Crop Protection 28 (2009) 338–342

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Nematode, fungi, and weed control using Telone C35 and colored plastic mulches

J.E. Thomas [a,*], L.-T. Ou [a], L.H. Allen, Jr. [b], J.C. Vu [b], D.W. Dickson [c]

[a] Soil and Water Science Department, University of Florida, Gainesville, FL 32611, USA

[b] US Department of Agriculture, Agricultural Research Service, Center for Medical, Agricultural, and Veterinary Entomology, Chemistry Research Unit, 1700 SW 23rd Drive, Gainesville, FL 32608, USA

[c] Entomology and Nematology Department, University of Florida, Gainesville, FL 32611, USA

ARTICLE INFO

Article history:
Received 29 September 2008
Received in revised form
1 December 2008
Accepted 2 December 2008

Keywords:
Methyl bromide
1,3-Dichloropropene
Chloropicrin
Polyethylene film
Virtually impermeable film
Nutsedge

ABSTRACT

Methyl bromide controls three major problems in crop production: weeds, nematodes and phytopathogenic fungi. An alternative system was investigated that used various colored plastic mulches with Telone C35 (63.4% 1,3-dichlropropene, 34.7% chloropicrin, 1.9% inert ingredients). This alternative to methyl bromide was to investigate: 1) control weeds through wavelength selective plastic mulches, 2) control fungi by chloropicrin, and 3) control weeds and nematodes by 1,3-dichloropropene. These mulches control weeds by a thickness that prevented weed penetration, especially nutsedges, by retaining phytotoxic fumigant longer, or by allowing infra-red and red light to penetrate through the film while restricting other photo synthetically active wavelengths. Infra-red and red light changed the morphology of nutsedges from a hard plastic-penetrating point to a soft leafy structure that cannot tear the film. The mulches tested were blue virtually impermeable film (VIF), black VIF, black polyethylene film (PE), as well as blue, green, olive, brown, and metalized PE. Conclusions after a two-year study were: 1) that there was no direct correlation between the amount of light transmitted through colored mulch with tomato yield per plant, 2) that the use of fumigation with plastic mulches led to an average increase of 40% in crop yield compared to non-fumigated beds, and 3) finally, that if the grower decided not to use any pesticide, fungicide, or herbicide, then metalized PE mulch would maximize weed control and crop yield.

1. Introduction

Methyl bromide (MBr), a very effective broad-spectrum fumigant, was to be phased out in 2005 (UNEP, 1995). Effective alternatives to methyl bromide must control three major areas of potential damage to crop production: weeds, phytopathogenic fungi, and nematodes. Currently, no single chemical or non-chemical method can exhibit the efficiency of methyl bromide in these areas (Yates et al., 2002). However, the integration of non-chemical with chemical methods may match methyl bromide's efficiency and cost. This research is focused on finding a low-cost, readily available alternative to MBr.

The use of infrared transmitting colored plastic mulches with the fumigant Telone C35 (63.4% 1,3-dichlropropene, 34.7% chloropicrin, and 1.9% inert ingredients as listed on the manufacturer's specimen label) from Dow Agrosciences (Indianapolis, IN) is a combination that has not yet been reported in the literature. The two active ingredients of Telone C35, 1,3-dichloropropene (1,3-D) and chloropicrin (CP), would control nematodes and fungi, respectively. The use of virtually impermeable film (VIF) would allow greater retention of 1,3-D and CP than the conventional polyethylene (PE) mulch (Ou et al., 2008). Greater retention would lead to better control of nematodes and fungi while, concurrently, the colored mulches would control weeds, including nutsedges which presently only MBr can manage (Patterson, 1998; Ngouajio and Ernest, 2004).

Patterson (1998) demonstrated that the lack of penetration by purple nutsedges through colored plastic mulch is not due to solarization, but rather due to the wavelength selective nature of the plastic film. Apparently, penetration of sufficient photo synthetically active radiation through translucent films stimulates leaf development, inhibits rhizome growth, and alters the sharp-pointed shoot tip so that it fails to penetrate translucent mulch. Solar infrared transmitting translucent film might be marginally better for suppressing nutsedge penetration. However, nutsedge shoots may survive and accumulate under translucent mulch

* Corresponding author. Soil and Water Science Department, University of Florida, 2169 McCarty Hall, P.O. Box 110290, Gainesville, FL 32611, USA. Tel.: +1 352 392 1951; fax: +1 352 392 3902.

E-mail address: thomas@ufl.edu (J.E. Thomas).

0261-2194/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cropro.2008.12.003

(Chase et al., 1998). The capability of film penetration by nutsedge rhizomes appears to be governed by light dependent morphological changes from rhizome growth in darkness to leaf development in light (Chase et al., 1998). This change from a sharp film-penetrating point to a leafy morphology would occur before film penetration with translucent mulch and after film penetration with opaque mulch. Further refinement of the research on colored mulch control of weeds was done by Ngouajio and Ernest (2004), who found that a better estimate of weed infestation by wavelength selective films could be made only if the photo synthetic active radiation (400–700 nm) being transmitted through the mulch was considered. However, their study did not include nutsedges. Patterson (1998) reported that the thickness of the plastic mulch can also influence weed emergence. The thicker plastic mulches would prevent punctures by purple nutsedge (*Cyperus rotundus* L.) or yellow nutsedge (*Cyperus esculentus* L.). The lack of holes in the film would, in turn, restrain opportunistic weeds, such as goosegrass (*Eleusine indica* L. Gaertn.), crabgrass (*Digitaria* spp.), and Florida pursley (*Richardia scabra* L.) from growing.

The goal of this research was to demonstrate a quickly implemented MBr alternative that had an effectiveness comparable to using MBr. Two hypotheses were tested: the first was whether wavelength selective plastic films can adequately control weeds, and the second was whether Telone C35 can manage fungi and nematodes under PE as well as under VIF. The overall effort was to determine if the use of infrared transmitting colored plastic mulches, in combination with the fumigant Telone C35, would give equivalent pest control and crop yield as MBr.

2. Materials and methods

During the spring of 2006 and 2007, research conducted at the University of Florida Plant Science Education and Research Unit near Citra, FL focused on the combination of colored plastic mulches with pre-crop fumigation. Raised beds (0.9 m wide by 12 m length by 10 cm height) were established on nematode infested parcels which in previous seasons exhibited heavy weed pressure. Each plot was irrigated with 1.3 cm water the day before fumigation to allow for better bedding. The day after irrigation, each bed got 2.2 kg of 14-7-14 fertilizer (2.24 tons/ha) prior to fumigation. Beds were formed in a north–south direction and using three swept-back chisels on a Kennco mini-combo unit (Ruskin, FL). The pre-crop fumigants, 65:35 methyl bromide:chloropicrin (MBr:Pic from Great Lakes Chemical Co., Buffalo, NY) and Telone C35 (Dow AgroSciences, Indianapolis, IN), were chisel injected to a depth of 30 cm at the rates of 234 and 327 l per hectare, respectively. Untreated beds were constructed concurrently. The MBr:Pic was applied only to black VIF and black PE covered beds, while the Telone C35 and untreated beds were done with all plastic mulches. No herbicides were used at any time on these beds. Treatments were placed in a random block design with four replicates.

Each treatment was planted with twenty 6-week old "Talladega" tomato seedlings twenty days after fumigation as recommended on the fumigant specimen label. Since the plant heights were mildly stunted in the Telone C35 treated plots compared to those in the non-treated and MBr-treated plots, it was assumed that some phytotoxicity occurred even after waiting the recommended plant-back time. Weed counts were conducted weekly after fumigation using 0.3 m × 0.9 m PVC frames placed across the bed every 3 m avoiding plant holes. Although purple nutsedge (*Cyperus rotundus)* was the predominant weed species to puncture the plastic mulch, there were some yellow nutsedge (*Cyperus esculentus*) and opportunistic weeds, such as goosegrass (*Eleusine indica*), crabgrass (*Digitaria* spp.), and Florida pursley (*Richardia scabra*) that were included in the weed count. Yields were obtained by harvesting the fruit twice. The first harvest had only ripe fruit picked, while the second harvest, seven to nine days later, had all the remaining fruits collected. Root galling indexing for root-knot nematode (*Meloidogyne incognito* (Kafoid & White) Chitwood) damage on a 1–10 scale and plant stem inspection on 0–100% scale for Southern blight caused by *Sclerotium rolfsii* Sacc. were done visually after harvesting was completed.

Identical colored mulches (Table 1) were used for both years, with the exception of the metalized plastic mulch which had a 10 cm black stripe in the middle during 2006 that was absent during 2007 trial. Colored mulches included blue VIF (Bruno Rimini Ltd, London, United Kingdom), black VIF (Klerk's Plastic Products Manufacturing Inc., Richburg, SC), black PE (Sunoco Inc., Hartsville, SC), as well as blue, green, olive, brown, and metalized PE (Pliant Corp., Schaumburg, IL). Percent transmission of the plastic films was measured on a Spectronic Unicam UV1 spectrometer (Cambridge, UK).

Data obtained from the field experiments were subjected to analysis of variance and significant differences among treatment means were separated by Waller–Duncan K-ratio test at $p \leq 0.05$ using the generalized linear module of SAS software version 9.1.3. The statistical analyses were done with combined data from both years. The results from fumigated and non-fumigated plots were analyzed separately in order to more clearly elucidate statistical differences between the mulches without interference from the fumigant effects.

3. Results and discussion

The first hypothesis to be tested was whether weed control could be obtained using wavelength selective plastic mulches. If weed control was sufficient, then it might be possible to correlate the crop yield to plastic films that maximize percent transmission (%*T*) at the wavelengths of 645 nm to reduce weed penetration, while simultaneously minimizing the %*T* values from 400 to 645 nm to inhibit weed growth beneath the plastic (Table 1). The numerical order for %*T* at 645 nm was: blue PE > brown PE > olive PE > green PE > blue VIF > metalized with black stripe PE ∼ all metalized PE > black VIF > black PE. Based on this ranking, it would be expected that blue PE would restrict nutsedge from puncturing the plastic film; therefore, the blue PE would have fewer weeds overall compared to the other colored films. Conversely, the black PE, which is the most common color used in the United States, would have the greatest number of weeds. The maximum %*T* below 645 nm changed the

Table 1
Plastic mulch properties.

Plastic mulch[a]	Thickness (μm)	Company	%*T* (645 nm)	Maximum %*T* at or below 645 nm
Blue VIF	64	Bruno Rimini	0.0319	0.0365 (485 nm)
Black VIF	36	Klerk's	0.0034	0.0034 (645 nm)
Black PE	32	Sonoco	0.0029	0.0002 (485 nm)
Blue PE	32	Pliant	1.70	5.48 (485 nm)
Green PE	32	Pliant	0.95	7.37 (485 nm)
Olive PE	32	Pliant	1.17	3.48 (485 nm)
Brown PE	32	Pliant	1.67	1.78 (485 nm)
Metal side of metalized PE with black stripe (2006)	32	Pliant	0.0041	0.009 (450 nm)
Black center of metalized PE with black stripe (2006)	32	Pliant	0.0053	0.013 (450 nm)
All metalized PE (2007)	32	Pliant	0.0043	0.008 (450 nm)

[a] VIF = virtually impermeable film, PE = low density polyethylene film.