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Soil Solarization, an Eco-Physiological Method of Weed Control

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Need for Soil Solarization- Weeds are the plants growing out of a place where they are not desired for a particular period of time. Weed problems have turned into a continuing struggle for farmers on account of the pressure to raise crops and maximize crop production to meet increasing demand of the fast growing human population. Weeds are the scarce and silent robbers of plant nutrients, soil moisture, solar energy and also occupy the space which would otherwise be available to the main crop; harbour insect-pests and disease causing organisms; exert adverse allelopathic effects; reduce quality of farm produce and increase cost of production. Weeds, unlike other pests, are omnipresent and account for at least one-third of this loss. Losses due to weeds are higher than those from insects and diseases – insects 30%, weeds 45%, diseases 20%, other pests 5% (Rao, 2000). Therefore, efficient weed management approach is expected to contribute significantly in sustaining agriculture. There are several methods for controlling weeds such as cultural method, manual and mechanical method, chemical method, allelopathy and integrated approach. The most practised one is hand weeding but it is laborious, time-consuming, costly and also is not feasible under all situations. Now-a-days, for effective and economic weed control, herbicides are gaining popularity among the farmers. Out of total pesticide use, 17% is herbicides.

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Soil Solarization, an Eco-Physiological Method of Weed Control

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I. Need for Soil Solarization

Weeds are the plants growing out of a place where they are not desired for a particular period of time. Weed problems have turned into a continuing struggle for farmers on account of the pressure to raise crops and maximize crop production to meet increasing demand of the fast growing human population. Weeds are the scarce and silent robbers of plant nutrients, soil moisture, solar energy and also occupy the space which would otherwise be available to the main crop; harbour insect-pests and disease causing organisms; exert adverse allelopathic effects; reduce quality of farm produce and increase cost of production. Weeds, unlike other pests, are omnipresent and account for at least one-third of this loss. Losses due to weeds are higher than those from insects and diseases – insects 30%, weeds 45%, diseases 20%, other pests 5% (Rao, 2000). Therefore, efficient weed management approach is expected to contribute significantly in sustaining agriculture. There are several methods for controlling weeds such as cultural method, manual and mechanical method, chemical method, allelopathy and integrated approach. The most practised one is hand weeding but it is laborious, time-consuming, costly and also is not feasible under all situations. Now-a-days, for effective and economic weed control, herbicides are gaining popularity among the farmers. Out of total pesticide use, 17% is herbicides. The compound growth rate of herbicide consumption has been 13.7% against – 3.88% of insecticides for the last one decade (Aulakh, 2005). But the continuous use of herbicides poses many problems such as, it

1. causes health hazards
2. pollutes the environment
3. contaminates drinking water
4. contaminates the soil and terrestrial system
5. contaminates food and agricultural produces
6. contaminates aquatic and marine products
7. causes toxicity to the succeeding crop
8. develops resistance in weeds
9. causes shift in weed flora.

Therefore, interest in non-chemical approaches which aim to reduce pesticide usage is growing. So, there is a great necessity for the development of alternative non-hazardous means of weed management. In this light, harvesting of solar energy through soil solarization for controlling weeds is a potential step to reduce the dependence on chemicals.

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II. Soil Solarization an its Mechanism

Soil solarization is a method of hydrothermal disinfestation by covering moist soil with transparent polyethylene film during the hot summer months. The basic principle behind weed control through soil solarization is built up of lethally high temperature in top soil where most of the dormant and viable weed seeds are present (Soumya et al.,2004). In agriculture, polyethylene mulches with black polyethylene sheets have been used as a post-planting treatment to obtain good control of weeds. However, in solarization transperant polyethylene sheets are used as a pre-planting treatment. Soil solarization was first described in 1976 by Katan and Co-workers in Israel. It involves mulching of the soil with transparent polyethylene films so as to trap the solar heat in the surface soil and thereby increasing the temperature. The common mulch used for solarization is transparent polyethylene and in some cases polyvinyl chloride. The efficiency of solarization depends on the type of the material used for solarization and its thickness. Transperant polyethylene sheets perform better than black polyethylene (Biradar et al.,1997). Transparent polyethylene sheets of 0.05 mm thickness are superior to 0.075 and 0.10 mm thick ones (Mudalagiriyappa et al.,1999, Biradar and Hosamani 1997). Soil solarization is a hydrothermal process, which brings about thermal and other physical, chemical and biological changes in the moist soil during and even after mulching (Stapleton and DeVay, 1986). Global radiation is composed of short-wave solar radiation and long-wave terrestrial radiation. The short-wave solar radiation passes through the transparent polyethylene sheet but the long-wave terrestrial radiation is held back resulting in trapping of the heat in the soil and thereby increasing the soil temperature, lethal to the soil-living pathogens, nematodes and weeds etc. Water evaporating from the moistened soil surface will condense on the inner side of the mulch and drip back to the soil surface. These water droplets on the inner side of the mulch will trap the long-wave radiation and thus prevent cooling of the soil surface. In order to reduce heat losses through sensible and latent heat

fluxes, the plastic mulch has to be kept intact (Mahrer et al., 1984).

III. Effect of Soil Solarization on Weeds

The possible mechanisms of weed control by soil solarization are breaking dormancy of weed seeds and solar scorching of emerged weeds, direct killing of weed seeds by heat and indirect microbial killing of weed seeds weakened by heating. It may also reduce germination of weeds (Lalitha et al.,2003). The temperature due to solarization is maximum at soil surface and it decreases with the depth of the soil(Shukla et al., 2000). Therefore, the weed seeds buried deep in the soil may survive.Soil solarization reduces intensity of all types of weeds – monocots and dicots (Mudalagiriyappa et al.,1999). Unlike other methods of weed control which are mostly curative, soil solarization is a preventive method where it helps to deplete reserves of dormant weed seeds in soil which otherwise provide a source of seeds for persistent weed problems that often require repeated control measures. The following recommendations should be followed under adequate climatic conditions (Katan, 1981) –

1. Transparent polyethylene sheet instead of black polyethylene sheet should be used since it transmits most of the solar radiation that heats up the soil.
2. Soil mulching should be carried out during the period of high temperature and intense solar radiation.
3. Adequate soil moisture is necessary during solarization to increase the thermal sensitivity, improve heat conduction in the soil and enable biological activities. Saturated soil is optimal for this purpose.
4. The thinnest polyethylene sheet should be used as it is both cheaper and more effective in heating due to better radiation transmittance than the thicker one.
5. Since the temperature at the deeper soil layers are lower than that at the upper ones, thus extending the solarization period usually for four weeks or longer, enable control at deeper layer.

IV. Effect on Soil Microflora

It has been reported that soil solarization affects the soil-microflora even though the effects are selective. Due to solarization, changes occur in the population of soil micro-organisms. Solarization causes increase in temperature and at higher temperature only a few species are able to survive close to the upper limit of temperature for that group. No eucaryotes are known to grow at temperatures above 60 – 61.5^{0}C. Among the microflora, soil borne fungi suffers most followed by actinomycetes and bacteria (Zaid et al.,1990, Sharma et al.,2004))

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