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REVIEW ARTICLE

WEED FLORA OF GINGER AND EFFECT OF SOIL SOLARIZATION IN WEED CONTROL

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ABSTRACT

Ginger (*Zingiber officinale* Rosc.) (Family: Zingiberaceae) is a herbaceous plant, the rhizomes of which are used as a spice. India is a leading producer of ginger in the world and during 2012-13 the country produced 7.45 lakh tonnes of the spice from an area of 157839 hectares.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) (Family: Zingiberaceae) is a herbaceous plant, the rhizomes of which are used as a spice. India is a leading producer of ginger in the world and during 2012-13 the country produced 7.45 lakh tonnes of the spice from an area of 157839 hectares. Ginger is cultivated in most of the states in India. However, states namely Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh and Gujarat together contribute 65 per cent to the country's total production. The area under ginger cultivation in Kerala has declined from 10706 ha in 2001- 2002 to 4538 ha in 2013-14. The major constraint in the production of ginger in Kerala is labour shortage, infestation by large number of weeds and high incidence of pests and diseases.

Ginger crop is highly susceptible to weed competition especially in the initial stages of crop growth. In most cases weed management accounts for the major share of the total cost of cultivation. As the crop receives a high amount of external nutrition coupled with initial slow growth, conditions favour weed emergence which later compete with the crop for moisture, nutrients, space and sun light. Studies by the All India Co-ordinated Research Project on Weed Control indicated that 30-45 per cent yield reduction in ginger may occur due to uncontrolled weed growth (KAU, 2006).

Soil solarization results in effective weed control lasting for a whole year or even longer (Horowitz, 1980; Bell and Laemmlen, 1991). A number of commonly occurring weeds, particularly annual weeds, can be effectively controlled by soil solarization. These include, *Cynodon dactylon, Cyperus rotundus*, and *Digitaria ciliaris* among monocots, and *Crotalaria mucunata*, *Indigofera hirsuita* and *Knoxia* sp among dicots. Increased growth response is observed in plants cultivated in solarized soil. This is mainly evident as increase in plant height, number of leaves, better root formation and yield (KAU, 2011). Several soil borne pathogens can be controlled by solarization. This includes fungi like *Pythium*, *Phytophthora*, *Fusarium*, *Rhizoctonia* etc. The possible mechanisms of weed control through solarization suggested by Katan (1981) are thermal killing of weeds, thermal killing of seeds induced to germinate, breaking of seed dormancy and consequent killing of the germinating seed and biological control through weakening or other mechanisms.

Weed flora of ginger crop

Almost all types of weeds can be found in ginger fields. However, the weed flora varies with location and season. According to Elmore (1983), the major weed flora in ginger field of California included *Amaranthus* sp., *Digitaria sanguinalis* and *Solanum nigrum*. Horowitz *et al*. (1983) and Satour *et al*. (1991) observed that *Amaranthus* sp. and *Portulaca oleracea* are the predominating weeds in ginger. Rubin and Benjamin (1984) reported that *Cynodon dactylon* was the worst weed in ginger because of its fast spreading and competitive nature. Similarly *Cyperus rotundus* was the worst weed observed in ginger crop in Israel by Katan *et al*., 1976.

According to Chandran (1989), the predominating weed species in ginger fields were *Ageratum conyzoides*,

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Alternanthera sessilis, Brachiaria ramosa, Curculigo orchioides, Desmodium triflorum, Hemidesmus indicus, Isachne miliacea, Lindernia crustacea, Merrimea tridentata and *Oldenlandia corymbosa*. Milevoj (1989) found that *Vernonia cineria* was the most dominant weed species in ginger.

A field experiment was conducted at Kerala Agricultural University, Thrissur by Sainamol (1992) to study the dominant weed spectrum in ginger. She reported that the dominant weed species found in ginger field were *Amaranthus viridis, Cassia* sp., *Centrosema* sp., *Curculigo orchioides, Euphorbia hirta, Knoxia* sp., *Phyllanthus niruri, Scoparia dulcis, Sida rhombifolia, Stachytarpheta indica* and *Vernonia cineria*.

Rashid *et al*. (1992) reported that a survey of turmeric field in Banu district, Pakistan, indicated the presence of 83 weed species which belong to 73 genera. Of the 34 families, five were monocotyledonous and 29 were dicotyledonous. The most dominant mono and dicotyledonous families were Poaceae with 21 species and Asteraceae with 8 species. Gill *et al*. (2000) from Punjab observed that *Digitaria ischaemum, Cynodon dactylon, Cyperus rotundus, Dactyloctenium aegypticum, Euphorbia hirta, Commelina benghalensis* and *Eragrostis pilosa* as dominant species

Effect of Soil solarization in weed control

Solarization is a method of hydrothermal disinfection. This is done by covering moist soil with transparent polythene sheet and exposing it to direct sunlight during the hottest period of the year. The presence of dormant weed seeds in agricultural soils provides a source for persistent weed problems that often require repeated control measures. Control of a wide spectrum of weeds is one of the visible results of solarization. Annual weeds are usually more sensitive than perennials.

Katan (1981) suggested the possible mechanisms of weed control are,

1. Thermal killing of weed seeds
2. Thermal killing of seeds induced to germinate
3. Breaking of seed dormancy and consequent killing of the germinating seeds
4. Biological control through weakening or other mechanisms

Solarization results in effective weed control lasted for a whole year or even longer (Horowitz, 1980; Bell and Laemmlen, 1991; Borges and Sequiera, 1992, Sainamol, 1992).

A field trial was conducted by Sainamol (1992) at College of Horticulture, Kerala Agricultural University to study the effect of soil solarization on weeds. In the experimental field, 30 different types of weeds were observed, out of which 6 were monocots and the remaining were dicots. Initially total weed population was almost same in the different treatment plots. At the time of removal of mulch, there were no weeds in the solarized beds, while the control and non-solarized beds were covered with different weed species.

A field experiment conducted at Kerala Agricultural University by Vilasini (1996) to study the effect of soil solarization to control weeds in ginger. She observed 48 different species of weeds growing in ginger, out of which seven were monocots and the remaining, were dicots. At the time of land preparation, the field was completely covered with *Cynodon dactylon, Mimosa pudica, Scoparia dulcis, Lantana camera, Stachytarpheta indica* and *Cletoria ternatea*. When the weed population was counted one month after removing the mulch, a total of 1008 weeds were observed in non solarized plots, of which 363 were monocots and the remaining were dicots. *Cynodon dactylon* and *Knoxia* sp. were the major monocot and dicot weeds respectively during this period. Among the solarized plots, better control of both dicots and monocots was noticed in 45 days solarized plots. There were only 111 weeds at the time of harvesting. *Cynodon dactylon* was the major monocot while *Knoxia* sp. and *Amaranthus viridis* were the major dicots respectively in solarized plots.

Reports from KAU (2011) shows that a number of commonly occurring weeds, particularly annuals, can be effectively controlled by solarization. These include, *Cynodon dactylon, Cyperus rotundus, Digitaria ciliaris* among monocots and *Crotolaria muconata, Indigifera hersuita* and *Knoxia* sp. among dicots.

The effectiveness of soil solarization is influenced by several factors such as soil moisture, soil type, season, duration of solar heating, type of mulching materials and organic and inorganic matter content of soil (Vilasini, 1996).

Type of polythene mulching material

The effectiveness of soil solarization is influenced by the type of polyethylene material used. Katan *et al*. (1976) reported that transparent and white polyethylene should be used for solarization, because it transmits most of the solar radiation that heat the soil. According to Pullman *et al*. (1981), polyethylene sheets of 25 μm thick were more effective in heating soils and in killing soil borne fungi than 100 μm thick sheets.

Increased plant growth response

Many theories have been put forward to explain the increased plant growth response in solarized soil. Upon solarization, minerals are released and the nutritional status in soil is improved which results in increased yield. Other mechanisms for stimulation of plant growth are stimulation of beneficial organisms (Nair *et al*., 1990), destruction of pathogens and nullification of toxins in soil (Katan, 1981) and production of beneficial chemicals like fulvic acid (Davis and Sorensen, 1986).

Effect on soil microbes

Fungi Extensive studies by Stapleton and DeVay (1982, 1984) on microbial changes in the soil during and after solarization reported that population of fungi was greatly reduced immediately followed solarization, while thermophilic and thermo tolerant fungi like *Aspergillus* spp. and *Penicillium* sp. were less affected or even increased. Similar observations were also recorded by Abdu-Gharbieh *et al*. (1991) and Arya and Mathew (1993). Martyn and Hartz (1985) observed that saprophytic fungi increased greatly in the deeper layers in solarized soil. The saprophytic *Fusarium* population in solarized soil in 30 days was eight times more than that of non solarized soil, while after 60 days, it was decreased but still three to five times more than that in the control.

According to Triolo *et al*. (1989), the number of different colonizing species was reduced in solarized soil but prevalence of *Aspergillus, Fusarium, Penicillium* and *Trichoderma* was increased. Chandran (1989) and Sainamol (1992) suggested that the fungal population was reduced by solarization.

Bacteria

Stapleton and DeVay (1982, 1984) reported that some species of soil borne bacteria are sensitive to soil solarization; their thermal sensitivity depends up on the nature of the individual taxa. Population density of *Agrobacterium* spp., fluorescent pseudomonas, pectolytic pseudomonas and certain gram positive bacteria were reduced by 69-98 per cent immediately after solarization. Fluorescent pseudomonas got rapidly recolonised in the treated soils and no significant difference among treatments three to six months later.

Actinomycetes and *Bacillus* spp., many of which are thermo tolerant but sometimes reduced to a much lesser extent (45-58 %) or even increased (26-158 %) following solarization (Stapleton and DeVay, 1982). Increases in these thermo tolerant bacteria may also increase disease resistance and crop growth (Stapleton and DeVay, 1984). Increased colonization of (183-631 %) of plant roots by plant growth promoting fluorescent pseudomonas from inoculated seed also occurred in solarized soil (Stapleton and DeVay, 1984). Meron *et al*. (1989) and Gamliel and Katan (1991) also reported the increased count of pseudomonas in solarized soil.

Katan (1987) observed that saprophytic bacteria survive much better than fungi in heated soil. According to Kaewruang *et al*. (1989) and Gamliel *et al*. (1989), solarization significantly increased the population of bacteria antagonistic to *F. oxysporum*, *F. solani* and *R. solani* at 0-10 cm depth, while Chandran (1989) and Sainamol (1992) failed to get the increased population of bacteria in solarized soil. Prakash and Mani (1991) found that bacterial populations increased during the first 30 days in both covered and uncovered soil but got decreased to 71 per cent in covered soil after 45 days.

Actinomycetes

Many of the actinomycetes are thermo tolerant, were sometimes reduced to a much lesser extent (45-58 %) or were even increased (26-158 %) following solarization (Stapleton and DeVay, 1984). Kaewruang *et al*. (1989) noticed that solarization significantly increased the population of actinomycetes (1.2 fold) antagonistic to *F. oxysporum*, *F. solani* and *R. solani* at 0-10 cm depth. Chandran (1989) and Sainamol (1992) found that a slight increase in the actinomycetes population in solarized plots. Whereas, Gamliel and Katan (1991) reported that actinomycetes were less affected by solarization.

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