CARIBBEAN FOOD CROPS SOCIETY

49

Forty-ninth Annual Meeting 2013

Port of Spain, Trinidad and Tobago
Vol. XLIX

PROCEEDINGS

OF THE

49TH ANNUAL MEETING

Caribbean Food Crops Society
49TH Annual Meeting
June 30 – July 6, 2013

Hyatt Regency Hotel
Port of Spain, Trinidad and Tobago

"Agribusiness Essential for Food Security: Empowering Youth and Enhancing Quality Products"

Edited
by
Wanda I. Lugo, Héctor L. Santiago, Rohanie Maharaj, and Wilfredo Colón

Published by the Caribbean Food Crops Society

ISSN 95-07-0410

Copies of this publication may be obtained from:

Secretariat CFCS
P.O. Box 40108
San Juan, Puerto Rico, 00940

or from:

CFCS Treasurer
Agricultural Experiment Station
Jardín Botánico Sur
1193 Calle Guayacán
San Juan, Puerto Rico 00936-1118

Proceedings of the Caribbean Food Crops Society. 49:391-397. 2013

ALTERNATIVE WEED MANAGEMENT STRATEGIES FOR VEGETABLES: SOLARIZATION AND MULCHING IN ONIONS

N.T.P. Reid[1] and J. Cohen[2]. Department of Life Sciences, The University of the West Indies, Mona, Kingston, Jamaica. [1]Present address: The Caribbean Agricultural and Research Institute, University Campus, Mona, Kingston, Jamaica

ABSTRACT: Strategies to replace or complement hand weeding in herbicide-free systems, such as solarization and mulching, need thorough investigation in tropical environments. The influence of pre-plant solarization and crop-mulching on weed growth were tested in organically-grown onion crops in two field-plot trials in St. Andrew, Jamaica. Solarization was conducted during the 'dry winter' season using clear or black plastic for varied durations. Onion crops were transplanted at the end of solarization, with mulches of grass or black-plastic included in combination with solarization or as individual treatments in the second trial. Solarization for only 2 weeks was insufficient, but durations of 4 or 6 weeks with clear plastic reduced weed growth for 5 weeks (by 56% compared to the non-weeded control); a minimum of 6 weeks' solarization using black plastic was needed for similar effect. Mulching with grass after solarization gave greater reductions in weed cover over the first 7 weeks than solarization alone, but under rainy conditions the mulch decomposed quickly, losing its ability to suppress weed growth. The grass needed replacing to maintain a thick enough layer of mulch for continued weed suppression. Black-plastic mulching provided long-lasting and effective weed control, which was not significantly increased by preceding solarization. The treatments altered weed composition, variably changing species abundance. Grass weed densities were lowest after clear-plastic solarization; nutgrass was reduced by black-plastic solarization of at least six weeks' duration. Both solarization and mulching showed potential for weed management in herbicide-free, tropical vegetable production, being equivalent to one or more handweeding operations. Strategies using combinations of the two methods, under different climatic conditions or seasons, especially warrant further investigation.

Keywords: grass mulch, plastic mulch, onions, organic crop production, soil solarization

Introduction

There has been limited research in tropical environments on strategies to replace or complement handweeding in herbicide-free systems. Two such strategies are solarization and mulching. The use of a combination of techniques for weed control in an integrated weed management approach rather than a single method is encouraged in general, and especially in organic crop production (Gaskell et al. 2000; Smith et al. 2000).

Soil solarization, also called solar heating, is the use of clear polyethylene plastic to cover moist soil in hot seasons to trap solar radiation and increase temperatures under the plastic. While it was initially developed to kill soil pathogens under Mediterranean climatic conditions (Chen and Katan 1980), solarization also has shown efficacy in weed control (Caussanel et al. 1998; Elmore 1991), including under local conditions (Cohen et al. 2000; Coates-Beckford et al. 1998). In solarization, the colour of plastic and duration of the process are two important factors that influence its effects on weed growth (Abu-Irmaileh 1991; Horowitz et al. 1983).

Combining solarization with mulching, which is a recommended technique for organic farming, can improve the levels of weed suppression (Abu-Irmaileh 1991). Onions have very little competitive ability and can be useful indicator crops in assessing levels of weed control.

The aim of this research was to assess the effects of pre-plant solarization and mulching in organically-grown onion crops on weed growth in the early stages of onion crop development as determined by weed cover, density and mass.

Materials and Methods

Field trials were conducted at King's House farm, St Andrew, Jamaica, on loam soil (Jamaican soils no. 22, USA Typic Haplustalfs). Onions were grown in small plots using organic techniques with solarization and mulching treatments in randomized block design. Solarization was conducted during the 'dry winter' season, December to March, using clear (0.04 mm thick) or black (0.05 mm thick) plastic. The soil was prepared in 15-cm raised beds by tillage to a depth of 20 cm, removal of weeds and watering to field capacity. The plastic sheets were laid to completely cover beds and edges were secured by covering with soil. The process was started at appropriate intervals to ensure that all solarization periods finished and plastic sheets were removed at the same time. At this time, beds for the non-solarized treatments were prepared and then all treatments planted at the same time with onion seedlings (*Allium cepa* cv. Texas Early Grano). Plots comprised beds of 2 m x 1 m, 0.5 m apart. Onion spacing was 10 cm within and 20 cm between rows, giving five rows (each of 20 onions) per plot in Trial 1 and 10 cm by 30 cm in Trial 2, giving three rows per plot. For the mulched treatments in Trial 2, mulches were laid before transplanting of onions, using: plastic, the same black plastic as used for solarization (with edges secured with soil); or grass of 4-5 cm depth using lawn cuttings, mainly *Digitaria ciliaris* and *Andropogon pertusus*. Onions were fertilized with compost applied along rows before transplanting; no pest control measures were required and no herbicides applied. Watering was done by overhead sprinklers as necessary. Time in weeks was reported from the end of the solarization process.

Trial 1 assessed duration of solarization with clear or black plastic compared to handweeding at varying frequency in nine treatments with four blocks:

- Two weeks clear plastic solarization
- Four weeks clear plastic solarization
- Six weeks clear plastic solarization
- Two weeks black plastic solarization
- Four weeks black plastic solarization
- Six weeks black plastic solarization
- Non-solarized, low frequency handweeding (at 8 weeks after solarization)

- Non-solarized, medium frequency handweeding (at 4 and 8 weeks after solarization)
- Non-solarized, high frequency handweeding (at 4, 8 and 12 weeks after solarization).

All solarized treatments were handweeded at 8 weeks after solarization.

Trial 2 assessed combinations of solarization and mulching in ten treatments with three blocks:

- Four weeks black plastic solarization, mulched with black plastic
- Four weeks black plastic solarization, mulched with grass
- Four weeks black plastic solarization, no mulching
- Seven weeks black plastic solarization, mulched with black plastic
- Seven weeks black plastic solarization, mulched with grass
- Seven weeks black plastic solarization, no mulching
- Non-solarized, mulched with black plastic
- Non-solarized, mulched with grass
- Non-solarized, no mulching (weedy control)
- Non-solarized, high frequency handweeding (at 4, 8 and 13 weeks after solarization).

Growth of weed species was assessed during the crop by weed cover, determined as percentage of ground covered; as shoot dry mass per 0.25 m^2 averaged from two sub-samples per plot. Weed density as number of shoots per 0.25 m^2 (from two sub-samples) was also determined in Trial 2.

Treatments were compared by analysis of variance followed by means comparison with LSD at $p=0.05$ for parametric data and by Friedman's test for non-parametric data. Rainfall and other meteorological data were obtained from the Meteorological Service of Jamaica.

Results and Discussion

Weather Conditions

Weather conditions were similar for the solarization period of both trials and suitable for the process: mainly dry with 8.9 mean sunshine hours per day, 31.2 °C maximum daily temperature. Overall, the weather followed the normal monthly pattern, as indicated by the 30-year mean values for Kingston and St Andrew from the Meteorological Service of Jamaica, except for higher than usual rainfall two weeks after solarization (early in the crop) for Trial 2.

Initial Weed Flora

The initial weed flora was similar in both Trials, a range of dicotyledonous and a few grass species. The former were frequent or occasional without any one species predominating and included *Borreria laevis* [L.] (button weed), *Portulaca oleracea* [L.] (pussley), *Phyllanthus amarus* [Shumach] (carry-me-seed), *Euphorbia hirta* [L.], *Euphorbia heterophylla* [L.], *Vernonia cinerea* [L.] (white top, wild worm wood), *Priva* *lappulacea* [L.], *Cleome viscosa* [L.] (wild caia), *Cleome rutidosperma* [DC], *Amaranthus dubius* [L.] (spanish callaloo) and *Amaranthus viridis* [L.] (garden callaloo). *Cynodon dactylon* [L.] (bermuda grass) was most abundant and the dominant weed in Trial 1; occasionally-occurring grasses were *Eleusine indica* [L.] (yard grass), *Digitaria ciliaris* [Retz] and *Anthephora hermaphrodita* [L.]. In Trial 2, *Sorghum halepense* [L.] (johnson grass) was of frequent occurrence, but as a group, grasses were less abundant in this Trial and the dominant species was *Cyperus rotundus* [L.] (nutgrass). *Commelina* spp. (water grass) were infrequent in both Trials.

Effects on Weed Growth

In Trial 1, there was no rainfall for 3 weeks after solarization and weed cover was low at the end of this period, but lowest ($p < 0.05$, standard error of the difference in means, sed, 4.8%) in treatments solarized for 4 and 6 weeks with clear plastic (mean 2%) compared to the mean of the non-solarized plots (9%). Other treatments varied from 4 to 16% cover. There was considerable weed growth in the following two weeks, but at 5 weeks the 4- and 6-week-solarization with clear plastic had continued to reduce weed cover, by 56% on average, compared to the unweeded control ($p < 0.05$) and to levels statistically similar to treatments handweeded once at 4 weeks (Figure 1).

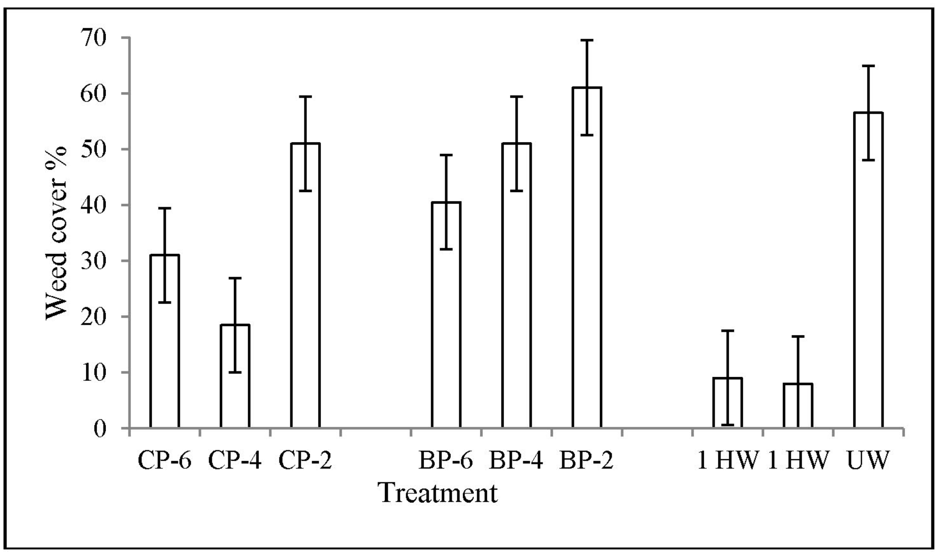

Figure 1. Weed cover (% of ground) at 5 weeks in an onion crop after pre-planting solarization treatments: CP-6/BP-6 = clear/black plastic for 6 weeks, CP-4/BP-4 = clear/black plastic for 4 weeks, CP-2/BP-2 = clear/black plastic for 2 weeks, 1HW = handweeded once at 4 weeks after solarization, UW = unweeded. (Means of 4 replicates ± $LSD_{0.05}$.)

Solarization using black plastic was less effective; weed control for 5 weeks after solarization in Trial 1 appeared to be correlated with duration and the longest duration, 6 weeks, gave almost significantly less weed cover than the unweeded

control. Two-week duration of solarization with clear or black plastic did not reduce weed cover (Figure 1).
In Trial 1, weed growth increased greatly from 5 to 7 weeks in those treatments previously less weedy, such that weed cover at 7 weeks after solarization ranged from 55 to 75% for all treatments; differences not quite significant at p = 0.06, sed 9.5%. However, increases were greater in the handweeded treatments than those solarized with clear plastic for 4 and 6 weeks. During the handweeding operation at 8 weeks after solarization, the shoot dry mass of weeds was found to be similar in all treatments ($p > 0.05$, general mean 76.6, sed 25.8 g/0.25 m^2).

Overall, there was greater initial weed pressure in Trial 2 than Trial 1. Weed cover was high at 3 weeks in Trial 2, being 42% in non-solarized/unweeded ('weedy') control plots (Table 1). However, the difference in weediness between trials diminished by 7 weeks, at which time weed cover in Trial 2 (ranging from 33% for one- handweeding to 82% for the unweeded control) was not much more than that in Trial 1. Table 1 gives weed growth for black-plastic solarized and control treatments; no clear plastic was used in Trial 2. In Trial 2, the effectiveness of black-plastic solarization of longer duration was repeated: 6-week duration significantly reduced weed growth at 3 weeks by 60% for weed cover and by 69% for weed density compared to the weedy control, but the 4-week duration was less effective. The suppression of weed numbers by black-plastic solarization persisted to 7 weeks and was still significant for the 6-week duration and almost significant for the 4-week duration. However, although there was lower density of weeds in these solarized plots, from 3 weeks the weed biomass increased such that weed cover in black-solarized treatments was no longer significantly less than the weedy control at 7 weeks (Table 1).

Table 1. Weed cover (% of ground) and weed density (number of plants per 0.25 m^2) in onion crops at 3 and 7 weeks after black-plastic solarization treatments (pre-planting solarization for 6 or 7 weeks and 4 weeks), unweeded or handweeded (at 4 weeks after solarization, w.a.s.). (Means of replicates: 4 for Trial 1; 3 for Trial 2; LSD at p=0.05.)

Date of assessment and Treatment	Trial 1 Cover	Trial 2 Cover	Trial 2 Density
At 3 weeks after solarization	$p<0.05^1$ LSD=10	$p<0.05^2$ χ^2_r	$p<0.05^3$ LSD=23
Unweeded	9	43	43
Black-plastic soln. for 4 weeks	6	36	32
Black-plastic soln. for 6/7 weeks	4	17	13
At 7 weeks after solarization	$p=0.06^1$ (LSD=20)	$p<0.05^2$ χ^2_r	$p<0.05^3$ LSD=28
Unweeded	75	83	72
Black-plastic soln. for 4 weeks	64	88	50
Black-plastic soln. for 6/7 weeks	63	73	24
Handweeded at 4 w.a.s.	58	33	46

[1] result of analysis of variance for randomized-block design ($F_{8,24}$)
[2] result of Friedman's Test (χ^2_r using at χ^2 at 6 df)
[3] result of analysis of variance for split-plot, randomized-block design ($F_{6,12}$)

Additional weed control was achieved by grass mulching after black-plastic solarization for both 6- and 4-week durations, as weed growth was lower in the combined treatments than the mulched-only or solarized-only treatments (Figure 2). However, by 9 weeks after solarization, determination of shoot dry mass showed there were no longer significant differences between the solarized-only and solarized/grass-mulched treatments ($p > 0.05$, general mean 99.7, sed 24.8 g/0.25 m^2). The grass mulch decomposed relatively quickly during the rainy periods. On the other hand, mulching with black plastic consistently suppressed weeds, as effectively when used alone as when used after solarization. The plastic-mulched treatments had so few weeds (up to harvesting of the crop) that they were not included in the analyses of weed cover, mass or density of the other treatments.

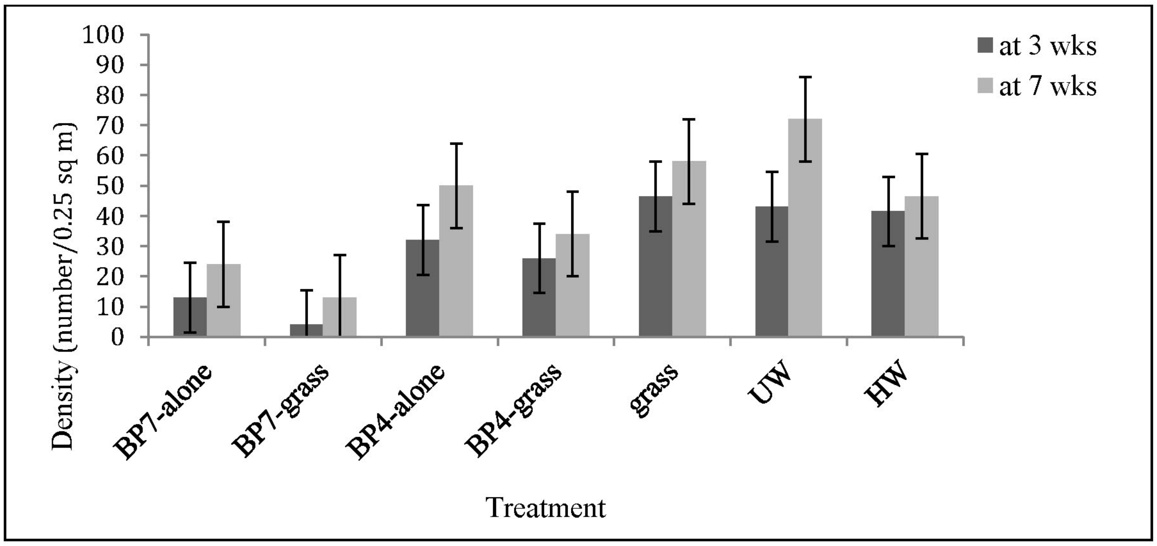

Figure 2. Weed density (numbers/0.25 m^2) in an onion crop for treatments solarized pre-planting with and without mulching of crop: BP7/4 = black plastic for 7/4 weeks; alone = no mulching; grass = grass mulching; UW = unweeded; HW = handweeded once at 4 weeks after solarization; at 3 and 7 weeks after solarization. (Means of 3 replicates and 2 sub-samples per replicate, ± $LSD_{0.05}$.)

Effects on Weed Species

Solarization differentially affected growth of weed species: densities were significantly lowered for true grasses by 4- or 6-week clear plastic treatment and for nutgrass by 6-week black plastic treatment (data not presented). At 7 weeks after the end of solarization, there were still fewer grasses in 4- and 6-week clear-plastic solarized plots than in other treatments, including those handweeded (in which grasses had re-grown). The reduction of grasses by 6-week black-plastic solarization was similar, but smaller. The lower incidence of grasses in Trial 2 precluded further conclusions. However, the high density of nutgrass that occurred in Trial 2 was significantly reduced by the 7-week black-plastic solarization.

Conclusions

In the dry season in Jamaica, solarization with clear plastic for 4 or 6 weeks reduced weed growth for 5 weeks by 56% compared to the non-solarized, unweeded treatment, whereas at least 6 weeks duration with black plastic was needed for similar effect. Mulching with grass after solarization further reduced weed growth, but under conditions encouraging rapid decomposition, the grass mulch degraded and needed replacing to maintain its ability to suppress weeds. Mulching with black plastic suppressed weeds throughout the onion crop. The treatments variably affected weed species: clear-plastic solarization reduced grasses, while black-plastic solarization for at least 6 weeks reduced nutgrass densities. Both solarization and mulching showed potential for weed management in herbicide-free, tropical vegetable production, being equivalent to one or more handweeding operations. Depending on climatic conditions or season, the use of combinations of the two methods would be beneficial and warrants further investigation.

Acknowledgements

Much gratitude is extended to the management of King's House for accommodating the trials and to the Jamaica Organic Agriculture Movement for financial assistance, facilitated by Dr Dwight Robinson. We thank Prof. P. Coates-Beckford who initiated research in soil solarization in Jamaica and motivated, in large part, the direction of this project. The research was also supported by The University of the West Indies (Mona Campus) Office of Graduate Studies and Research, and the Department of Life Sciences.

References

Abu-Irmaileh, B.E. 1991. Weed control in vegetables by solarization. FAO Plant Production and Protection Papers 109: 155-166.

Caussanel, J.P., A. Trouvelot, J. Vivant and S. Gianianzi. 1998. Effects of soil solarization on weed infestation and mycorrhiza management. FAO Plant Production and Protection Papers 147: 212-226.

Chen, Y. and J. Katan. 1980. Effects of solar heating of soils by transparent polyethylene mulching on their chemical properties. Soil Science: 271-277.

Coates-Beckford, P., J.E. Cohen, L.R. Ogle, C.H. Prendergast and D.M. Riley. 1998. Mulching soil to increase yields and manage plant parasitic nematodes in cucumber (*Cucumis sativus)* fields: influence of season and plastic thickness. Nematropica 28:81-93.

Cohen, J.E., L.R. Ogle, P. Coates-Beckford. 2000. Effects of plastic mulches on the levels of N, P and K in the soil and leaves of cucumber (*Cucumis sativus* L.). Tropical Agriculture (Trinidad) 77:207-212.

Elmore, C.L. 1991. Effects of solarization on weeds: Use of solarization for weed control. FAO Plant Production and Protection Papers 109:129-137.

Gaskell, M., B. Fouche, S. Koike, T. Lanini, J. Mitchell, and R. Smith. 2000. Organic vegetable production in California – science and practice. Horttechnology 10:699–713.

Horowitz, M., Y.Regev and G.Herlinger. 1983. Solarization for weed control. Weed Science 31:170-179.

Smith, R.I., W.T. Lanini, M.L. Gaskell, J.P. Mitchell, S.T. Koike and C. Fouche. 2000. Weed management for organic crops. University of California. Division of Agriculture and Natural Resources. Publication 7250. http://anrcatalog.ucdavis.edu/pdf/7250.pdf.