will be economical only when applications of other management strategies are not effective. Prevalence of high inoculums of soil borne plant pathogen necessitates the use of this technique. Soil type is yet another factor that may influence effectiveness of this technique. Duration of soil solarization, availability of solar irradiations and temperatures, etc. are few of the important factors that may improve efficiency of this method of soil disinfestations.

Some example of pathogen control in arid region

Hot arid region of India is one such region where soil solarization has been found highly effective. One basic advantage is availability of ample solar irradiations during a crop-free period i.e. April-June. In this region, soil borne plant pathogens like Macrophomina, species of Fusarium, Ganoderma, Cylindrocarpon, etc. cause heavy losses in many economically valuable crops. Considerable amount of work has been done at the Central Arid Zone Research Institute, Jodhpur on use of polyethylene mulching in control of soil borne plant pathogens during past two decades.

Macrophomina phaseolina

By utilizing 50µ plastic sheet, a field experiment was conducted for 15 days to ascertain effectiveness of solarization on viable propagules of M. phaseolina. Polyethylene mulching considerably increased the soil temperature. The maximum soil temperature at 2 PM in mulched plots was 58°C (wet) and 69°C (dry) at 5 cm depth, which in non-mulched plots did not exceed 53°C (wet) and 63°C (dry). During mulching period, soil temperature reached 65°C or more for atleast 6 days while in other parts of the world it never exceeded 65°C in dry mulched soil. These temperature ranges were higher than the thermal death time-temperature (50°C for 90 minutes) reported for M. phaseolina. Elevated soil temperature and a shift in favour of antagonists reduced the population of M. phaseolina from 350 to 7 sclerotia g-1 soil at 5 cm depth but reduction decreased with increase in soil depth. The decrease in population in the top soil is of considerable importance because highest population and survival rate of M. phaseolina is at 0-5 cm soil depth .

Polyethylene mulching was also effective in controlling the population of weeds in standing crop; reduction being greater in the wet mulched plots. Common weed species reduced includes Cenchrus biflorus, Prosopis juliflora, Heliotropium subulatum, Cyperus rotundus, Cynodon dactylon, Boerhaavia diffusa and Gisekia pharnacidoes. Control of weeds was also beneficial because these compete with principal crop for moisture and nutrients. Besides, someweed species are also host to M. phaseolina. Clusterbean crop raised in mulched plots remained diseases free till harvest, whereas non-mulched plots recorded 12-18% mortality.

Fusarium solani

F. solani is a root rot pathogen of several economically important plants like Jojoba, Gayule, Eucalyptus, etc. In an experiment conducted to ascertain efficiency of soil solarization revealed that mulching increased the soil temperature and resulted in pronounced reduction in the population of F. solani . At 5 cm depth, the maximum temperature difference was 12°C (dry) and 9°C (wet) at 2 PM between mulched and non-mulched plots. As a result, during a period of 15 days, a net reduction of 71 and 68% of F.solani population in dry and wet mulched treatments was achieved.

Root knot nematode:

Soil solarization has also been found highly effective in controlling root knot nematode of vegetable crops (Fig 2).

Fig.2. Effect of soil solarization on root knot nematode

Extending efficacy of soil solarization

Studies on soil solarization showed that a sizable proportion of pathogenic propagules survived below 15 cm soil depth. This increased the chances of rebuild of inoculum density after 2-3 years of solarization. Since repeated mulching with polyethylene film was expensive and cumbersome, it was thought worthwhile to integrate other means of management for extending the benefits of soil solarization.

Field tests were carried out to examine efficacy of soil solarization in conjunction with urea (20 kg N ha-1) and farm yard manure (10 ton ha-1) for the simultaneous control of dry root rot of clusterbean and wilt of cumin in the same field. During a 15 day soil solarization period, maximum soil temperatures were always higher in the solarized than non-solariaed plots at all the depths. Increase in temperature coupled with amendments greatly reduced the population of Fusarium in the samples buried in the soil. The fungal population declined from the initial 400 propagules to 14 propagules g-1 soil in dry mulched and further to 9 propagules in wet mulched plus N treatments at 5 cm soil depth amounting to a net reduction of 92 and 95%, respectively. The population of Fusarium remained suppressed in solarized plots despite the cultivation of susceptible cumin crop. After the harvest of the second crop of cumin, the Fusarium population remained significantly low only in wet plus N plus manure compared to dry mulched plots. Solarization greatly decreased the mortality of cumin in both seasons, which resulted in yield promotion. The percent increase in the yield was more consipicuous in the second year of cumin cultivation, where increase ranged from 77-121% in all the solarized plots. There was a pronounced reduction in the population of M. phaseolina also due to soil solarization. The native population of 54 sclerotia g-1 soil declined by 9.7% in non-solarized dry plots, 68.5% in dry solarized and further to 85.2% in wet plus N plus manure mulched plots. The population also remained at low levels in all the mulched treatments after the harvest of the clusterbean in 1987 and after fallow in 1988. The population in wet plus N plus manure and wet plus N non-solarized treatments was significantly lower than those of dry non-mulched plots after fallow. Clusterbean crop raised in the wet and dry solarized plots remained disease free till harvest, whereas there was 19 and 235 mortality due to dry root rot in the non-mulched wet and dry plots. This resulted in an increase in seed yield (55-72%) in the solarized plots.

In the moistened N plus manure solarized plots, a reduction in the formation of new persisting propagules was observed. Similarly, sclerotia of M. phaseolina germinate and the subsequent hyphae is readily attacked by soil bacteria and actinomycetes whose population increase significantly in amended soil . Soil moisture alone affected the sensitively of resting structures to a heat treatment resulting in considerable reduction of Fusarium (31.6%) and M. phaseolina (42.6%) propagules in non-mulched soils. Incorporation of N plus manure further reduced the population of Fusarium (31.7%) and M. phaseolina (57.1%). These results suggests a novel approach for partial control of soil-borne pathogens in hot arid regions by merely one irrigation in the summer months even without polyethylene mulching in case the soil is amended with N plus manure. In another study, combining cruciferous residues with soil solarization augmented the control of M. phaseolina .

Soil solarization can also be combined with bio-control agents or reduced dosage of pesticides.

Limitations

Inspite of proven effectiveness, this technique has not received wider acceptance under Indian arid conditions due to limitations like high initial cost of polyethylene film, damage of film due to high animal population in the region, wind velocity, non-availability of devices for mulching the film and proper disposal of the film.

Usefulness in arid region

Raising saplings of forest plants, ornamentals, etc. is one such area where soil solarization can gain wide acceptance. Usually a large scale mortality is observed in saplings raised in nursery due to many soil borne plant pathogens and nematodes. Solarizing nursery soil before raising saplings can provide substantial gain in healthy and vigorous seedlings. In this manner, cost of raising seedlings can also be reduced to considerable extent. It is also feasible for repeated cultivation of high value crops, mass production of AM fungal inoculum, floriculture, seed production and post-plant effect.

Satish Lodha

WORLD ENVIRONMENT DAY, 2011

The ENVIS Centre at CAZRI celebrated the World Environment Day on 5th June. An essay competition for Higher School children was organised on theme "Forests: Nature at your service". On this occasion, two best essays by Prem Singh and Himansu Bawankar were awarded. Most of the participants felt that these types of essay competitions increased their awareness towards the environment protection. Dr. Amal Kar was the invited speaker and delivered a lecture on the theme at this occasion. Dr. M.M. Roy, Director, CAZRI, presided over the function. Dr. Raj Singh, Principal Scientist welcomed the guests. Shri Tirth Das, ENVIS Coordinator briefed about the ENVIS activities at CAZRI and proposed the Vote of thanks.

WORLD DAY TO COMBAT DESERTIFICATION, 2011

The Center celebrated the World Day To Combat Desertification on 17th June by organizing a lecture, followed by a group discussion, wherein more than 45 scientists and other officers from CAZRI participated. The speaker Dr. Ranjana Arya, AFRI, Jodhpur delivered a lecture on the theme "Forests Keep Drylands Working". Dr. R.K. Bhatt, I/C Director, CAZRI, presided over the function. Convenor Dr. N.S. Panwar welcomed the Chief Guests and participants. Shri Tirth Das, ENVIS Coordinator proposed the Vote of thanks.

FORTHCOMING CONFERENCES AND EVENTS

International Symposium on Drought and National Drought Policies, 9-11 November 2011 at Casablanca, Morocco.

Website:http://www.wmo.int/pages/mediacentre/press_releases/pr_WMO UNCCD.html

2011 United Nations Climate Change Conference Durban, South Africa, 28-11-2011 to 9-12-2011. Website:http://en.wikipedia.org/wiki/2011_United_Nations_Climate_Change_Conference

Conference on "Planet Under Pressure" 26- 29 March 2012 at London. UK.

Website:http://www.planetunderpressure2012.net

7th Annual International Symposium on Environment at Athens, Greece, 14-17 May 2012.

Website:http://www.atiner.gr

Conference on Changing scenario of food science, technology and agicultural products, 11-12 November 2011, at Jhansi, U.P. , India.

Website:http://iftbu.org/seminar.htm

International Conference on Chemical, Ecology and Environmental Sciences (ICCEES'2011)
17-18 December 2011.
Website:http://psrcentre.org/listing.php

Central Arid Zone Research Institute, Jodhpur 342 003, INDIA

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Editors **: Tirth Das and Dr. R.K. Dave;** ***Advisor*** **: Dr. Uday Burman**

Web: www.cazri.res.in E-mail: tdas@cazri.res.in Fax: 0291-2788706 Phone: 0291-2786931