Solarization practice as a component of integrated weed management in cluster onion
(*Allium cepa* L.var. aggregatum Don)

T. UMA MAHESWARI AND M.RAJKUMAR

Department of Horticulture, Faculty of Agriculture,
Annamalai University, Annamalainagar- 608 002

Abstract

The present investigation on "Solar heating of soil for the weed management in cluster onion" was taken up in a farmer's field at Sandhapadugai, a village located 10 Km away from Chidambaram. Onion is one of the most important bulb vegetable crops grown in India and around the globe. The demand for onion is worldwide. It is used both in raw and mature bulb stage as vegetable and spices. It is rich in vitamin A, thiamine and riboflavin. Recently the demand for organically produced food is increasing considerably. The experiment was conducted to study the effect of solarization in bio amended soil for the eco friendly weed management in onion involving solarization with various amendments viz., bulky organic manures, concentrated oil cakes, along with biofertilizers and foliar organic nutrition. The experiment was laid out in a randomized block design with 14 treatments replicated thrice. The treatments include a combination of solarization for four weeks with three different amendments *viz.*, Vermicompost, Farm Yard Manure (FYM), and neem cake along with non solarized control and solarization without amendment. At the end of treatment period, inoculation with Consortium Bio Fertilizers was done for specific treatments. The results of the experiment revealed that solarization treatment with vermicompost and neem cake followed by solarization with FYM and neem cake were found to be effective in increasing the soil temperature in all depths and on all days of observation. Similarly the lowest weed population, weed bio mass and highest weed control index were registered in the treatment receiving solarization with vermicompost and neemcake

Key words: Solarization, cluster onion, weed management

Introduction

Onion is one of the most important bulb vegetable crops grown in India and around the globe. The demand for onion is worldwide. It is used both in raw and mature bulb stage as vegetable and spices. The pungency in onion is due to a volatile oil known as allyl-propyl disulphide. It is rich in vitamin A, thiamine and riboflavin. It also contains calcium 32 mg and protein 1.4 mg per 100 g of bulb.

Solar heating of soil involves covering moist soil with transparent polyethylene sheet during hot months for sufficient time to raise the soil temperature to the levels lethal for soil borne pests such as weeds, insects, disease pathogen, nematodes, etc. Artificial soil heating or soil solarization is the only non-chemical soil disinfestation method which has been tested on a large scale under farming conditions. Combining organic amendments with soil solarization is a developmental approach for the control of soil borne plant diseases (Jeffschalan, 2003). Higher soil temperatures may be obtained with dark-colored nature of organic amended soils since they absorb more solar radiation than light-colored soils (Stapleton and Devay, 1986). Although the major benefit of solarization is reduction of soil borne pathogens by soil-heating effects, there are many other possible additional beneficial effects that can result in an increased growth response (IGR) of plants. Such additional effects include control of weeds and insect pests and release of plant nutrients (Stapleton, 1997).

Based on the above said requisites an investigation was conducted to study the impact of solarization with organic amendments and bioregulators for the weed control process in cluster onion.

Materials and Methods

The present investigation was taken up in a farmer's field at Sandhapadugai, a village located 10 Km away from Chidambaram. The experiment was conducted to study the effect of solarization in bio amended soil for the eco friendly weed management in onion involving solarization with various amendments viz., bulky organic manures, concentrated oil cakes, along with biofertilizers and foliar organic nutrition. The experiment was laid out in a randomized block design with 14 treatments replicated thrice. The treatments include a combination of solarization for four weeks with three different amendments viz., Vermicompost, Farm Yard Manure (FYM), and neem cake along with non solarized control and solarization without amendment. At the end of treatment period, inoculation with Consortium Bio Fertilizers was done for specific treatments. The observations *viz,* soil temperature, weed population, weed biomass, weed control index were recorded after solar heating of the soil.

Results and Discussion

The observations on soil temperature revealed that there was an increase in soil temperature at various depths on all days of observation due to solarization and the types of amendments used. The rise in soil temperature was the highest at 5 cm depth on all days of observation. At 5 cm depth, the treatment, T_{14} (Solarization with vermicompost and Neem cake) recorded the maximum temperature of 45.22^{o}C which was on par with the treatment T_{10} which recorded 45.05^{o}C and followed by T_{12} (Solarization with FYM and Neem cake) recorded 44.81^{o}C in order. The temperature of 42.83^{o}C was recorded in non solarizaed control.

At 10 cm depth, there was a slight decrease in the temperature in all the treatments when compared to 5 cm depth. Here also the same treatment, T_{14} recorded the highest temperature of 40.05^{o} C, which was on par with the treatment, T_{10} (39.89^{o}C) and followed by T_{12} (39.67^{o}C) in order. The least value for temperature was recorded in non solarized control (38.74^{o}C).

Among the solarized treatments at 15 cm depth, the treatment, T_{14} recorded the maximum temperature value of 36.75ºC which was on par with the treatment T_{10} (36.65ºC) and followed by T_{12} (36.49ºC). T_1 recorded the least value of 35.18º C (Table 1).

The moist soil covered with polyethylene sheet recorded higher temperature mainly due to prevention of evaporation; the solar energy which could have otherwise been used in evaporation of water from the soil was stored as sensible heat in the irrigated mulch soil. The formation of small water droplets initially attain water film later on the underside of the polyethylene sheet increased the transmittance of polyethylene sheet to incoming short wave solar radiation but prevented the escape of outgoing long wave radiation from the soil (Horowitz *et al.,* 1983). The sudden rise in soil temperature under the polyethylene sheet is due to prevention of back radiation of solar long waves through transparent polyethylene films thus trapping and preventing the heat loss. The fluctuation in soil temperatures recorded at 5, 10 and 15 cm depths due to solarization with amendments followed a pattern. The highest value for temperature at 5 cm depth was recorded in the treatment, solarization with vermicompost and neem cake followed by solarization with FYM with neem cake when compared to other treatments. The same trend was followed on all days of observation. The probable reason for the increase in the temperature may be because of the dark colour of the soil (influenced by the application of amendments) that might have absorbed more solar energy and raised the soil temperature as reported by Clay Robison and Dirt (2006). This is also in accordance with the findings of Kaskavalci(2007). Increase in soil moisture and thermal conductivity in compost amended soil and on exothermic microbial activity are reported to be other possible reasons for the increase in soil temperature over non amended solarized soil (Gamliel and Stapleton, 1993).With increasing soil depths, maximal soil temperatures decreased. This is in accordance with the findings of Wajid *et al.* (1995).

Data on the total number of weeds per square meter (Table 2) showed the existence of significant treatment differences when compared to control. Among the treatments, T_{14} recorded the desirable lowest value (15.32 m^{-2}) followed by T_{10} (22.82 m^{-2}), whereas the control recorded the highest value for weeds (107.41 m^{-2}) (Table 2).

One of the objectives in using solarization is to provide adequate weed control in most of the freshly consumed vegetables in which no safe herbicide is available (Standifer *et al*., 1984). Solarization with amendments produced two different complementary effects like foliar scorching of emerged plants under plastic cover and decreased weed emergence after removing the plastic sheets. This residual effect on weeds is considered as the principal benefit of the treatment. In this investigation, solarization with vermicompost and neem cake suppressed the weed population at higher level. The excess heat generated during the period of solarization with vermicompost might have contributed for suppressing germination of weed seeds as well as vegetative structures present in the upper layer of the soil. Studies by Herdricks and Taylorson (1976) further revealed that heating weed seeds from 30 to 35ºC modified the membrane permeability, which resulted in leakage of endogenous amino acid and simultaneous reduction in germination rate. In the present study also, the highest level of soil temperature attained over control in all days of observation resulted in efficient suppression of weed growth though not in complete elimination as reported earlier by Abu-Irmaileh (1991).

Data on dry weight of weeds exhibited a desirably lesser value in T_{14} (7.12 g m^{-2}) which was on par with T_{10} (11.12 g m^{-2}). This was followed by T_{12} which recorded 15.81 g m^{-2} whereas 59.31 g $^{-1}$ was recorded in non solarized control (Table 2).

The effect of solarization with amendments in reducing the dry weight of weeds was almost similar to that in reducing the weed count. Specific environmental conditions such as light, temperature, carbon-di-oxide, oxygen and other volatile compounds in the soil controls the process of weed seed germination (Rubin and Benjamin, 1984). Hence seeds located at a soil depth where the prevailing conditions due to solarization are not favourable for germination may remain dormant, but viable until the conditions change. However, when the temperature increases, seeds may die or otherwise increase in temperature in the deep layers probably may not be high enough to be lethal, but significant to break the dormancy and force the germination. Changes in carbon-di-oxide oxygen levels in soil under polyethylene mulch may also play an important role in partial or complete breaking of seed dormancy thus enhancing germination. Thus, during their emergence, the seedlings were killed by the temperature of hot upper layer.

Data on weed control index, revealed that, T_{14} recorded the maximum weed control index (87.99) followed by T_{10} (81.25) (Table 2). Due to reduction in weed population and weed dry weight, there was considerable increase in the weed control index. In comparison with non solarized control and solarization without amendments, the highest weed control index was achieved in the treatment solarization with vermicompost and neem cake. Weed emergence after solarization to a greater extent is the function of weed seed tolerance to solar heating. Levitt (1980) reported that dry weeds are resistant to higher temperatures (120^{o}C) whereas the hydrated ones are killed at even lower temperature (< 50^{o}C). The process of solar weed control, according to Jacobson *et al*. (1980) involves biological process in addition to physical process which occur when soil temperature is raised, as discussed earlier (i.e.) sub lethal temperature may weaken the resting structures, thus rendering them more vulnerable to antagonists in the soil.

Table 1. Effect of solarization in bio amended soil on Soil temperature at different depths after one month of Solarization

Treatments	5 cm	10 cm	15 cm
T_1	42.83	38.74	35.18
T_2	44.04	38.92	35.99
T_3	43.03	37.96	35.32
T_4	44.24	39.10	36.12
T_5	43.23	38.15	35.44
T_6	44.43	39.30	36.25
T_7	43.44	38.34	35.58
T_8	44.62	39.48	36.37
T_9	43.66	38.55	35.74
T_{10}	45.05	39.89	36.65
T_{11}	43.64	38.52	35.71
T_{12}	44.81	39.67	36.49
T_{13}	43.85	38.73	35.87
T_{14}	45.22	40.05	36.75
S.Ed.	0.09	0.09	0.06
CD(p=0.05)*	0.19	0.18	0.12

Table 2. Effect of solarization in bio amended soil on weed population, weed dry weight and weed control Index

Treatments	Weed population m^{-2*}	Weed dry weight g m^{-2*}	Weed control Index**
T_1	107.41 (10.36)	59.31(7.70)	-
T_2	57.42 (7.58)	33.15 (5.76)	(44.23)41.69
T_3	99.21(9.96)	54.81 (7.40)	(7.59)15.99
T_4	48.92 (6.99)	28.83 (5.37)	(51.39)45.80
T_5	90.91 (9.53)	50.44 (7.10)	(14.96)22.75
T_6	40.52 (6.37)	24.50 (4.95)	(58.69)50.00
T_7	82.51 (9.08)	46.08 (6.79)	(28.71)32.40
T_8	35.13 (5.93)	20.17 (4.49)	(65.99)54.33
T_9	74.12 (8.61)	41.80 (6.47)	(29.52)32.91
T_{10}	22.82 (4.77)	11.12 (3.33)	(81.25)64.34
T_{11}	74.01 (8.60)	41.73 (6.46)	(29.64)32.91
T_{12}	32.22 (5.68)	15.81 (3.98)	(73.34)58.91
T_{13}	65.72 (8.11)	37.48 (6.12)	(36.81)37.35
T_{14}	15.32 (3.91)	7.12 (2.67)	(87.99)69.72
S.Ed.	0.18	0.13	1.38
CD(p=0.05)*	0.35	0.25	2.75

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