TIF continues to take root … fumigant dose reduction in in melon trial in Costa Rica

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ABSTRACT
TIF™ is a mulch film with superior vapor retention properties versus Nylon based VIF. The heart of the TIF technology is the high barrier to various fumigants provided by Kuraray's EVAL™ ethylene vinyl alcohol copolymer (EVOH)[2]. Numerous past flux studies involving many treatments have demonstrated TIF's ability to significantly reduce fumigant emissions while allowing for significant dosage rate reductions [1,6,12]. In this paper we will discuss how materials selection, structure design, processing conditions used during the film production all contribute to the barrier performance and successful field deployment of the TIF film on numerous laboratory and field trials with multiple fumigants and crops in multiple geographies. Additionally, efficacy results from a rate reduction trial using TIF and MBPic 98:2 for *Harper* cantaloupes completed last year in Costa Rica will be presented. The objective of the trial was to evaluate the efficacy of weed and the root-knot nematode control with reduced dosages of MBPic 98:2 using different tarps.

BACKGROUND
In 2007 fumigant permeation and soil retention tests conducted by UC Davis showed that TIF had higher fumigant barrier compared to other tarps[1,3]. TIF offers high barrier properties not only to methyl bromide but also to the alternative fumigants [1,7]. In 2008 - 2009 a full efficacy study carried out with *Albion* strawberries by Steven Fennimore of the University California Davis in Salinas California[5]. Dose response data from this study suggested that the use of TIF mulch film with PicClor60 at a rate of 225 kg/ha (50% of standard dose) provided marketable fruit yield that was competitive with the yield obtained when using 393 kg/ha of a 67/33wt% blend of methyl bromide and chloropicrin (MBPic) in combination with standard PE mulch. PicClor60 is a product of TriCal Inc. a 37.1/56.7/5.0wt% blend of 1,3-dichloropropene, chloropicrin and a surfactant. We have had similar successes with bell peppers and eggplants in Argentina, sweet potatoes in Japan, and ginger root in China [4,8]. Outstanding results in row mulch field trials have been confirmed with dimethyl disulfide (DMDS) and TIF by Joshua Freeman and Theodore McAvoy of Virginia Tech after significant rate cutting[9,10]. Seven hundred acres of potato fields, quarantined for potato cyst nematode by the United States Department of Agriculture (USDA), have been treated using TIF. The United States Environmental Protection Agency (USEPA) has recognized the performance of TIF by categorizing it in the cluster of mulches with the highest possible MB and Pic buffer zone credit [7,11].

INTRODUCTION

The *Harper* cantaloupe trial in Costa Rica was conducted on the first and second growing seasons of 2009 – 2010. The treatments were made in an area of the farm with a heavy population of *Meloidogyne incognita*. Of the root-knot nematodes, *M. incognita*, is the most common species which attacks this crop. When *M. incognita* is present at planting time it stunts the young plants soon after emergence and causes severe galling of the roots.

METHODS AND MATERIALS

The fumigant used was MBPic 98:2 and the application rate ranged from 79 to 150kg/ha. This was a shank application on raised beds. Six types of films were tested. Two of the films were a black/white TIF and a black/black TIF. The other four films, LDPE, SIF, VIF, and Saran based films were sourced by the grower from different suppliers. Three 450m long beds, 1.6m on center were used to conduct the study. The fumigant application was made with a three-up commercial tractor outfitted with a King Model 710 flow meter by Smither Equipment. The seedlings were transplanted on 24Nov09 for the first cycle and on 09Feb10 for the second cycle. Each of the treatments was replicated five times and fully randomized. Due to nematode control issues in the rest of the farm, an application of 1,3-D had to be made between the end of the first and beginning of second cycle to the entire farm including the experimental beds. For this reason, the control data reported in the results section of this paper corresponds to the first cycle only.

PRODUCTION OF TIF FILMS

The TIF films deployed at this trial were designed by Kuraray and produced on a pilot scale film coextrusion line at the Kuraray Research & Technical Center located in Pasadena Texas, USA. The film structure used for the black/white TIF film is provided in detail in Table 1. A similar design was used for the black/black TIF.

Table 1. Layer structure of 7-layer coextruded black/white TIF

Layer	vol%	µm	Layer Composition (wt%)
Layer A	25.0%	7.65	LLDPE / mLLDPE / Blk MB / UVI MB / Slip MB = 68 / 20 / 10 / 4 / 4wt%
Layer B	10.0%	3.06	LLDPE / mLLDPE / Blk MB / UVI MB / Slip MB = 68 / 20 / 10 / 4 / 4wt%
Layer C	10.0%	3.06	Admer AT2474A = 100wt%
Layer D	10.0%	3.06	EVAL SP292B = 100wt%
Layer E	10.0%	3.06	Admer AT2474A = 100wt%
Layer F	10.0%	3.06	LLDPE / mLLDPE / Wht MB / UVI MB / Slip MB = 42 / 30 / 20 / 4 / 4wt%
Layer G	25.0%	7.65	LLDPE / mLLDPE / Wht MB / UVI MB / Slip MB = 42 / 30 / 20 / 4 / 4wt%
	100.0%	30.6	

Where the resins and masterbatches (MB) used are:

- LLDPE = Octene monomer based Linear Low Density Polyethylene, Sclair FP120A
- mLLDPE = metallocene LLDPE, Elite 5401
- UVI MB = Hindered Amine Light Stabilizer Ultraviolet inhibitor, Ampacet 100840
- Slip MB = Euracamide loaded into LLDPE, Ampacet 10090
- White MB = 70% TiO2 loaded into LLDPE, whethering type, Ampacet 112122
- Black MB = 40% carbon black loaded into LLDPE, Ampacet 190580

The coextrusion line was a 7-layer, 7-extruder blown film line with the specifications as listed on Table 2.

Table 2. Pilot Scale Blown film specifications at the Kuraray Research & Technical Center

Kuraray America, Inc. Pilot Blown Film Line	
Die System	7 layer Brampton Engineering SCD pancake die with 3" or 6" lips 0.060" die gap; 23-12-11-8-11-12-23% nominal layer ratios 'B', 'C' and 'D' layers are temperature isolated UniFlo dual lip air ring
Extruders	Five 30 mm (B,C,D,E,F) layers & two 45mm (A,G) layers Single flighted screws, general purpose design Gravimetric layer ratio control all extruders with PC line management system
Tower Assembly	Air cushion bubble cage, roller collapsing frame with roller side guides 44" wide vertical oscillating hauloff with discharge nip, with 360° oscillation motion Regenerative DC drive on nips

The trial was conducted using the 150mm die lip set. A film lay-flat width of 735mm resulting in a blow-up ratio (ratio of film bubble circumference to die lip circumference) of 3.09 was used. The total machine output and line speed were 43kg/h and 17m/min respectively. The tubing was collapsed, wound on a single winder, and subsequently slit on one edge, split open and trimmed to 1.4m using other downstream equipment. Specific process conditions such as motor load, screw rpm, resin output, resulting layer thickness and temperature of the melt for each of the seven extruders are summarized in Table 3.

Table 3. Extruder process conditions of 7-layer Brampton Engineering blown film line

		%I					95.4	95.4			1.20	1.20			5.06 pph/inch (Die)
A = Inside Layer G = Outside Layer					psig	°F	pph		%		mil		°F		
G		43	27.9	0.835	2226	519	23.3	23.3	25.00	25.00	0.30	0.30	430	428	FP120/WHT MB
F		38	47.8	0.195	2072	439	9.3	9.3	10.00	10.00	0.12	0.12	430	0	FP120/WHT MB
E		41	27.4	0.340	2015	400	9.3	9.3	10.00	10.00	0.12	0.12	430	426	Admer AT2474A
D		41	29.3	0.391	2627	434	11.5	11.5	10.00	10.00	0.12	0.12	430	430	SP292B
C		42	31.5	0.296	1013	441	9.3	9.3	10.00	10.00	0.12	0.12	430	431	Admer AT2474A
B		41	42.3	0.220	2834	430	9.3	9.3	10.00	9.99	0.12	0.12	430	0	FP120/BLK MB
A		45	32.2	0.724	2545	436	23.3	23.3	25.00	25.01	0.30	0.30	430	429	FP120/BLK MB

RESULTS AND DISCUSSION

Weed assessment was conducted 24 days after transplanting. No weed control issues were experienced during either of the crop cycles. Weed densities were minor to null during both growing cycles. The root disease (gall) severity index and degree of plant damage were measured 63 days after transplanting and summarized in Table 4. The highest root-knot nematode severity index and plant damage was observed with the 3-layer SIF film at cut fumigant rate.

Table 4. Summary of treatments, root disease and plant damage 63 days after transplanting

Film ID	Technology	MB (kg/ha)	Film thickness (µm)	Root-knot severity index	Degree of damage
HB PNTC	3-layer Polyethylene	150	30	0.04	2.9%
HP PN	3-layer "high barrier" SIF	79	30	0.33	20%
TIF BB	TIF black/black with EVAL	79	30	~0	~0%
TIF PN	TIF silver/black with EVAL	79	30	~0	~0%
VIF PP	VIF silver/silver with Nylon	79	30	0.015	1.6%
SARAN	PVdC	79	28	0.015	1.5%

Cantaloupe productivity was also measured 58 days after transplanting and provided on Table 5. No significant differences in marketable fruit yield were observed between the control treatment and the two treatments covered with TIF despite the reduced fumigant rate.

Table 5. Summary of melon yield 58 days after transplanting

Film ID	Technology	MB (kg/ha)	Film thickness (µm)	Marketable fruit (box/ha)	Total fruit (box/ha)
HB PNTC	3-layer Polyethylene	150	30	1350	1430
HP PN	3-layer "high barrier" SIF	79	30	1270	1290
TIF BB	TIF black/black with EVAL	79	30	1290	1350
TIF PN	TIF silver/black with EVAL	79	30	1250	1270
VIF PP	VIF silver/silver with Nylon	79	30	1190	1230
SARAN	PVdC	79	28	1220	1240

SUMMARY

TIF continues to take root. Consistent performance in reducing emissions of fumigants has made it the leading methyl bromide alternative tool to support the overriding goal of lowering the ecological impact of fumigation. TIF also provides opportunities for rate reduction in the commercial cultivation of fruits and vegetables. The melon trial covered in this paper is just one example of the value proposition of TIF mulch films where a similar crop yield was achieved while using nearly half the fumigant dose.

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