

**METAM COMBINATIONS AS ALTERNATIVES TO METHYL BROMIDE
IN US-GROWN STRAWBERRIES AND MULCHED VEGETABLES**

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ACKNOWLEDGEMENTS

< IR-4 Methyl Bromide Alternatives Program IR-4, Princeton, NJ

< AMVAC Chemical Corporation

< Dow AgroSciences, LLC

< Dr. Jim Gilreath, University of Florida, retired.

< Dr. B.M. Santos, University of Florida, Baum Research Station, FL

< Dr. Husein Ajwa, UCD, San Jose, CA

< Dr. Michael Nelson, Plant Sciences, Inc., Watsonville, CA

< Dr. Stanley Culpepper, University of Georgia, Tifton, GA.

< Dr. Frank Louws, UNC, Raleigh, NC.

< Mr. John Mirusso, Mirusso Enterprises, Inc., Boynton Beach, Florida.

<Mr. Bennett Aduddell, Edmond, OK

Today's Presentation Reviews/Discusses the Following

- < **Many variations in application technique and procedure.**
- < **Variations due to soils, cultural practice and pest spectra common to the areas of production.**
 - **Seep irrigated crops in FL vs. drip irrigation in SE US and in CA.**
 - **Nematode and disease pressure differences, SE US vs. CA**
 - **Weed spectra differences SE US vs. CA**
 - **Soil characteristic differences**
- < **Adaptation to new application technology is evolving, and is frequently tailored to the specific needs and preferences of the grower.**
- < **Products in wide-scale use involve the active ingredients, metam sodium (Vapam®HL), metam potassium (K-Pam® HL), 1, 3-dichloropropene and chloropicrin.**
- < **Importance of delaying Vapam® HL or K-Pam® applications following 1, 3-dichloropropene + chloropicrin or chloropicrin alone applications.**
- < **Pros and Cons of drip- applications of Vapam® HL or K-Pam® HL.**

Continued..

- < The important role of precision placement application equipment gaining usage in FL and the SE US (i. e. “The Mirusso Rig” and variations thereof).**
- < A review of data from 2 and 3-way applications as alternatives to MeBr/PIC.**
- < Pros and Cons of the 2 and 3-way applications based on data reviews and comments from key University researchers.**

Two and Tree-Way Applications

The Products

- Vapam® HL ---- metam sodium
- K-Pam® HL ----- metam potassium
- Telone® II ----- 1, 3-dichloropropene
- Telone® C-17 --- 1, 3-dichloropropene + 17% chloropicrin
- Telone® C-35 --- 1, 3-dichloropropene + 35% chloropicrin
- InLine® ----- Same as Telone® C-35 + emulsifier for drip-application
- Chloropicrin ---- 100% chloropicrin
- Chloropicrin EC --- 100% chloropicrin + emulsifier for drip-application

Trademarks

- Vapam® HL and K-Pam® HL are registered trademarks of AMVAC Chemical Corporation.
- Telone® II, Telone® C-17, Telone® C-35 and Inline® are registered trademarks of Dow AgroSciences, LLC.

Two and Three-Way Applications Using Precision

Application Equipment

Rates, Sequence of Applications and Application Depths

- Vapam® HL ---- 75 gallons/treated acre
- K-Pam® HL --- 60 gallons/treated acre
- Chloropicrin ---- 120-150 lbs/treated acre
- Telone® C-35----- 20-35 gallons/treated acre

Two-Way Combinations of Chloropicrin + Vapam® HL or K-Pam® HL

(FL and SE US)

- 1.) Apply the chloropicrin first at the bottoms of the beds during bed formation.
Or
Apply Telone® C-35 first at the bottoms of the beds during bed formation.
 - Can use same equipment once used to apply MeBr/PIC.
- 2.) Re-shape and firm up beds if necessary.
- 3.) Follow with Vapam® HL or K-Pam® HL using precision placement equipment, applying 4 inches between outlets in top 4 inches of finished beds.
- 4.) Install drip tapes and lay plastic mulch.
- 5.) Wait 21 days and transplant.

Note: Some growers have found that the metam-based products, when placed precisely where needed, can obviate the need for the chloropicrin for disease control.

Two and Three-Way Applications Using Precision Application Equipment

Rates, Sequence of Applications and Application Depths

- Telone® II --- 10 to 12 gallons per treated acre
- Chloropicrin --- 120-150 lbs per treated acre
- Vapam® HL ---- 75 gallons per treated acre
- K-Pam® HL --- 60 gallons per treated acre

Three-Way Combinations of Telone® II + Chloropicrin + Vapam® HL or K-Pam HL (FL and SE US)

- 1.) During bed formation, apply Telone II deep, slightly below bed bottoms and chloropicrin slightly higher above the bed bottoms.
 - Can use same equipment once used to apply MeBr/PIC.
- 2.) Re-shape and firm up beds if necessary.
- 3.) Follow with Vapam® HL or K-Pam® HL using precision placement equipment, applying 4 inches between outlets in top 4 inches of finished beds.
- 4.) Install drip tapes and mulch beds.
- 5.) Wait 21 days and transplant.

Other Vapam® HL or K-Pam® HL Combinations used with Good Effect in Florida and Other Parts of the SE US

Sequential Applications

Coulter System Applications

- 1.) Apply Telone® C-35 at 20-35 gallons per acre broadcast through a Coulter system (Mirruso Coulter Rig) and leave undisturbed (without plastic mulch) for 14 days.
- 2.) Form beds, install drip tapes (2 per bed) and lay plastic mulch.
- 3.) Apply Vapam® HL at 75 gallons per treated acre or K-Pam® HL at 60 gallons per treated acre through drip tapes in sufficient water to assure wetting across the bed tops (usually 1 acre inch or more).
- 4.) Wait 21 days and transplant.

Note: Delaying the Vapam®/K-Pam® application 5-7 days after applying the Telone® C-35 will usually enhance efficacy significantly, especially against *Cyperus* spp.

Coulter System Applications (Continued)

An alternative to the proceeding broadcast Coulter application—

- 1.) Form false beds and inject Telone® C-35 deeply into the false beds (12 inches below grade), using 3 shanks or coulters per bed.**
- 2.) Re-shape beds immediately and make beds as firm as possible.**
- 3.) Install drip tapes (2 per bed) and lay plastic mulch.**
- 4.) Wait 5-7 days and drip-apply Vapam® HL or K-Pam® HL at 75 or 60 gallons per treated acre, respectively. Apply in sufficient water to assure wetting across bed tops.**
- 5.) Wait 21 days and transplant.**

Note: In some cases, Telone® C-17 is used instead of Telone® C-35 in the sequential Coulter system applications, but this is minimal due to the disease pressures common to FL/ SE US.

California

< Essentially 100% of the strawberry and mulched vegetable acreage is grown under drip irrigation.

- 1.) InLine® (= Telone® C-35 + Emulsifier) is commonly applied at 20 -25 gallons per acre or Chloropicrin EC is applied at rates in the range of 200-400 lbs per acre.
- 2.) Applications are made through drip tapes (minimum 2 per bed) in at least 1 acre inch of water per acre.
- 3.) Inline® or Chloropicrin EC alone generally provides excellent disease control, frequently making additional fumigant treatments unnecessary.
- 4.) Very good control of some weeds has also been reported but generally these treatments are weak against weeds, especially clovers and Malva species.
- 5.) Waiting 5-7 days after the drip applications of InLine® or Chloropicrin and drip-applying Vapam® HL or K-Pam HL at 75 or 60 gallons per treated acre, respectively, has been shown to give excellent broad spectrum control of diseases and weeds.
- 6.) Applying Vapam® HL or K-Pam® HL at 75 or 60 gallons per treated acre on bed tops and mechanically incorporated into the top bed area has also given excellent results.

Now, let's look at some data.

IR-4 Methyl Bromide Alternatives Programs (1999-2003)

- < Data Somewhat Dated --- but Still Applies
- < Large Scale Field Programs – Commercially Applied
- < Treatments Replicated 4-6 Times
- < 4 Strawberry Trials/Year (2 CA; 2 FL)
- < 4 Fresh Market Tomato Trials/Year (2 CA; 2 FL)
- < All Trials – Full Season Commercial Yields
- < Harvested Fruit Quality
- < Telone® C-35/Inline Applied at 26 Gallons per Treated Acre.
- < Vapam® HL Used in All Trials at 37.5 to 75 Gallons per Treated Acre
- < Vapam® HL Applied Within a Few Hours After Telone® C-35 Applications.
- < MB/PIC Standard (350 lbs per treated/A) – All Trials

Mean Marketable Fruit Yields Expressed as Mean Percentages of MB/PIC Yields

IR-4 Programs

<u>Treatment</u>	<u>Strawberry (1999-2003)</u>		<u>Tomato (1999-2002)</u>	
	<u>CA</u>	<u>FL</u>	<u>CA</u>	<u>FL</u>
Telone® C-35/ InLine® + Metam	104.9 a	108.8a	107.0a	73.8b
MeBr/PIC	100a	100a	100a	100a

- Means followed by the same letter are not significantly different ($P \leq 0.05$, DMRT).
- For Strawberry, averages are from 4 years of trial work, 2 CA and 2 FL trials per year.
- For tomato, averages are from 3 years of trial work, 2 CA and 2 FL trials per year.

IR-4 Programs Continued...

- Primary soilborne pests in CA trials were “root nibbling” fungal pathogens, including *Rhizoctonia solani*, *Pythium* spp. and *Cylindrocarpon* spp.
- Primary pests in FL strawberry tests were sting nematode (*Belonolaimus longicaudatus*) and to a lesser extent, yellow nutsedge (*Cyperus esculentus*) and winter annual weeds.
- Primary pests in CA tomato trials were the soilborne fungal pathogens, *Verticillium dahliae* and *Fusarium oxysporum*.
- Pests in FL tomato trials were light infestations of the rootknot nematode (*Meloidogyne* spp.) and the pathogen, *Verticillium dahliae*. The primary pest problem was weeds, mainly heavy yellow nutsedge (*Cyperus esculentus*) pressure.
- Metam applied within a few hours following Telone® C-35/InLine® and either incorporated into bed tops by shallow mechanical means, or it was drip applied in ~ 1 acre inch of water

Chloropicrin + Vapam® HL Combinations in Fresh Market

Tomatoes--- Florida

- < Pest problems of particular importance in the production of tomatoes in FL include—
- The fungal pathogen *Fusarium oxysporum*, the bacterium *Ralstonia solanacearum*, the plant parasitic nematodes, *Meloidogyne* spp., *Tylenchorhynchus* spp. and *Belonolaimus* spp., and the perennial weeds *Cyperus esculentus* and *Cyperus rotundus* (Santos et al, 2005).
 - In the following trials, Chloropicrin was shank injected into pre-formed beds at 150 lbs per treated acre and followed 3-7 days later by drip-applied (2-3 tapes per bed) Vapam® HL at 75 gallons per treated acre.

Efficacy of the MeBr/PIC Alternative, Chloropicrin + Vapam® HL on *Fusarium oxysporum* and *Ralstonia solanacearum* Wilt incidence, and *Belonolaimus* spp. populations in Fresh Market Tomatoes, Bradenton, FL, Spring 2003.

	<i>Fusarium oxysporum</i> Wilt Incidence			<i>Ralstonia solanacearum</i> Wilt Incidence			<i>Belonolaimus</i> spp. Population
	<u>14WAT</u>	<u>17WAT</u>	<u>19WAT</u>	<u>14WAT</u>	<u>17WAT</u>	<u>19WAT</u>	<u>19WAT</u>
MeBr/PIC	0.0	2.5	3.8	0.0	0.0	0.0	5
CP + MS	0.0	0.0	0.0	0.0	2.5*	2.5*	1
UTC	16.3*	35.0*	35.0*	3.8*	8.8*	8.8*	15*

- **Friedman's non-parametric test (P=0.05). Values followed by * are significantly different to MeBr/PIC (P= 0.05) based on Dunnett's comparison procedures**

Efficacy of MeBr/PIC Alternative, Chloropicrin + Vapam® HL on *Tylenchorhynchus* spp. and *Belonolaimus* spp. Populations and *Cyperus* spp. Densities in Fresh Market Tomatoes, Bradenton, FL. Fall 2003

	Tylenchorhynchus	Belonolaimus	Cyperus			
	Population	Population	Density			
	11WAT	11WAT	4WAT	8WAT	11WAT	15WAT
MeBr/PIC	1.0	0.0	0.0	0.8	2.0	3.3
CP + MS	2.0	0.0	0.1	1.2	3.7	4.7
UTC	49.2*	31.0*	8.6*	39.6*	53.2*	52.0*

< Friedman's non-parametric test (P=0.05). Values followed by * are significantly different to MeBr/PIC (P= 0.05) based on Dunnett's comparison procedures.

Effect of the MeBr/PIC Alternative, Chloropicrin + Vapam® HL, on Fresh Market Tomato Marketable Yields, Bradenton, FL, Spring and Fall 2003, and Spring 2004.

	Spring 2003 Yield--- t/ha	Fall 2003 Yield--- t/ha	Spring 2004 Yield --- t/ha
MeBr/PIC	26.0	39.6	19.8
CP + MS	25.9	40.5	20.8
UTC	15.1*	16.4*	1.7*

< Friedman's non-parametric test (P=0.05). Tomato yield data by ANOV (P=0.05). Values followed by * are significantly different to MeBr/PIC (P=0.05) based on Dunnett's comparison procedure.

Importance of Delaying Metam Applications after Applying Chloropicrin Shown by Dr. Jim Gilreath in 2006 and Reported on By Paul Vaculin in 2007 (MBAO San Diego).

Details—

- < Chloropicrin shank injected into pre-formed beds at 150 lbs/treated acre, three shanks per bed Spring , 2006.
- < K-Pam® HL drip-applied at 60 gallons/treated acre at 0, 1, 2, 4, 6 and 8 days after the Chloropicrin application.
- < K-Pam® HL applied in 1 acre inch of water through 2 tapes per bed and over a period of at least 4 hrs.
- < 28 inch bed tops, 32 inches at base.
- < Bromostop VIF white on black film.
- < 6 Reps per treatment, Latin Square Design.
- < No true UTC.
- < No Crop.

K-Pam® HL Effect on Nutsedge at Varied Days after Chloropicrin Application*

Nutsedge** Evaluations 44 to 55 Days after Application

<u>K-Pam® Applic. Timing Days after Chloropicrin Application</u>	<u>Nutsedge Control Percent</u>
0	47 d
1	65 bc
2	46 d
4	52 cd
6	76 ab
8	85 a

*Dr. James P. Gilreath, University of Florida, Bradenton; Reported on by Mr. Paul Vaculin, AMVAC Chemical Corporation, 2007 MBO Conference, San Diego, CA.

**Mixed population of *Cyperus esculentus* and *Cyperus rotundus*.

Examples of Results from 3-Way Applications Using Precision Placement Equipment

Pepper / Dr. Stanley Culpepper University of GA 2006/2007 Trial

Treatments

- **3-Way----- Telone II applied at 10 G/A + Chloropicrin applied at 146 lbs/A + Vapam® HL applied at 75 G/A, LDPE Mulch.**
- **Midas ---- Midas applied at 171 lbs/A, Blockade VIF Mulch**
- **Standard -- MeBr/PIC (57:43) applied at 443 lbs/A, LDPE Mulch**
- **UTC ----- Untreated Control.**

Application Information: < Fumigants were applied, beds were formed, and mulch was laid within minutes of one another.

< Telone II applied by Yetter applicator 10-12 inches deep.

< MB/PIC, Midas and PIC applied by super bedder plastic layer and injected 8 inches deep with 3 knives on a 32 inch bed tops.

< Vapam® HL injected 4 inches deep, knives 4 inches apart using precision application equipment (“Culpepper Rig”).

Weed Control Results

Pepper / Dr. Stanley Culpepper University of GA 2006/2007 Trial

Primary weeds were *Cyperus esculentus* and *Sida rhombifolia*. Each of the above fumigant treatments gave comparable and excellent control of both weeds.

	<u>Total Value/A Harvested Crop</u>	<u>Fumigant/Mulch Cost</u>
MeBr/PIC	\$12,056 a	\$1,184 b
Midas	\$11,484 a	\$1,515 a
3-Way	\$11,155 ab	\$764 c

Fall Weed Control in Double Cropped Cucurbits (Squash and Cucumber) Following 2 and 3-Way Combinations in Spring-Treated Tomato and Eggplant

Dr. Stanley Culpepper, University of GA, Spring/Fall 2007

Selected Treatments

UTC --- Mulched with LDPE

2-Way -- Pic Chlor 60 at 21 G/A + Vapam® HL 75 G/A -- LDPE

3-Way --- Telone II at 12 G/A + Chloropicrin at 150 lbs/A + Vapam® HL at 75 G/A – LDPE

Application Information

Applications of fumigants same as in pepper test discussed above.

Applied in tomato and eggplant February 26, 2007.

Double Cropped Cucurbits/ Fall 2007/ Dr. Culpepper

	Cantaloupe % Injury <u>9/1/07*</u>	Cucumber % Injury <u>9/1/07*</u>	<i>Cyperus rotundus</i> % Control <u>9/1/07*</u>	<i>Cyperus rotundus</i> # / Plot <u>9/7/07*</u>
UTC/LDPE --	0.0 a	0.0 a	0 d	596 a
2-Way -----	0.0 a	0.0 a	92 a	26 b
3-Way -----	0.0 a	0.0 a	88 ab	39 b

* Applied February 26, 2007 in tomato and eggplant.

Note: Sandea overspray cleaned up escaping *Cyperus* without injuring cucurbits.

What has been learned?

- < Full labeled rates of Vapam HL (75 Gallons/Treated Acre) K-Pam® HL (60 Gallons/Treated Acre) are needed for optimal performance.
- < In tomatoes, in Florida where *Cyperus* spp pressure was heavy, the Telone® C-35/InLine® + Vapam® HL treatments evaluated were not consistently adequate for yields equivalent to MeBr/PIC.
- < The treatments evaluated by IR-4 were adequate for strawberry in CA and in FL, and in tomato in CA where soilborne diseases were the primary pests.
- < Getting uniform distribution of Metam across bed tops in drip applications is difficult, often resulting in poor or no control of *Cyperus* spp on bed shoulders.
- < Delaying Metam applications after Chloropicrin or Telone®C-35/InLine results in improved efficacy, especially against *Cyperus* spp.

Continued...

- < Using drip-applications of the full labeled rate of Vapam® HL (75 gallons/treated acre) 5-7 days after applying Chloropicrin in beds at 150 lbs per treated acre can control the major pests of tomatoes in FL and produce tomato yields equal to MeBr/PIC.
- < Concentrating Vapam®/K-Pam® in the top 4 inches of bed and applying uniformly across bed tops results in significantly improved efficacy. This benefit is achieved by using precision application equipment.
- < Use of selective herbicides (Sandea, Envoke in mulched vegetables or Goal in strawberries) may be needed to augment weed control for results comparable to MeBr/PIC

Pros and Cons of Vapam® HL/K-Pam® HL Two and Three Way Combinations as MeBr Alternatives

Pros

- < Efficacy against pests controlled by MeBr generally as effective.**
- < Drip-application technology now widely adapted in US specialty crops making sequential drip treatments practical.**
- < New precision placement equipment (i. e. “Mirruso Rig”, and variations thereof”) now in place and gaining wide-scale popularity and acceptance.**
 - an estimated 40-50% of 2008 GA Spring Vegetable Crop used 2 and 3-Way Treatments of Dr. Culpepper, U of GA.**
- < New precision placement equipment fits seep irrigation culture in FL.**
- < Economics, Economics, Economics.**
- < Can use LDPE vs. VIF, resulting in one mulching for several crops with LDPS vs. one crop for VIF. VIF is relatively costly. Again—Economics.**

Pros and Cons of Vapam® HL/K-Pam® HL Two and Three Way Combinations as MeBr Alternatives

Cons

- < Not as “forgiving” as MeBr/PIC.
- < Psychological effects against change.
- < Drip applications frequently miss *Cyperus* spp on bed shoulders.
- < Additional cost of drip tapes for drip application.
- < Precision planting a must with multiple drip-tapes per bed.
- < Squeezed planting interval if Vapam®/K-Pam® is delayed in drip-applications.

THANK YOU