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Effect of soil solarisation on weed control index and efficiency of *Amaranthus species*

K.MUTHUMANICKAM AND A. ANBURANI

Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608 002, Tamil Nadu, India

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ABSTRACT

Field experiment was conducted to study the influence of soil solarisation on weed control index and efficiency in Amarantus species during 2018 at Annamalai University, Annamalai Nagar, Chidambaram in Cuddalore district, Tamil Nadu. The experiment was laid out in a randomized block design with seven treatments in three replications. The two species of Amaranthus viz., Amaranthus dubius (CO 1) and Amaranthus tristis (CO 3) popularly grown in this region were used for the present study. The results revealed that the application of transparent polyethylene sheet of 0.05 mm thickness significantly recorded the lowest count of weeds (15.85 m^2), highest weed control efficiency (63.29),least weed biomass (10.15 gm^2) and the highest weed control index (60.84 %) in Amaranthus dubius. In Amaranthus tristis, the lowest count of weeds (15.03 no.m^2), highest weed control efficiency (63.78),least weed biomass (5.12 gm^2) and the highest weed control index (67.61 %) were recorded with this treatment (T_6).The total maximum weed population was recorded under Amarnathus dubius than that of Amaranthus tristis is respective of various treatments. The lowest weed control efficiency, maximum weed biomass and lowest weed control index in both varieties recorded were in control.

Key words: Soil solarisation, Amaranthus *species*, weeds control index and efficiency

INTRODUCTION

Soil solarisation is a non-chemical method of soil disinfection that results in pathogen control and nematode, insect, and weed management (Bonanomi *et al.,* 2008) and it is currently adopted all over the world. However, soil solarisation is a climate-dependent process, typically lasting more than 4 weeks (Gilardi *et al.,* 2014). This long duration decreases compatibility with intensive agricultural systems. Hence, soil solarisation has become a more widely adopted method and it is always combined with other methods, such as organic amendments and flooding (Ashworth *et al.,* 2013; Gilardi *et al.,* 2014).Weed control is considered the major obstacle for the growers in the organic farming. Lower plant productivity in organic farming mainly related to the poor weed control. It is widely known in most cases, that losses caused by weeds exceeded the losses from any category of agricultural pests. Weeds are a significant problem in crop production and their management in modern agriculture is crucial to avoid yield losses and ensure food security. Intensive agricultural practices, changing climate and natural disasters affect weed dynamics and that requires a change in weed management protocols. The existing manual control options are no longer viable because of labour shortages; chemical control options are limited by ecodegradation, health hazards, and development of herbicide resistance in weeds. The ecofriendly methods like, soil solarization, polyethylene mulch biodegradable mulch, natural herbicides, hot water, and agronomic practices have been successfully adopted in many countries as safe methods for controlling weeds in the organic farming (Abouziena and Haggag, 2016).Thermal weed management has also been observed as a useful technique, especially under conservation agriculture systems. Soil solarisation controls many annual and perennial weeds. While some weed species are very sensitive to soil solarisation, others are moderately resistant and require optimum conditions (good soil moisture, tight-fitting plastic and high radiation) for control. Soil solarisation is especially effective in controlling weeds in fall-seeded crops such as onions, garlic, carrots, broccoli and other brassica crops and lettuce *etc.* Solarisation generally does not control perennial weeds as well as it controls annual weeds because perennials often have deeply buried underground vegetative structures such as roots and rhizomes that may resprout. Hence an experiment was conducted to study the effect

Corresponding author Email: muthusai121@gmail.com

of soil solarisation management practices on weed management of *Amaranthus species.*

MATERIALS AND METHODS

A field experiment was carried out during 2017-2018 at Department of Horticulture, Annamalai University, Annamalai Nagar and Chidambaram in Cuddalore district of Tamil Nadu, India. The experiment was laid out in a randomized block design with three replications and seven treatments *viz.,* T_1- Control, T_2 - Summer ploughing 1 time (30 days), T_3 - Summer ploughing 2 times (30 days), T_4 - Summer ploughing 1 time (45 days), T_5 - Summer ploughing 2 times (45 days), T_6 - Application of transparent polythene sheet of 0.05 mm thickness and T_7 - Application of biodegradable polythene sheet of 0.05 mm thickness. The two species of genus *Amaranthus viz., Amaranthus dubius* (CO 1) and *Amaranthus tristis* (CO 3) popularly grown in this region were used for the present study. The experimental field was divided into seven equal strips of which, one was maintained as fallow (Control) and the others were subjected to off-season land management treatments in six different methods. Immediately after receiving the summer showers, the solarisation works were started in strips (strips allotted for summer ploughing 1 and 2 times) by ploughing one time in one strip and in the another strip for two times at 15 days intervals for 30 and 45 days, respectively, so as to bring the soil to a fine tilth and more aerated. Then the solarisation treatment was done for 45 days in May-June by covering with transparent polyethylene film of 0.05 mm thick in one strip and with biodegradable polyethylene film in another strip. The polyethylene films should be tarped over the levelled soil and the sides were buried into the soil to maintain air tight condition.After the completion of the solarisation period the experimental area was ploughed thoroughly to bring to fine tilth and the field was divided in to beds of 2m X 2m size. At the time of last ploughing the required quantity of farmyard manure was incorporated. The seeds of *Amaranthus dubius* and *Amaranthus tristis* were sown separately and irrigations were applied as per requirement of the crop. The recommended intercultural operations were carried out as per the requirement of the crop. Observations were recorded on randomly selected six plants in each treatment. The observations on dominant weed species, weed count i.e. number of monocot and dicot weeds ($no.m^2$), weed biomass (gm^{-2}) and weed control index (%),weed control efficiency and nutrient removal by weeds were recorded. The data were statistically analysed by adopting standard procedures.

RESULTS AND DISCUSSION

The results of the present investigation revealed that the dominant weed flora in the experimental field were monocots *viz.*, *Cynodon dactylon, Comimelina benghalensis* and *Cyperus rotundus,* and dicots *viz., Trianthema portulacastrum, Cleome viscose and Echinochloa crus-galli.* Soil solarisation is a special mulching technique in which moist soil is covered by transparent polyethylene film and heated by solar radiation for several weeks. It is used for soil thermic disinfestation, being accomplished by mulching the soil under a plastic film,which produces a greenhouse effect, so that soil temperature rises to levels which are lethal or injurious to many soil borne organisms, including pathogens, seeds and weed seedlings (Ashworth *et al.,* 2013). One of the objectives of using soil solarization for weed control can be dated to the ancient Indian civilization that utilized sun radiation to apply heat treatment for weed seeds (Gamliel and Katan, 2012). It was found to be very effective for the control of weeds. The major effect of solarisation was on those propagules that were in the initial process of germination. Solarisation 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 solarisation. Solarisation with transparent polyethylene film of 0.05 mm thick (T_6) resulted in lowest count of weeds (15.85 $no.m^2$)), highest weed control efficiency (63.29) in *Amaranthus dubius.* In *Amaranthus tristis,* the lowest count of weeds (15.03 $no.m^2$), highest weed control efficiency (63.78) were recorded with T_6 treatments. Similar finding was reported by Yanyan Dai *et al.* (2016). The reason for decrease of weed count could be attributed by root branching and fresh weight, rhizosphere microflora and yield of collards were negatively

Table 1: Effect of soil solaraization management on weed population (m^2) of *Amaranthus dubius*

Treatments	* Monocots			* Dicots			Total population
	Cynodon dactylon	*Cyperus rotundus*	*Commelina benghalensis*	*Trianthema portulacastrum*	*Cleome viscosa*	*Echinochloa crusgalli*	
T_1	5.48 (30.03)	4.82 (23.23)	11.12 (123.65)	5.63 (31.69)	4.39 (19.27)	12.04 (144.96)	43.18 (1864.51)
T_2	5.24 (27.46)	4.60 (21.16)	10.35 (107.12)	5.10 (26.01)	4.17 (17.38)	8.87 (78.67)	38.33 (1469.18)
T_3	5.20 (27.04)	4.45 (19.80)	9.25 (85.56)	4.85 (23.52)	4.08 (16.64)	7.64 (58.36)	35.47 (1258.12)
T_4	5.12 (26.22)	4.23 (17.89)	8.63 (74.47)	4.52 (20.43)	3.87 (14.97)	6.51 (42.38)	32.88 (1081.09)
T_5	4.73 (22.37)	4.08 (16.64)	7.24 (52.41)	4.10 (16.81)	3.49 (12.18)	5.49 (30.14)	29.13 (848.55)
T_6	2.94 (8.64)	2.52 (6.35)	3.67 (13.46)	2.36 (5.56)	2.12 (4.49)	2.24 (5.01)	15.85 (251.22)
T_7	3.92 (15.36)	3.86 (14.89)	5.43 (29.48)	3.75 (14.06)	3.11 (9.67)	4.41 (19.41)	24.48 (599.27)
S.Ed	0.04	0.03	0.03	0.06	0.05	0.06	0.05
C.D (0.05)	0.08	0.06	0.06	0.12	0.10	0.12	0.10

** Values are square root transformed and those in parenthesis indicate original*

T_1- Control, T_2 - Summer ploughing 1 time (30 days), T_3 - Summer ploughing 2 times (30 days), T_4 - Summer ploughing 1 time (45 days), T_5 – Summer ploughing 2 times (45 days), T_6 - Application of transparent polythene sheet of 0.05 mm thickness and T_7 - Application of biodegradable polythene sheet of 0.05 mm thickness.

correlated with increased by soil solarization. The lowest weed count might be due to the excess heat produced during solarization *i.e.* rise in soil temperature resulting lethality of weed seeds as well as vegetative structures present in the upper layer of the soil (Suchindra and Anburani., 2014). The effect of solarisation treatments in reducing the weed biomass was almost similar to that in reducing weed count. In *Amarnthus dubius,* weed biomass was the least (10.15 gm-^{2}) and highest in fallow (42.78 gm-^{2}). In *Amaranthus tristis,* the least weed biomass was 5.12 gm-^{2} in transparent polyethylene film of 0.05 mm thick for 40 days and the highest in fallow (31.35 gm-^{2}). Similar findings were reported by Singh *et al.* (2004) in soybean.

Table 2: Effect of soil solaraization management on weed population (m^2) of *Amaranthus tristis*

Treatments	* Monocots			* Dicots			Total population
	Cynodon dactylon	*Cyperus rotundus*	*Conimelina benghalensis*	*Trianthema portulacastrum*	*Cleome viscose*	*Echino chloacrusgalli*	
T_1	5.25 (27.56)	4.43 (19.62)	12.12 (146.89)	5.41 (29.26)	4.27 (18.23)	10.04 (100.80)	41.50 (1722.25)
T_2	5.15 (26.52)	4.30 (18.49)	10.35 (107.12)	5.05 (25.50)	4.10 (16.81)	8.18 (66.91)	37.13 (1378.63)
T_3	5.10 (26.01)	4.24 (17.97)	9.25 (85.56)	4.71 (22.1)	4.02 (16.16)	7.26 (52.70)	34.58 (1195.77)
T_4	5.03 (25.30)	4.19 (17.55)	8.53 (72.76)	4.39 (19.27)	3.63 (13.17)	6.32 (39.94)	32.09 (1029.76)
T_5	4.65 (21.62)	4.11 (16.89)	7.24 (52.41)	4.03 (16.24)	3.28 (10.75)	5.29 (27.98)	28.60 (817.96)
T_6	2.54 (6.45)	2.31 (5.33)	3.74 (13.98)	2.23 (4.97)	2.12 (4.49)	2.09 (4.36)	15.03 (225.90)
T_7	3.81 (14.51)	3.70 (13.69)	5.43 (29.48)	3.52 (12.39)	3.01 (9.06)	4.20 (17.64)	23.67 (560.26)
S.Ed	0.03	0.02	0.03	0.05	0.04	0.05	0.05
C.D (0.05)	0.06	0.04	0.06	0.10	0.08	0.11	0.10

** Values are square root transformed and those in parenthesis indicate original*

Soil solarisation is also an effective and safe practice, which could be an important component of the overall weed management strategy in several crops. It was developed for control of soil pathogens by mulching the soil during the hot season (Gamliel and Katan 2012). Its effects are greater in moist or wet soils thus its success depends on moisture for maximum heat transfer to soil borne microorganisms and weed seeds. The specific environmental conditions such as light, temperature, carbon-dioxide, oxygen and other volatile compounds in the soil controls the process of weed seed germination. Rao (2000) has pointed out that total weed emergence was reduced by 97% one week after removal of plastic sheets and up to 77% for the season. Solarization for a period of 5 weeks may be adequate for controlling most summer and winter annual weeds, while a period of at least 5 months is required for such perennial weeds. Vito *et al.* (2000) have reported that soil solarisation for a 6-week period effectively controlled both nematodes and weeds, and consequently increased marketable carrot yield compared to a nonsolarised one.

Table 3: Effect of soil solaraization management on weed control efficiency, weed biomass and weed control index of *Amaranthus species*

Treatments	*Amaranthus dubius*			*Amaranthus tristis*		
	Weed control efficiency	**Weed biomass (gm-^{2})	*Weed control index (%)	Weed control efficiency	**Weed biomass (gm-^{2})	*Weed control index (%)
T_1	0.00	42.78 (1830.12)	0.00	0.00	35.31 (1246.79)	0.00
T_2	11.23 (126.11)	37.88 (1434.89)	11.45 (19.82)	10.53 (126.11)	28.23 (796.93)	20.05 (26.60)
T_3	17.85 (318..62)	35.03 (1227.10)	18.11 (25.18)	16.67 (277.88)	25.18 (634.03)	28.68 (32.30)
T_4	23.85 (568.82)	31.60 (998.56)	26.13 (30.74)	22.67 (513.92)	23.43 (548.96)	50.70 (45.40)
T_5	32.53 (1058.20)	28.04 (786.24)	34.45 (35.94)	31.08 (965.96)	20.21 (408.44)	42.76 (40.83)
T_6	63.29 (4005.62)	10.15 (185.23)	76.27 (60.84)	63.78 (4067.88)	5.12 (26.21)	85.49 (67.61)
T_7	43.30 (1874.89)	22.35 (499.52)	47.75 (43.71)	42.96 (1845.56)	15.23 (23.19)	56.86 (48.94)
SE.d	0.05	0.04	0.05	0.05	0.04	0.05
CD(0.05)	0.09	0.08	0.10	0.09	0.08	0.10

** Figures in parentheses indicates arc-sine transformed values*
*** Values are square root transformed and those in parenthesis indicate original*

There was a considerable increase in the weed control index (WCI) with solarisation management treatments. In comparison to the fallow, the weed control index achieved in *Amaranthus dubius* was 60.84% and in *Amaranthus tristis* it was 67.31% with solarisation with transparent polyethylene film of 0.05 mm thick**.** Weed emergence after solarisation to a greater extent is the function of weed seed tolerance to solar heating. Similar findings were also reported by Ali *et al.* (2015). The possible reason for decreased weed level might be due to transparent polythene mulch which increased the soil temperatures, inhibits photosynthesis and suppressed the weeds during crop development. Hence, based on the present investigation, application of transparent polyethylene sheet recorded the least weed population, highest weed control index and weed control efficiency when compared to other treatments in *Amaranthus species* .Among the two species studied the performance of *Amarnathus tristis* as was higher as compared to *Amaranthus dubius.*

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