CHAPTER 17

SOIL SOLARIZATION
AN ECO-FRIENDLY APPROACH FOR WEED MANAGEMET

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The search for new effective, economic and eco-friendly methods for controlling weeds is a continuous process, as none of the existing methods can be used in all situations. Manual weeding though effective and commonly used in many under developed and developing countries is expensive and time consuming, and hence economically restricted to certain crops and seasons. Use of herbicides for controlling weeds is very effective and economical but has been criticized by the environmentalists for polluting the ecosystem. Besides, there is inherent danger of resurgence of weeds resistant to herbicides. Use of solar energy as soil solarization for controlling soil-borne pests including weeds, pathogens and nematodes has potential for reducing the dependency on chemicals.

At present three basic approaches exist for the disinfestation of soil. These are heating (steaming), fumigation and solarization (Katan, 1981). Fumigation is the most common and widespread method of soil disinfestation. Various non-selective fumigants, including methyl bromide, chloropicrin, carbon disulfide, formaldehyde, metham sodium and more selective material, such as ethylene dibromide are used (Wilhelm, 1966; Krentzer, 1960). These affect various populations of soil microflora and fauna. Under certain conditions, some of the fumigants may acts as eradicants which can destroy most of the soil microflora. Fumigation frequently may suppress plant growth. Compared to steam and chemical fumigation, soil solarization can be regarded as a relatively mild treatment. Nevertheless, a broad spectrum of pathogenic fungi, weeds, nematodes and other pests are controlled by solarization in diverse agricultural systems. Further, in view of the increasing public demand for organic products in recent years, curtailment of pesticide use, threats to environmental pollution and the everlasting need to control pathogens, weeds and pests, the solarization technique offers hope for the future.

Soil mulching is a common method employed in extreme weather conditions to moderate soil temperature and to improve crop growth and yield. Although, plant residues are traditionally used, paper and plastics have been used lately for the purpose. Besides other benefits, mulching suppresses weeds primarily by cutting off light. Soil solarization is a special mulching technique developed in the seventies by Katan and associates in Israel, where moist soil is covered by thin transparent polyethylene film during summer months for several weeks to trap the heat and disinfest the soil. This hydro-thermal process results in elevation of temperatures to levels that are lethal to many soil-borne plant pathogens, insects and weeds, and causes other physical and biological changes in soil which are beneficial to crop

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growth (Katan, 1981; Stapleton and Lopez, 1988). The method has been variously named as solar sterilization, solar heating or pasteurization, plastic or polyethylene mulching or tarping etc. This approach of killing weed seeds and propagules seems to have greater potential in tropical and sub-tropical regions where air temperature goes upto 45 °C during summer months.

PRINCIPLES OF SOLAR HEATING

Visible solar radiation and short-wave infrared radiation are responsible for heating of the soil through the mulch. The radiation from earth (terrestrial radiation) is normally in the form of long wave infrared radiation, which are not permeable through glass or plastic. Hence, heat is trapped beneath the transparent polyethylene mulch. Polyethylene also reduces heat convection and evaporation of water from the soil. The formation of water droplets on the inner surface of the polyethylene film also reduces the transmissivity to long wave infrared radiation substantially, resulting in better heating due to an increase in its greenhouse effect (Malik and Tran, 1973). The following are to be borne in mind for maximum benefit from soil solarization.

1. Transparent not black polyethylene should be used since the former transmits most of the solar radiation that heats the soil.
2. Soil mulching should be carried out during the period of high temperatures and intense solar radiation.
3. Soil should be kept wet during mulching to increase thermal sensitivity of resting structures and improve heat conduction.
4. The thinnest polyethylene tarp possible (25-30 µm) is recommended, since it is both cheaper and somewhat more effective in heating due to better radiation transmittance, than thicker films.
5. The mulching period should be sufficiently extended, usually four weeks or longer, to heat the soil at deeper layers.

The key factors involved in solarization effects on soil-borne organisms are temperature, soil moisture and possibly volatile compounds. The damaging effect of high temperatures has been attributed to metabolic and structural changes in cells that become irreversible with increasing temperature (Christiansen, 1978).

FACTORS AFFECTING SOIL SOLARIZATION

Soil Preparation

The heating of the soil is best when the polyethylene film is laid close to the soil with a minimum of airspace to reduce the insulating effect of an air layer. Hence, good land preparation is essential to provide a smooth even surface.

Soil Characteristics

Dark soils absorb more radiation than light soils; this may partly account for the higher maximum temperatures achieved in some soils. Small differences in soil characteristics or moisture content can translate into large differences in soil heat transfer characteristics (Smith, 1964).

Soil Moisture

Adequate soil moisture is required at the beginning of solarization for two different purposes: (a) to increase soil heat conductivity and (b) to sensitise the weed seeds and other resting structures to high temperature. Moist soil, either irrigated before mulching or irrigated under the plastic film increases the thermal heat transfer or conduction in the soil (Mahrer et al., 1984).

Polyethylene Film Types and Characteristics

Transparent polyethylene films are more efficient than black films in trapping solar radiation (Horowitz et al., 1983; Bhasker et al., 1998; Mudalagiriappa et al., 1999) and reducing weed emergence (Table 1). Mulching of the soil with low-density clear polyethylene sheets (0.1 mm thick) proved more effective than mulching with black plastic in reducing bromrape (*Orobanche* spp.) parasitism on the following crop of eggplant (Braun et al., 1984). Chase et al. (1998) found that soil solarization through transparent polyethylene reduced the emergence of purple nutsedge (*Cyperus rotundus* L.) (5 plants/m^2) as compared to black low-density polyethylene (35.7 plants/m^2) after 5 weeks. The lower emergence was attributed to lethal soil temperature resulting from solarization, which killed *Cyperus* tubers. In rows mulched with black films, rhizomes punctured the film and leaf expansion occurred above the film. Besides clear transparent polyethylene costs less and has high strength. It also allows maximum transmittance of radiation from 0.4 µm to 36 µm (Waggoner et al., 1960). Thinner films, 19-25 µm are more effective for solar heating than thicker films (50-100 µm) and are proportionately less expensive (Stapleton and DeVay, 1986). Higher soil temperature under thin films could be attributed to favourable properties such as higher transmission and lower reflection (Stapleton, 1997). Basavaraju and Nanjappa (1999) observed that soil solarization for 45 days with thin films (25µm) recorded significantly lower weed population in chilli and delayed the emergence of crabgrass (*Digitaria marginata* L.) to an extent of 40 days as compared to non-solarization. The transparent polyethylene of 0.05 mm thickness was superior to that of 0.10 mm thickness (Habeeburrahman and Hosmani, 1999b). However, Patel et al. (1995) found that thickness of transparent polyethylene did not significantly alter pest control as much as duration of solarization did. Clear mulch warms the soil more effectively, and plastic mulches have been developed that filters out photosynthetically active radiation (PAR), but let through infrared light to warm the soil. These infrared transmitting (IRT) mulches have been shown to be effective at controlling weeds (Majek and Neary, 1991).

Table 1. Effect of solarization with black and transparent plastic on weed emergence after plastic removal (Horowitz et al., 1983).

Species emerged	Weed emergence (No./0.5 m^2)		
	Control	Black	Transparent
Pigweed (*Amaranthus* spp.)	30^a	12^b	4^{bc}
Common purslane (*Portulaca oleracea* L.)	78^a	68^a	4^b
Henbit (*Lamium amplexicaule* L.)	146^a	0^b	4^b
Bull mallow (*Malva niceaensis* All.)	330^a	107^b	16^c
Compositae*	524^a	0^b	0^b
Total annuals	1294^a	194^b	44^c
Broomrape (*Orobanche crenata* Forsk.)	40^a	9^b	0^b

*Mainly daisy (*Chrysanthemum segetum* L.) and annual sowthistle (*Sonchus oleraceus* L.). Figures in the same line followed by the same letter do not differ at 5% level of significance

Shoots of the field bindweed (*Convolvulus arvensis* L.) appeared in great numbers after solarization with black plastics but none emerged with the transparent plastic (Horowitz, 1980). At a depth of 5 cm, the maximum temperature was increased by 9.3°C for black and 17-19°C for transparent plastic. Soil temperature under plastic cover is a function of incoming solar radiation and thermal characteristics of the mulching material and the soil (Mahrer and Katan, 1981). Type of transparent plastic differs in their transmittance characteristics and resulting heating (Table 2). Thin transparent polyethylene has good mechanical and thermal properties and a relatively low cost (Horowitz et al., 1983). Soil solarization with thermal-infrared-retentive (TIR) film resulted in higher soil temperature than with a 30μm low-density polyethylene (LDPE) clear film. With TIR films, greater proportions of emerged purple nutsedge plants were killed by foliar scorching, and 6 weeks of soil solarization was more effective at reducing purple nutsedge density than with the LDPE film (Chase et al., 1999).

Beds – Width and Direction

For control of weeds where vegetables are planted on beds, the beds must be preformed and solarized. Studies on beds have shown excellent weed control, whether irrigated after bedding and before tarping, receiving natural rainfall before tarping, or with drip irrigation under the tarp. Mahrer and Katan (1981) found that there was usually a 2 to 4 °C lower temperature at the edge of the mulch than at the centre, at the same soil depth. Horowitz et al. (1983) measured the mulch width of polyethylene as related to maximum soil temperature and irrigation, prior to or during solarization and observed that there was no weed emergence from a 20- to 140- cm mulch width and that the temperatures at the 5 cm depth were comparable. Temperatures were generally as much as 5°C higher at the 15 cm depth with the widest mulch width prior to and during irrigation while solarization was in progress. Beds running in a north-south direction were preferable to an east-west direction to avoid a lower temperature on one side of the bed (Elmore, 1991).

Table 2: Effect of plastic type on soil temperature during solarization and weed control (Horowitz et al., 1983)

Type of plastic	Maximum soil temperature (°C) at depth		Weed emergence (No./m^2) after plastic removal			
			Pigweed		Common purslane	
	5 cm	15 cm	1 month	11 months	1 month	11 months
Control	30.4	28.2	92^a	70^a	24^a	12^a
Black polyethylene	39.7	31.4	8^b	1^b	29^a	2^b
Transparent P.V.C*	47.4	35.9	0^b	0^b	12^b	2^b
Transparent thin (0.03 mm) polyethylene	49.5	36.1	1^b	0^b	8^b	3^b
Transparent thick (0.10 mm) polyethylene	47.7	35.0	1^b	1^b	6^b	2^b

*P.V.C. = Polyvinyl chloride (0.09 mm)
Figures in the same column followed by the same letter do not differ at 5% level of significance.

Timing and Duration of Soil Solarization

Soil solarization is most effective when it is done during the warmest part of summer and plastic sheeting left in place for as long as practical. However, a duration of 4-6 weeks would be adequate under many situations (Yaduraju, 1993; Habeeburrahman and Hosmani, 1996; Singh et al., 2000). Shorter duration is often sufficient in tropical countries. In India, April-May in the south and May-June in northern areas experience intense radiation and are best suited for solarization (Yaduraju and Kamra, 1997). The land is also idle during this period, which is important, as many farmers do not like to lose a crop in favour of soil solarization. Soil solarization for 40 days was found more effective in controlling weeds as compared to 20 days (Bhasker et al., 1998). Solarization is most effective in the upper 10 cm of soil; however, pest control at greater depths may be achieved sometimes, with extended periods of polyethylene mulching. Egley (1983) found that just one week of solarization treatment significantly reduced the number of viable seeds of prickly sida (*Sida spinosa* L.),common cocklebur (*Xanthium pensylvanicum* Wallr.), velvetleaf (*Abutilon theophrasti* Medic.) and spurred anoda (*Anoda cristata* L. Schlecht.). When the duration was increased to 2 weeks, additional species were controlled. In India, Singh et al. (2000) observed that solarization for a period of 3 weeks during May to June was enough to control most of the annual weeds in soybean (Table 3).

Soil solarization for a period of 5 weeks effectively controlled most summer and winter annual weeds at Rehovot, Israel for a period of at least 5 months but particularly controlled perennial weeds such as purple nutsedge, Johnsongrass (*Sorghum halepense* (L.) Pers.) and bermudagrass (*Cynodon dactylon* (L.) Pers.) (Rubin and Benjamin, 1983). Solarization for a period of 10 weeks effectively controlled perennial weeds (Rubin and Benjamin, 1983). Horowitz et al. (1983) obtained excellent weed suppression after 2 weeks of solarization (Table 4). The effect was very clear on common purslane and appreciable on the field bindweed.

CAUSES OF SEED DEATH

According to available information, following mechanisms may be involved in the weed control process using soil solarization (Rubin and Benjamin, 1984):

- direct thermal killing of germinating or even dormant seeds;
- thermal breaking of seed dormancy followed by thermal killing;
- thermally induced changes in CO_2/O_2, ethylene and other volatiles which are involved in seed dormancy release followed by thermal killing;
- direct effect of high temperature interacting with toxic volatiles released from decomposing organic matter or seed metabolism;
- indirect effects via microbial attack of seeds weakened by sub-lethal temperature.

Table 3: Effect of period of solarization on population and dry weight of weeds and seed yield of soybean (Singh et al., 2000).

Period of solarization	Weed density/m^2		Weed dry weight (g/m^2)		Seed yield (kg/ha)
	30 DAS	60 DAS	30 DAS	60 DAS	
Control	96.9[a]	122.9[a]	43.9[a]	69.6[a]	831[a]
Solarization for 3 weeks	0.0[b]	43.6[b]	0.0[b]	46.1[b]	1391[b]
Solarization for 4 weeks	0.0[b]	40.1[b]	0.0[b]	32.2[b]	1403[b]
Solarization for 5 weeks	0.0[b]	38.8[b]	0.0[b]	32.1[b]	1473[b]
Summer ploughing	83.6[a]	79.4[c]	20.8[c]	76.4[a]	910[a]

Figures in the same column followed by the same letter do not differ at 5% level of significance.
DAS = Days after sowing

Table 4. Effect of duration of soil solarization in early summer in Newe-Yaar (Israel) on soil temperature and weed emergence after plastic removal (Horowitz et al., 1983).

Duration (weeks)	Maximum soil temperature (°C) at depth		Weed emergence after plastic removal			
			Common purslane		Field bindweed	
	5 cm	15 cm	3 months	12 months	3 months	12 months
0	32.5	29.5	1322[a]	137[a]	17[a]	18[a]
2	46.5	37.7	1[b]	16[b]	11[a]	2[b]
4	44.2	37.6	0[b]	16[b]	1[b]	2[b]
6	45.3	39.5	0[b]	10[b]	0[b]	5[b]

Figures in the same column followed by the same letter do not differ at 5% level of significance.

EFFECT ON WEED EMERGENCE

Elevated temperature in soil following soil solarization results in reduction in the population of soil borne pathogens, nematodes and weeds. The response to solarization in weeds varies with weed species. Soil solarization was most effective at controlling broad-leaved weeds than sedges and grasses (Reddy et al., 1998). Abdullah (1998) also found that seed bed solarization gave 100, 80 and 16 % weed reduction for annual broad leaf weeds, annual grasses and perennial weeds, respectively in onion. Winter weeds are generally more susceptible, whereas summer weeds especially *Cyperus* spp. and field bindweed are generally more resistant. Nasr-Esfahani et al. (2000) reported that soil solarization effectively reduced the population of almost all weeds by around 100 % except for purple nutsedge and spiny sowthistle (*Sonchus asper* (L.) Hill), which was reduced by 59 and 44 %, respectively. At the International Crop Research Institute for Semi-Arid Tropics, Hyderabad (India), Chauhan et al., (1988) observed a marked decrease in annual weeds in chickpea and pigeonpea due to solarization. The perennials such as purple nutsedge and bermuda grass however recovered gradually. A large number of annuals and many perennial weeds are sensitive to soil solarization. However, a few weed species *viz.*, pigweed, bermudagrass, three flower beggarweed (*Desmodium* spp.), *Astragalus* spp., *Cyperus* spp., purple nutsedge, yellow nutsedge (*Cyperus esculentus*), sweet clover (*Melilotus* sp.), yellow sweet clover (*Melilotus indica* (L.) All.*), M. sulcatus*, horseweed (*Conyza canadensis* (L.) Cronq.), crabgrass, mallow (*Malva* sp.) defy solarization treatment (Yaduraju, 1993). Common purslane was also reported to be resistant to solarization (Tamietti and Valentino, 2000). Several workers (Egley, 1983; Rubin and Benjamin, 1984; Yaduraju, 1993) have also observed the tolerance of sweet clover to soil solarization. While a solarization for just 10 days gave complete control of littleseed canarygrass (*Phalaris minor* Retz.) and winter wild oat (*Avena ludoviciana* Durieu.) – the most dominant grass weeds in winter season crops in India-there was an increase in the population of sweet clover with 40 day of solarization. The heat tolerance of yellow sweet clover has been attributed to its thick seed coat (Yaduraju, 1993).

In perennials with an established underground system of deep roots, rhizomes or tubers, the failure of solarization is probably due to the limited penetration of heat in soil beyond 10 cm depth (Horowitz et al., 1983). Most perennials are capable of

regenerating rapidly from partially damaged underground organs. The survival of purple nutsedge tubers in the soil has been reported by several workers (Kumar et al., 1993; Horowitz et al., 1983; Rubin and Benjamin, 1984) and it has been attributed to heat resistance of the tubers. As the solarization effect diminishes with soil depth, weeds that are capable of emergence from deeper layers survive the treatment. Although, solarization did not control purple nutsedge directly, it weakened the plants to the extent it was more susceptible to applications of glyphosate (Gonzalez et al., 1992).

Parasitic weed broomrape (*Orobanche* spp.) has been effectively controlled with solarization (Mauromicale et al., 2001; Meti, 1993; Krishnamurthy et al., 1993; Abu-Iramaileh, 1991; Jacobsohn et al., 1980). Mulching with clear plastic for 36 days resulted in almost complete eradication of *O. aegyptiaca* from carrot and eggplant fields soon afterward, and in partial control of other weeds (Jacobsohn et al., 1980; Katan et al., 1976). At Jerusalem, Israel, no carrot plant was parasitised with broomrape upto 110 days after planting in solarized plots whereas 90% of the plants got parasitized at 75 days after planting in non-solarized plots (Jacobsohn et al., 1980). In Sudan, soil solarization controlled broomrape by 72-100 % (Braun et al., 1988). Soil solarization controlled broomrape for two successive years in faba bean and tomato in Egypt (Satour et al., 1991), and in lentil and faba bean by over 90 %. (Sauerborn et al., 1989). In cabbage, solarization for 2-6 weeks alone killed broomrape seeds at soil surface, but had no significant effect on seeds below the surface. Solarization with chicken manure, however, killed broomrape seeds at all depths. (Haidar and Sidahmed, 2000).

Soil solarization for 4-6 weeks in summer not only gave excellent weed control in soybean but also in the succeeding wheat crop (Yaduraju and Ahuja, 1996). The weed control in soybean was better with soil solarization alone than with manual weeding (1 or 2) and pre-emergence application of pendimethalin (0.75-1.5 kg/ha). Soybean yields were significantly higher with soil solarization than with pendimethalin. This was attributed to the poor control of dominant weed tropical spiderwort (*Commelina benghalensis* L.) and *Digera arvensis* Forsk. with the herbicide. Soil solarization, however, gave excellent control of these weeds. Application of crop residues and soil solarization with 0.05 and 0.075 mm transparent polyethylene resulted in maximum weed reduction and the highest yield in groundnut-frenchbean cropping system (Mudalagiriappa et al., 2001).

EFFECT OF SOIL SOLARIZATION ON BURIED WEED SEEDS

The reserves of dormant weed seeds in agricultural soils act as a potential source of persistent weed problems that often require repeated control measures (Egley, 1983). A reduction in the number of dormant weed seeds in the soil should also correspondingly reduce weed persistence and weed control requirements. Hence, soil solarization would be desirable as a means of reducing the dormant weed seed reserves in the soil. However, solarization was not found to eliminate dormant weed seeds from the germination zone (Egley, 1983). The treatments killed non-dormant seeds and greatly reduced the number of weed seedlings that otherwise would have emerged. Soil solarization for one week, significantly reduced the percentage of buried seeds (64-98%) of prickly sida, common cocklebur, velvetleaf and spurred anoda remaining in the soil (Table 5). The emergence of grasses and pigweed was also significantly reduced due to solarization for just one week. However, emergence of purple nutsedge was increased in some instances (Table 6). Five weeks of solarization with clear polyethylene films at Waimanalo, Hawaii raised the mean soil temperature at 15 cm depth by 5.8 ^0C in spring and 7.2 ^0C in summer and increased the final sprouting percentage of *C. rotundus* in the field from 74 to 97 % in spring and 97 to 100 % in summer (Miles et al., 2002). Solarization reduced annual blue grass (*Poa annua* L.) seed survival from 89 to 100 % in the upper 5 cm of soil, but did not reduce survival below 5 cm (Peachey et al., 2001).

Although weed seeds in the surface 5 cm of soil are killed to a great extent, soil solarization has rather a poor effect on weed seeds at deeper layers because of lower temperatures (Kumar et al., 1993). Chandrakumar et al. (2002) also reported higher soil temperature in top 0-5 cm soil depth as compared to 5-10 cm soil depth. Solarization for 40 days killed common dayflower in the top 11 cm of soil but seeds of annual *Cyperus* spp. and barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) only within the upper 3 to 4 cm (Standifer et al., 1984). It is possible that all weed seeds are unaffected at deeper layers but weeds with bold seeds are capable of emerging from lower depths while small-seeded weeds lie dormant.

Effect of Soil Solarization on Crop Growth and Yield

Soil solarization can have a tremendous impact on crop growth and yield by eliminating or reducing the infestation of soil-borne pathogens, nematodes and weeds. The magnitude of increase depends upon the type of pest problem and the degree of control. Control of weeds by solarization increased the yield of onion by 100-125% (Katan et al., 1980), groundnut by 52% (Grinstein et al., 1979), sesame by 72% (Stapleton and Lopez, 1988), carrot by 28 %, cabbage by 34 %, beet by 37 %, greengram by 32% (Ricci et al., 2000) and soybean by 77% (Kumar et al., 1993; Singh et al., 2000). Solarization is very effective in controlling the parasitic weed broomrape and a yield of 78 t/ha of carrots was reported from solarized plots, while no yield was obtained from the non-solarized plots (Jacobsohn et al., 1980).

Solarization has been found to enhance the growth and yield of crop plants even in places where there is no infestation of either soil-borne pathogens, nematodes or weeds. This could be attributed to several chemical and biological changes in soil caused by solar radiation when covered by clear plastic films especially when the soil has a high moisture content (Yaduraju and Kamra, 1997). With adequate control of weeds and nematodes through chemical or mechanical methods, solarization still enhanced the yield of soybean (Yaduraju, 1993).

Effect on Soil Properties and Mineral Nutrients

Solarized soils contained higher levels of soluble mineral nutrients than untreated soils (Baker and Cook, 1974; Stapleton et al., 1985). Significant increases in ammonium-nitrogen, nitrate-nitrogen, Ca^{+2}, Mg^{+2} and electrical conductivity were consistently found. Phosphorus, K^+ and Cl^- were also increased in some soils. However, the availability of other micro-nutrients *viz*., Fe^{+2}, Mn^{+2} and Cu^{+2} were not increased (Stapleton and DeVay, 1986). An increase in nitrate-N and ammonical-N was observed in New Delhi soils but organic carbon content was not altered (Kumar and Yaduraju, 1992).

Table 5. Effect of soil solarization through transparent polyethylene cover upon survival of buried weed seeds (Egley, 1983).

Weeds	Viable seeds remaining 4 weeks after removal of cover (%)	
	Not covered	Covered
Prickly sida (*Sida spinosa L.*)	76	5[a]
Common cocklebur (*Xanthium pensylvanicum* Wallr.)	62	9[a]
Velvetleaf (*Abutilon theophrasti* Medic.)	73	47[a]
Spurred anoda (*Anoda cristata* (L.) Schlecht.	66	45[a]
Pitted morningglory (*Ipomoea lacunosa* L.)	46	34
Common purslane (*Portulaca oleracea* L.)	96	94
Johnsongrass (*Sorghum halepense* (L.) Pers.)	44	57

Means followed by "a" are significantly different from corresponding non covered (control) at the 5% level of significance as determined by the standard T-test.

Table 6. Effects of soil solarization on weed seedling emergence (Egley, 1983).

Weed species	Not covered	Weeds emerged (no./m^2) Period covered (weeks)			
		1	2	3	4
Grasses	841[a]	306[b]	41[c]	15[c]	9[c]
Pigweed (*Amaranthus* species)	300[a]	65[b]	13[b]	0[b]	0[b]
Morningglory (*Ipomoea* spp.)	76[a]	54[ab]	17[b]	0[b]	2[b]
Horse purslane (*Trianthema portulacastrum* L.)	74[a]	22[a]	26[a]	4[a]	0[a]
Purple nut sedge (*Cyperus rotundus* L.)	24[a]	43[a]	43[a]	9[a]	22[a]
Total[b]	1385[a]	495[bc]	140[c]	28[c]	33[c]

[a] Within each weed class, means followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.
[b] Total includes weeds in addition to those identified in the table.

However, with extensive studies in different soils types and nutrient sources, it has been shown that the increases in the levels of soil nutrients are transient and do not persist long (Yaduraju and Kamra, 1997).

Effect on Soil Microorganisms

Effects of solarization are more selective on soil microorganisms in comparison with most other methods of soil disinfestation (Krentzer, 1965; Baker and Cook, 1974). Solarization causes changes in soil biota and substrate that provide a favourable environment for colonization by microorganisms with greater competitive ability. These organisms are usually saprophytes, rather than phyto-pathogens, which may subsequently inactivate surviving phytopathogenic fungi, bacteria, nematodes, and weed seeds that are damaged or weakened by solarization. These effects may persist for several seasons. Several investigations have been conducted on the effect of solarization on native as well as inoculated *Rhizobium*. The native populations in pigeonpea and chickpea were decreased with solarization

(Linke et al., 1990; Rupela and Sudershana, 1990). A population of *Rhizobium*, sufficient to cause heavy nodulation of bean roots, survived solarization in Israel (Katan, 1981). Improved yields of mungbean, soybean and groundnut in response to seed inoculation of *Rhizobium* (Table 7) were observed in New Delhi (Yaduraju, 1993).

Effect of Soil-Borne Fungi

Verticillium and *Fusarium* wilts of several crops have been successfully controlled by solarization, as well as diseases caused by *Bipolaris sorokiniana, Didymella lycopersicii, Phytophthora cinnamomi, Plasmodiophora brassicae, Pysenochaeta lycopersici, P. tervestris, Pythium myrothecium, P. ultimum, Rhizoctonia solani, Sclerotium oryzae, S. rolfsii* and *Thielaviopsis basicola*. Pathogenic fungi including *Pythium irregulare, S. cepivorum* and *Sclerotinia minor* were reduced in artificially inoculated soils (Stapleton and DeVay, 1986). However, the destruction of beneficial organisms such as arbuscular mycorrhizal (AM) may also occur, there by reducing the positive effect of solarization. Schreiner et al. (2001) found that solarization did not reduce the infectivity of AM fungi immediately after the solarization period. But infectivity was greatly reduced 8 months after solarization. Solarization apparently reduced AM fungi in soil indirectly by reducing weed populations that maintained ineffective propagules.

Table 7. Effect of solarization and *Rhizobium* inoculation on seed yield (kg/ha) of some legumes (Yaduraju, 1993).

Crop	Solarized		Non-Solarized	
	- Inoculation	+ Inoculation	- Inoculation	+ Inoculation
Soybean	1833	2683	717	1383
Groundnut	1489	1756	844	1112
Mungbean	1191	1315	547	556

Effect on Soil-Borne Bacteria

The thermal sensitivity of soil-borne bacteria depends upon the nature of the individual taxa. *Agrobacterium* spp., fluoresent pseudomonads, pectolytic pseudomonads and some Gram – positive bacteria have been reduced by 69-98% due to solarization. However, pseudomonads rapidly recolonized treated soil and no significant difference between treatments was apparent 3-6 months later (Stapleton and DeVay, 1986). Actinomycetes and *Bacillus* spp., many of which are thermo-tolerant, were sometimes reduced to a much lesser extent (45-58%) or were even increased (26-158%) following solarization (Stapleton and DeVay, 1982). Increased colonization (183-631%) of plant roots by plant growth-promoting fluorescent pseudomonads from inoculated seed also occurred following soil solarization (Stapleton and DeVay, 1984).

Effect on Soil-Borne Nematodes and Mites

Solarization reduced the population of plant parasitic nematodes including *Tylenchus, Heterodera, Xiphinema, Hoplolaimus, Pratylenchus* by about 42 to 100% (Kumar et al., 1993; Katan, 1984; Barbercheck and Von Broembsen, 1986; Stapleton and DeVay, 1984), but the nematode levels had largely recovered after 70 days (Kumar et al., 1993). With regards to soil-borne mites, solarization has been used to control the plant-parasitic mite, *Rhizoglyplus robini*, in Israel (Katan, 1984). Soil solarization significantly reduced ant and earthworm numbers but had no effect on millipede population (Ricci et al., 1999).

Applicability and Potential of Soil Solarization

Soil solarization is an unique method of pest control. It is (i) non-hazardous, (ii) user-friendly, (iii) environmentally benign, (iv) non-dependent on fossil fuel, (v) effective on a variety of pests including soil-borne fungi, bacteria, nematodes and weeds, (vi) often effective for more than one season or a year, and (vii) stimulatory to crop growth. It has great applicability in organic agriculture and high value crops.

Cost Effectiveness and Long-Term Benefits

Solarization falls into the medium price range of soil disinfestation treatments. As solarization technology advances, the overall cost of application should decrease. The major constraint in developing countries is the high cost of the treatment. Thinner films, which are more efficient, would be more economical. Control of different types of pests, in successive crops, lower fertilizer requirements and increased yield of crops, all will have to be taken into consideration while computing the economics of soil solarization treatment. In areas, where only 2-4 weeks treatment is sufficient and where summers are long, the same polyethylene films can be used in more than one place in the same season. Further, in a long-term study, it was seen that soybean grown without solarization on a field otherwise solarized for two successive summers gave yield of soybean similar to 3-year solarization, provided the soil was not disturbed (Yaduraju and Ahuja, 1996). These measures will help to cut costs substantially.

Application of Soil Solarization

The technology for applying plastic films to large acreages already exists (Pullman et al., 1984) and is similar to use of soil fumigation. Solarization is also ideal for treating nurseries. Duxbury (2002) found that the combination of vitavax-200 and solarization of soil in the rice nursery controlled the root-knot nematode *Meloidogyne graminicola* and increased the rice yield upto 45%. He further noted that around 30-40% rice yield was increased just by solarizing the soil in the rice nursery. It is widely used in raising nurseries of tobacco and vegetables in India (Patel et al., 1995; Sudha et al., 1998; Reddy et al., 1998). Vizantinopoulos and Katrains (1993) reported that solarization gave better weed control than pre-emergence pendimethalin+atrazine, imazaquin+metolachlor, metribuzin+alachlor or acetachlor + atrazine at their recommended rates in maize in Greece. It can reduce the use of toxic soil fumigants. This technology may be more promising in high value crops, such as in vegetable growing, floriculture, etc. In India, pre-plant-solarization films may be left in place, after plant emergence, as post-plant mulch. Soil solarization has been shown to enhance degradation of pesticide residues in soil (Gopal et al., 1997), hence could be employed for decontamination of polluted soils.

Soil solarization is a fully integrated pest control method, based on easily manipulated physical factors, but its use is restricted to regions with intense sunshine and field is free of crops for about one month or more at the time of mulching. Solarization can be viewed as part of soil preparation before planting. To date, there are no contra-indications against use of solarization in any crop, except economic considerations. In estimating its economic value, it should be considered not only as a possible replacement for herbicide and other pesticide treatments but also as an eventual solution for situations in which no other safe and efficient method is available.

LIMITATIONS OF SOIL SOLARIZATION

Despite huge benefits, soil solarization has not found large-scale adoption yet, possibly because of some of the following limitations:

- Solarization is in fact indirectly dependent on fossil fuel, since they are used in the production of the plastics.
- Disposal of plastic film is by for the greatest problem. Disposal by burning pollutes the environment and disposal in a landfill takes up considerable space. The answer to this problem could be use of biodegradable plastic films.
- Retention of solarization films as production mulches usually requires additional inputs of paint and labour to paint the mulch white so that cooler soils prevail for the production of the crop.
- Removal and reuse of the film is not feasible in large-scale operations that utilize machines to lay plastic films.
- The technique is more useful for crops grown immediately following the solarization period. Thus, in the northern hemisphere, it is more useful for fall-grown crops than spring-grown crops.
- Lack of persistence of nematode control and poor control of some weeds mean that supplemental control methods are often needed, particularly in crops that occupy a field for a long duration.
- In some climates cloudiness and rainfall during the hottest part of the year can limit effectiveness.
- Difficult to retain the films intact during period of heavy winds.

CONCLUSION

Soil solarization is a novel technique for the control of soil borne diseases, nematodes and weeds. Covering the moist soil for a period of 2-6 weeks during hot summer months can elevate the surface soil temperature by about 6-16 ^{0}C depending upon the soil type, moisture content, thickness of polyethylene films and the intensity of solar radiation. Besides pest control, the polyethylene mulching also alters the soil chemical and biological properties. These changes usually bring about enhancement in crop growth and yield. The technique is successful in controlling a wide range of annual grasses, broadleaved weeds, sedges and some perennials in a variety of crops.

Despite several advantages, the large-scale adoption of this technology has not taken place primarily due to economic reasons. Disposal and non-biodegradation of plastic in the environment are the major concerns, which need to be seriously addressed. Development of biodegradable polyethylene films and safer alternative methods of re-use could allay such fears by environmentalists. However, it has definite advantage in nurseries, where solarization can reduce or eliminate use of soil disinfectants such as methyl bromide, chloropicrin, carbon disulfide, formaldehyde, metham sodium, etc, which are hazardous or poisonous. It can also find application in high value crops and in organic agriculture.

REFERENCES

Abdullah M.M.F. Improving vegetable transplant using soil solarization. II. Onion, "*Allium cepa*" Proceedings of the Seventh Conference of Agricultural Development Research, Cario, Egypt, 15-17 December, 1998.

Abu-Iramaileh B.E. Soil solarization controls broomrapes (*Orobanche* spp.) in host vegetable crops in Jordan Valley. Weed Technol 1991, 5:575-581.

Baker K.F., Cook R.J. *Biological control of plant pathogens*. Freeman, San Francisco, C.A., 1974.

Barbercheck M.E., Von Broembsen S.L. Effect of soil solarization on plant-parasitic nematodes and *Phytophthora cinnamomi* in South Africa. Plant Dis 1986; 70:945-450.

Basavaraju H.K., Nanjappa H.V. Weed dynamics in chilli-maize cropping sequences as influenced by solarization. Indian J Weed Sci 1999, 31:183-186.

Bhasker K.V., Nanjappa H.V., Ramachandrappa B.K. Solarization for weed control in sunflower (*Helianthus annuus* L.). Mysore J Agric Sci 1998; 32:142-147.

Braun M., Burgstaller H., Walker H. Critical evaluation of control methods for *Orobanche ramosa* L. occurring in smallholder vegetables farms of the Khartoum province, Sudan. Proceedings of third International Symposium on Parasitic weeds, Aleppo, Syria. pp. 245-249, 1984.

Braun M., Koch W., Mussa H.H., Steifvaler M. "Solarization for weed and pest control, possibilities and limitations." In *Weed Control in Vegetable Production*. Proceedings of meeting of the EC experts group, Stuttgard.28-31 October, 1986, Rottendrum, Balkome, 1988; pp.169-178.

Chandrakumar S.S, Nanjappa H.V., Ramachandrappa B.K., Baig M.K. Weed control in sunflower (*Helianthus annuus* L.) through soil solarization. Crop Res (Hisar) 2002, 23:287-289.

Chase C.A., Sinclair T.R., Locascio S.J. Effect of soil temperature and tuber depth on *Cyperus* spp. control. Weed Sci 1999; 47:467-472.

Chase C.A., Sinclair T.R., Shilling D.G., Gilreath J.P., Locascio S.J. Light effect on rhizome morphogenesis in nut sedges (*Cyperus* spp.): implications for control by soil solarization. Weed Sci 1998; 46:575-580.

Chauhan Y.S., Nene Y.L., Johansen C., Haware M.P., Sayene N.P., Singh S., Sharma S.B., Sahrawat K.L., Burford J.R., Rupela O.P., Kumar Rao J.V.D.K., Sithanantham S. Effect of soil solarization on pigeonpea and chickpea. Res Bull No. 11, ICRISAT, Patancheru, Andhra Pradesh, India. 1988.

Christiansen M.N. "The physiology of plant tolerance to temperature extremes." Pages 173-191 In *Crop Tolerance to Suboptimal Land Conditions*.G.A. Jung, ed. American Society of Agronomy, Madison, Wisconsin, 1978; Special Publication No. 32.

Duxbury J.M.Improving crop productivity and sustainability in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Extended Summaries Vol. 1. 2nd International Agronomy Congress, November, 26-30 2002, New Delhi, India :31-32.

Egley G.H. Weed seed and seedling reduction by solarization with transparent polyethylene sheets. Weed Sci 1983; 31:404-409.

Elmore C.L. "Weed control by solarization." In *Soil Solarization*,. J. Katan, J.E. DeVay, eds. Boca Raton: CRC Press Inc., 1991; pp. 62-72.

Gonzalez T.R, Agudo B.M., Lopez G.M.C., Zaragoza L.C. Integrated use of solarization and glyphosate in the control of *Cyperus rotundus* L. Proceedings of the 1992 congress of the Spanish Weed Science Society. 1992, 337-340.

Gopal M., Mukherjee I., Yaduraju N.T. Soil solarization: A tool for decontamination of soil pesticides. Proceedings of National Seminar on Plant Protection in India. Plant Protection Association of India, December 22-24, 1997, Hyderabad, India. R-25.

Grinstein A., Orion D., Greenberger A., Katan J. "Solar heating of the soil for the control of *Verticillium dahliae* and *Pratylenchus thornei* in potatoes." In *Soil-Borne Plant Pathogens*. B. Schippers, W. Gams, eds. London: Academic Press, 1979; pp.431-438.

Habeeburrahman P.V., Hosmani M.M. Effect of soil solarization on weed growth and yield of succeeding rainy season sorghum (*Sorghum bicolor*). Indian J Agron 1996; 41:54-57.

Haidar M.A., Sidahmed M.M. Soil solarization and chicken manure for control of *Orobanche crenata* and other weeds in Lebanon. Crop Prot 2000; 19: 169-173.

Horowitz M. Weed research in Israel. Weed Sci 1980; 28: 457.

Horowitz M.; Regve Y., Herzlinger G. Solarization for weed control. Weed Sci 1983; 31 : 170-179.

Jacobsohn R; Greenberger A; Katan J.; Levi M., Alon H. Control of Egyptian broomrape (*Orobanche aegyptiaca*) and other weeds by means of solar heating of the soil by polyethylene mulching. Weed Sci 1980; 28: 312-318.

Katan J. "Soil solarization." In *Second International Symposium on Soil Disinfestation. Acta Hortic No. 152*, C. Van Assche, ed. Leuven, Belgium, International Society for Horticultural Science, 1984,Wageningen, Netherlands, p. 227.

Katan J. Solar heating (solarization) of soil for control of soil-borne pests. Annu Rev Phytopathol 1981; 19: 211-236.

Katan J., Greenberger A.; Alon H.; Grinstein A. Solar heating by polyethylene mulching for the control of diseases caused by soil-borne pathogens. Phytopathology 1976; 66:683-688.

Katan J., Rotem I., Finkel Y., Daniel J. Solar heating of the soil for the control of pink root and other soil borne diseases in onions. Phytoparasitica 1980; 8: 39-50.

Krentzer W.A. "Soil treatment." In *Plant Pathology: An Advanced Treatise* Vol.3 II. *The Diseased Population, Epidemics and Control*, J.G. Horsfall, A.E. Dimond, eds. New York: Academic Press, 1960.

Krentzer W.A. "The reinfestation of treated soil." In *Ecology of soil-borne pathogens: Prelude to Biological Control*, K.F. Baker, W.C. Snyder, eds. Berkeley and Los Angeles. University of California Press, 1965. p. 495.

Krishnamurthy G.V.G., Raju C.A., Murty G.V.G.K., Pieterse A.H. Effect of solarization on the germinability of broomrape seeds (micro-plot study). Proceedings of the 3rd International Workshop on Orobanche and related Striga Research. Amsterdaqm, Netherlands, pp. 493-495.1993.

Kumar B., Yaduraju N.T. Effect of soil solarization on the temperature and physico-chemical properties of soil. Plasticulture, 1992; 94: 13-20.

Kumar B., Yaduraju N.T., Ahuja K.N., Prasad D. Effect of soil solarization on weeds and nematodes under tropical Indian conditions. Weed Res 1993; 33: 423-429.

Linke K.H., Saxena M.C., Sauerborn J., Marsi H. Effect of soil solarization on the yield of food legumes and on pest control – Proceedings of the first International Conference on Soil Solarization, Amman, 139-147, 1990.

Mahrer Y., Katan J. Spatial soil temperature regime under transparent polyethylene mulch: numerical and experimental studies. Soil Sci 1981; 131: 82-87.

Mahrer Y., Naot O., Rawitz E., Katan J. Temperature and moisture regimes in soils mulched with transparent polyethylene. Soil Sci Soc Am J 1984; 48 : 362-367.

Majek B.A., Neary P.E. Selective wavelength transmitting mulches for yellow nutsedge control. Proceedings Brighton Crop Protection Conference-Weeds, Brighton, U.K., 1991; pp. 263-268.

Malik M.A.S., Tran U.V. A simplified mathematical- model for predicting the nocturnal output of solar stile. Solar Energy 1973; 14: 371-385.

Mauromicale G., Restuccia G., Marchese M. Soil-solarization, a non-chemical technique for controlling *Orobanche crenata* and improving yield of faba bean. Agronomie 2001, 21: 757-765.

Meti S.S. Control of *Orobanche cernua* in bidi tobacco by soil solarization. M.Sc. Thesis. UAS, Dharwad India 1993.

Miles J.E., Kawabata O., Nishimoto R.K. Modeling in purple nutsedge sprouting under soil solarization. Weed Sci 2002, 50: 64-71.

Mudalagiriappa N.H.V., Ramachandrappa, B.K. Effect of crop residue and solarization on weeds and yield of groundnut-frenchbean cropping system. Karnataka J Agric Sci 2001; 14: 462-464.

Mudalagiriappa N.H.V., Ramachandrappa B.K. Effect of soil solarization on weed growth and yield of *kharif* groundnut (*Arachis hypogaea*). Indian J Agron 1999; 44: 396-399.

Nasr-Esfahani M., Akhiani A., Fatemi R., Hassanpore H. Soil solarization effect on soil-borne fungal diseases, nematodes and weeds in autumn cucumber fields. J Sci Technol Agric Nat Res 2000. 4:111-123.

Patel H.R., Makwana M.G., Patel B.N. The control of nematodes and weeds by soil solarization in tobacco nurseries. Plasticulture 1995; 107:21-27

Peachey R.E., Pimkerton J.N., Ivors K.L., Miller M.L., Moore L.W. Effect of soil solarization, cover crops and metham on field emergence and survival of buried annual blue grass (*Poa annua*) seeds. Weed Technol 2001; 15: 81-88.

Pullman G.S., De Vay J.E., Elmore C.L., Hart W.H. Soil solarization – a non chemical method for controlling diseases and pests. Cooperative Extension, Division of Agriculture and Natural Resources, Leaflet 21377. Davis, California, University of California, 1984.

Reddy C.N., Reddy M.D., Devi M.P. Solarization for weed control in vegetable nurseries. Indian J Weed Sci 1998; 30:88-89.

Ricci M.D.S.F., Almedia D.L. De, Fernandes M. Do C.A., Ribeiro R. De L.D., Cantanheide M.C. Dos S. Effect of soil solarization on purple nutsedge population density and on productivity of vegetable crops under organic cultivation. Pesquisa Agropecuaria Brasileira 2000; 35: 2175-2179.

Ricci M.S.F., Almedia D.L. De, Ribeiro R. De L.D., Aquino A.M. De, Pereira D.C., De-Polli H., Reis, V.M., Eklund C.R. *Cyperus rotundus* control by solarization. Biol Agric Hort 1999; 17:151-157.

Rubin B., Benjamin A. Solar heating of the soil: effect on weed control and soil incorporated herbicides. Weed Sci 1983; 31:810-825.

Rubin B., Benjamin A. Solar heating of the soils: involvement of environmental factors in the weed control process. Weed Sci 1984; 32:138-142.

Rupela O.P., Sudarshana M.R. Displacement of native *rhizobia* nodulating chickpea (*Cicer arietinum* L.) by an inoculant strain through soil solarization. Biol. Fertil. Soils 1990; 10: 207-212.

Satour M.M., EL-Sherif E.M., El-Ghareeb-L., El-Hadad S.A., El-Wakil H.R. Achievements of soil solarization in Egypt. FAO Plant production and protection papers (1991). No. 109:200-212

Sauerborn J., Linke K.H., Saxena M.C., Koch W. Solarization: a physical control method for weeds and parasitic plants (*Orobanche* spp.) in Mediterranean agriculture, Weed Res 1989; 29: 391-397.

Schreiner R.P., Ivors K.L., Pinkerton J.N. Soil solarization reduces arbuscular mycorrhizal fungi as a consequence of weed suppression. Mycorrhiza 2001; 11:273-277.

Singh V.P.; Dixit A.; Prasadbabu M.B.B., Mishra J.S. Effect of period of soil solarization and weed control measures on weed growth and yield of soybean (*Glycine max* L.). Extended Summaries, International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century Feb. 14-18, 2000; New Delhi, India. Vol. 3: 1457-1459. 2000.

Smith E.M. Potential field for heat transfer in soil covered by different plastic mulches. Proceedings of the National Agricultural Plastic Conference 1964, 5: 80-92.

Standifer L.C., Wilson P.W., Gorbel R.S. Effect of solarization on weed seed populations. Weed Sci 1984; 32: 569-573.

Stapleton J.J. Mode of action of solarization and bio-fumigation. Proceedings of the 2nd International Conference on Soil Solarization and Integrated management of soil-borne pests, 16-21 March, 1997, Aleppo, Syria.

Stapleton J.J., DeVay J.E. Effect of soil solarization on populations of selected soil-borne micro-organisms and growth of deciduous fruit tree seedlings. Phytopathology 1982; 72: 323-326.

Stapleton J.J., DeVay J.E. Soil solarization: a non-chemical approach for management of plant pathogens and pests. Crop Prot 1986; 5:190-198.

Stapleton J.J., DeVay J.E. Thermal components of soil solarization as related to changes in soil and root microflora and increased plant growth response. Phytopathology 1984; 74:255-259.

Stapleton J.J., Lopez J.G.G. Mulching of soils with transparent (solarization) and black polyethylene films to increase growth of annual and perennial crops in south-western Mexico. Trop Agric (Trinidad) 1988; 65(1) : 29-32.

Stapleton J.J.; Quick J., DeVay J.E. Soil solarization: effect on soil properties, crop fertilization and plant growth. Soil Biol and Biochem 1985; 17: 369-373.

Sudha T., Nanjappa H.V., Udikeri S.S. Influence of solarization on weed management in tomato and tobacco nursery. Mysore J Agric Sci 1998; 32: 269-274.

Tamietti G., Valentino D. Effectiveness of soil solarization against soil-borne plant pathogens and weeds in Piedmont (northern Italy). Proceedings of the Fifth International Symposium on Chemical and Non-chemical soil and Substrate Disinfestation. Torino, Italy, 11-15 September, 2000.

Vizantinopoulos S., Katranis N. Solarization in Greece. Weed Res 1993;33:225-230.

Waggoner P.E., Miller P.M., De Roo H.C. Plastic mulching: principles and benefits. Conn Agric Exp Stn Bull. 1960; 634. 44 pp.

Wilhelm S. Chemical treatment and inoculum potential of soil. Annu Rev Phytopathol 1966; 4, 53.

Yaduraju N.T. The role of soil-solarization in weed management. Proceedings of International Symposium. Indian Society of Weed Science, Hisar, November 18-20, 1993; Vol. I : 343-349.

Yaduraju N.T., Ahuja K.N. Effect of solarization with or without weed control on weeds and productivity in soybean-wheat system. Proceedings of Second International Weed Control Congress. Copenhagen. 1996; 721-727.

Yaduraju N.T., Kamra A. "Soil solarization-a novel non-chemical method of pest control". In *Ecological Agriculture and Sustainable Development*, Vol.2, Proceedings of the International Conference on

Ecological Agriculture Towards Sustainable Development, Chandigarh, India, 15-17 November, 1997. (Edited by Dhaliwal, G.S., Arora, R.,Randhawa, N.S., Dhawan, A.K.). Indian Ecological Society, Chandigarh, 2:189-201.

CHAPTER 18

RATIONALE, APPROACH AND ADOPTION OF INTEGRATED WEED MANAGEMENT

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The management of pests in crop production is a key component among all farming practices. Weed management is one of the components of pest management. The practice of integrated pest management (IPM) is old in its use of cultural strategies or other control methods that served as the basis for pest control before the advent of pesticides. However, the current focus of IPM for weeds has been expanded to include weed biology, bio-economics, modeling of crop-weed interference, and cropping system effects on weed dynamics.

The term IPM has been defined in many different ways. Shaw (1982) suggested that there is no widely accepted definition from the classic, academic point of view. IPM has been defined as a control strategy in which a variety of cultural, biological and chemical control methods are combined to provide stable and long-term pest control (Shaw, 1982). IPM has also been defined as a biologically oriented pest control strategy that deemphasizes pest control chemicals (Goldstein, 1978). In general, the goals of IPM range from maximizing profit margins to safeguarding natural resources and minimizing the impact on the environment (Burn et al., 1987). According to the U.S. National IPM Coordinating Committee (1988), the primary goals of IPM programs are to reduce pesticide use and subsequent environmental impact and to rely more on other strategies to control pests.

The concept of integrated weed management (IWM) is not new, and was defined by Buchanon (1976) as the deliberate selection, integration and implementation of effective weed control measures with due consideration of economic, ecological and sociological consequences. Thus, IWM is undoubtedly broader and more descriptive than just weed control. IWM emphasizes integration of control tactics with all other practices that influence the ecosystem, and links weed control back to the larger picture of ecosystem management.