METHYL BROMIDE CRITICAL USE NOMINATION FOR PREPLANT SOIL USE FOR PEPPERS GROWN IN OPEN FIELDS ON PLASTIC TARPAULINS

FOR ADMINISTRATIVE PURPOSES ONLY: **DATE RECEIVED BY OZONE SECRETARIAT:** ***YEAR:*** ***CUN:***

NOMINATING PARTY:	The United States of America
BRIEF DESCRIPTIVE TITLE OF NOMINATION:	Methyl Bromide Critical Use Nomination for Preplant Soil Use for Peppers Grown in Open Fields on Plastic Tarpaulins (Prepared in 2005)

NOMINATING PARTY CONTACT DETAILS

Contact Person:	John E. Thompson, Ph. D.
Title:	International Affairs Officer
Address:	Office of Environmental Policy U.S. Department of State 2201 C Street N.W. Room 4325 Washington, DC 20520 U.S.A.
Telephone:	(202) 647-9799
Fax:	(202) 647-5947
E-mail:	ThompsonJE2@state.gov

Following the requirements of Decision IX/6 paragraph (a)(1), the United States of America has determined that the specific use detailed in this Critical Use Nomination is critical because the lack of availability of methyl bromide for this use would result in a significant market disruption.

☐ Yes ☐ No

__________________ __________________ __________________

Signature Name Date

Title: ____________________________________

CONTACT OR EXPERT(S) FOR FURTHER TECHNICAL DETAILS

Contact/Expert Person:	Steve Knizner
Title:	Acting Division Director
Address:	Biological and Economic Analysis Division Office of Pesticide Programs U.S. Environmental Protection Agency Mail Code 7503C Washington, DC 20460 U.S.A.
Telephone:	(703) 305-6903
Fax:	(703) 308-8090
E-mail:	Knizner.steve@epa.gov

LIST OF DOCUMENTS SENT TO THE OZONE SECRETARIAT IN OFFICIAL NOMINATION PACKAGE

List all paper and electronic documents submitted by the Nominating Party to the Ozone Secretariat

1. PAPER DOCUMENTS: **Title of Paper Documents and Appendices**	**Number of Pages**	**Date Sent to Ozone Secretariat**

2. ELECTRONIC COPIES OF ALL PAPER DOCUMENTS: **Title of Electronic Files**	**Size of File (kb)**	**Date Sent to Ozone Secretariat**

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PART A: SUMMARY

1. NOMINATING PARTY:

The United States of America (U.S.)

2. DESCRIPTIVE TITLE OF NOMINATION

Methyl Bromide Critical Use Nomination for Preplant Soil Use for Peppers Grown in Open Fields on Plastic Tarpaulins (Prepared in 2005)

3. CROP AND SUMMARY OF CROP SYSTEM

Peppers grown in Alabama, Arkansas, California, Florida, Georgia, Kentucky, Louisiana, Michigan, North Carolina, South Carolina, Tennessee, and Virginia. These crops are grown in open fields on plastic tarps, often followed by various other crops. Harvest is destined for the fresh market**.**

4. METHYL BROMIDE NOMINATED

TABLE 4.1: METHYL BROMIDE NOMINATED

YEAR	NOMINATION AMOUNT (KG)	NOMINATION AREA (HA)
2007	**1,151,751**	**7,343**

- This amount includes 2,844 kg for research.

5. BRIEF SUMMARY OF THE NEED FOR METHYL BROMIDE AS A CRITICAL USE:

The U.S. nomination is only for those areas where the alternatives are not suitable. In U.S. pepper production there are several factors that make the potential alternatives to methyl bromide unsuitable. These include:

- Pest control efficacy of alternatives: the efficacy of alternatives may not be comparable to methyl bromide in some areas, making these alternatives technically and/or economically infeasible for use in pepper production.
- Geographic distribution of key target pests: i.e., some alternatives may be comparable to methyl bromide as long as key pests occur at low pressure, and in such cases the U.S. is only nominating a CUE for peppers where the key pest pressure is moderate to high such as nutsedge in the Southeastern U.S..
- Regulatory constraints: e.g., 1,3 D use is limited in Georgia and Florida due to the presence of karst geology.
- Potential delay in planting and harvesting: e.g., the plant-back interval for 1,3 D + Chloropicrin may be up to two weeks longer than methyl bromide + chloropicrin. In Michigan an additional delay would occur because soil temperature must be higher to fumigate with alternatives. Delays in planting and harvesting may result in users missing key market windows, and adversely affect revenues through lower prices.

Michigan, California, Florida, Southeastern U.S. (except Georgia and Florida) are each presented as separate regions in this nomination to reflect the separate applications from growers in these areas. A brief description of their need for MB follows, also presented on a regional basis.

Michigan

The key pest of peppers in Michigan is the soil fungi *Phytophthora capsici*, which can easily destroy the entire harvest from affected areas if left uncontrolled. While 1,3-D + chloropicrin provided some control in small plot trials with peppers and other vegetable crops in Michigan (Hausbeck and Cortright 2003), the level of control was lower than that afforded by MB. *P. capsici* has recently been shown to also occur in irrigation water in Michigan (Gevens and Hausbeck 2003). This will increase the likelihood of spread of this pathogen. It is also not yet clear whether these small-scale research results accurately reflect efficacy of MB alternatives in pepper production. Furthermore, regulatory restrictions due to concerns over human exposure and ground water contamination, along with technical limitations, result in potential economic infeasibility of this formulation as a MB alternative. Among the more important ones are a potential delay in planting as long as 28 days, (which could lead to missing a key market window) due to label restrictions and low soil temperatures, and a mandatory 30 meter buffer for treated fields near inhabited structures.

Based on the small-plot trial conducted on Michigan peppers (cited above), the best-case yield loss estimate for Michigan using the best available MB alternative (1,3-D + chloropicrin) was estimated to be 6 %, based on plant loss. In a second trial undertaken by Hausbeck and Cortright (2004), yields from pepper plots treated with metam potassium, alone or in combination with chloropicrin, and from plots treated with 1,3-D + chloropicrin were comparable to yields from plots treated with MB + chloropicrin and yields from untreated (control plots). These results Likely indicate a very low pest pressure in all treated and control plots.

Michigan pepper farmers requesting MB must plant by the first week of May to capture an early market window. Soil fumigation must therefore be completed by mid April to allow 14-21 days for aeration. However, 1,3-D and metam labels recommend that applications be made when soil temperatures (at application depth) are above 4.4°C. Furthermore, optimum soil temperatures for 1,3-D are in the 10°C - 25°C range (University of California, Davis, undated). Since soil temperatures in Michigan do not climb over 10°C until after mid to late May (Schaetzl and Tomczak, 2001), neither 1,3-D nor metam products can be used effectively for early pepper planting in Michigan. Metam products have the additional disadvantage that when the soil is wet and cold (below 15°C), the minimum recommended plant back period is 30 days, which would push the crop beyond the early market window.

California

The California peppers situation is similar to Michigan's in that the critical pest controlled by MB is *P. capsici*. The other important pest targeted by MB use in this region is the root knot nematode. California is requesting MB for about 10 % of its pepper area, mainly along the coast. As in Michigan, climatological conditions in these coastal areas - primarily long periods of rainy, cloudy weather – exacerbate problems involving the use of MB alternatives, particularly formulations of 1,3 D, which cannot be used when soils are very wet. Growers are also reporting lack of efficacy against both of these pests at the maximum label rates for this alternative. In addition, California has township caps that limit the amount of 1,3-D that can be applied in a given area, as well as 100 meter buffer zones near inhabited structures. Urban encroachment is increasing dramatically in California coastal counties, making the buffer zone requirement more prevalent. These conditions are present in the 10% of California pepper production area that need MB.

Southeastern United States (Including Florida and Georgia)

In the Southeastern United States, including Florida and Georgia, MB is requested primarily for control of moderate to severe infestations of nutsedge weeds. *P. capsici* is also an important pest targeted currently with MB in these regions. Many growers also use MB against root-knot nematodes. Left uncontrolled, any of these pests could completely destroy the harvests from affected areas.

Of currently available MB alternatives, metam-sodium offers inconsistent control of nutsedges and nematodes, while 1,3-D + chloropicrin provides adequate control of nematodes and disease (Locascio et al. 1997, Eger 2000, Noling et al. 2000). However, metam-sodium has yield losses of up to 44 % compared to MB where weed infestations are moderate to severe (Locascio et al. 1997). Metam-sodium also creates a planting delay as long as 30 days to avoid risk of phytotoxic injury to crops compared to a 14-day delay for MB. Furthermore, due to regulatory restrictions resulting from groundwater contamination concerns, 1,3-D + chloropicrin cannot be used in large portions of the southeastern United States due to the presence of karst geology, and anywhere in Dade County, Florida, where the majority of that region's peppers are grown. There is also a 28 day planting delay due to regulatory restrictions for 1,3-D + chloropicrin. In Florida particularly, growers are on a tight production schedule and must place pepper transplants in fields at a certain time of the year (see Table 11.2 in the Florida section for details). Relying only on metam sodium for preplant treatment would force growers to fumigate earlier in their season, which in turn would extend the fumigation schedule into rainy periods. Growers would have to fumigate earlier to avoid rain and lose a portion of the crop (Aerts, 2004).

Furthermore, trials of metam-sodium and 1,3 D + chloropicrin (and various combinations thereof) are based on small plot research trials conducted in the Southeastern United States on crops other than peppers. For fungi and nutsedge, no on-farm, large-scale trials have yet been done. Some researchers have also reported that these MB alternatives degrade more rapidly in areas where they are applied repeatedly due to enhanced metabolism by soil microbes (Dungan and Yates 2003, Gamliel et al. 2003). This may compromise long-term efficacy of these compounds and appears to need further scientific scrutiny.

In a recent field study conducted in Tifton, Georgia by Culpepper and Langston (2004), 1,3-D + chloropicrin, followed by more chloropicrin, was more effective than MB against yellow nutsedge, but less effective against purple nutsedge. Although this treatment performed as well as MB in terms of spring pepper yield, its fall yield performance was inferior to that of MB.

In a second treatment, 1,3-D by itself, followed by chloropicrin, was significantly less effective than methyl bromide for the control of both purple and yellow nutsedge, but as effective as MB for the control soil nematodes. In terms of spring and fall pepper yield, however, this treatment performed as well as MB.

In a third treatment, 1,3-D + chloropicrin, followed by metam sodium, was as effective as MB against yellow nutsedge, 36% less effective than MB against purple nutsedge, and as effective as MB for the control of soil nematodes. This treatment also performed as well as MB in terms of both spring and fall pepper yield.

Although these combinations are showing promise, they will require further testing and validation.

In sum, although promising, these MB alternatives require further testing and validation at the commercial level before being available for adoption by pepper growers. Threfore, MB remains a critical use for peppers in the United States.

TABLE A.1: EXECUTIVE SUMMARY.

Region	*Michigan*	*Southeastern U.S. except Georgia and Florida*	*Georgia*	*Florida*	*California*
AMOUNT OF APPLICANT REQUEST					
2007 Kilograms	15,195	240,086	347,183	1,415,207	136,078
AMOUNT OF NOMINATION*					
2007 Kilograms	11,396	66,089	178,778	880,121	12,522

**See Appendix A for a complete description of how the nominated amount was calculated.*

6. SUMMARIZE WHY KEY ALTERNATIVES ARE NOT FEASIBLE:

For Michigan pests 1,3 D + chloropicrin is the only key alternative with efficacy comparable to MB. Regulatory restrictions due to human exposure concerns, combined with technical limitations, reduce its use. Key among these factors are a potential delay in planting as long as 28 days, due both to label restrictions and low soil temperatures, and mandatory 30 to 100 meter buffers for treated fields near inhabited structures.

For the Southeastern United States, including Florida and Georgia, an application of 1,3-D + chloropicrin (Telone C35), along with a herbicide mix (e.g. clomazone + metolachlor) applied at bed formation, or Telone C35 followed by a chloropicrin or a metam application, may be the best available BM alternatives outside karst geology areas. In karst geology areas, including 31 counties in Florida, where Telone use is highly restricted, metam sodium or metam potassium remain at present the best alternatives. Although promising, these alternatives will require further testing and validation on commercial fields.

There is evidence that the efficacy of metam-sodium declines in areas where it is repeatedly applied due to enhanced degradation of methyl isothiocyanate, the active ingredient, by soil microbes (Ashley et al. 1963, Ou et al. 1995, Verhagen et al. 1996, Gamliel et al. 2003).

All other available MB alternatives are currently technically infeasible for U.S. peppers.

7. (*i*) PROPORTION OF CROPS GROWN USING METHYL BROMIDE

TABLE 7.1: PROPORTION OF CROPS GROWN USING METHYL BROMIDE

REGION WHERE METHYL BROMIDE USE IS REQUESTED	TOTAL CROP AREA IN 2003 (HA)	PROPORTION OF REQUEST FOR METHYL BROMIDE (%)
Michigan	816	16
Southeastern U.S. except Georgia and Florida	5806	16
Georgia	2889	79
Florida	7893	100
California	10659	7
NATIONAL TOTAL*	24954	50

** Includes States not requesting MB.*

7. (*ii*) IF ONLY PART OF THE CROP AREA IS TREATED WITH METHYL BROMIDE INDICATE THE REASON WHY METHYL BROMIDE IS NOT USED IN THE OTHER AREA AND IDENTIFY WHAT ALTERNATIVE STRATEGIES ARE USED TO CONTROL THE TARGET PATHOGENS AND WEEDS WITHOUT METHYL BROMIDE THERE.

In Michigan, areas not treated apparently do not have any infestation (i.e., zero oospores per unit soil) of the key fungal pests. Applicant states that soil infestation is spreading in the region annually. In California, areas where MB is not used rely on 1,3D + chloropicrin and post-emergence fungicides to control the same pests.

In southeastern U.S., Florida, and Georgia, areas not treated do not have nutsedges or nematodes naturally present in pepper fields. Simple absence of all pests is the only reason these areas are not presently treated with MB.

7. (*iii*) WOULD IT BE FEASIBLE TO EXPAND THE USE OF THESE METHODS TO COVER AT LEAST PART OF THE CROP THAT HAS REQUESTED USE OF METHYL BROMIDE? WHAT CHANGES WOULD BE NECESSARY TO ENABLE THIS?

No. For further discussion of limitations please see Part 5 (above), and the region-specific discussions below.

8. AMOUNT OF METHYL BROMIDE REQUESTED FOR CRITICAL USE

TABLE 8.1: AMOUNT OF METHYL BROMIDE REQUESTED FOR CRITICAL USE

REGION:	Michigan	Southeastern U.S. except Georgia and Florida	Georgia	Florida	California
YEAR OF EXEMPTION REQUEST	**2007**	**2007**	**2007**	**2007**	**2007**
KILOGRAMS OF METHYL BROMIDE	15,195	240,086	347,183	1,415,207	136,078
USE: FLAT FUMIGATION OR STRIP/BED TREATMENT	Strip/Bed	Strip/Bed	Strip/Bed	Strip/Bed	Flat
FORMULATION *(ratio of methyl bromide/chloropicrin mixture)* TO BE USED FOR THE CUE	67:33 or 50:50	67:33	67:33	Mostly 67:33	67:33
TOTAL AREA TO BE TREATED WITH THE METHYL BROMIDE OR METHYL BROMIDE/CHLOROPICRIN FORMULATION *(ha)*	127	1,599	2,312	8,417	759
DOSAGE RATE* *(g/m^2)* OF **ACTIVE INGREDIENT** USED TO CALCULATE REQUESTED KILOGRAMS OF METHYL BROMIDE	12.0	15.0	15.0	16.8	17.9

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9. SUMMARIZE ASSUMPTIONS USED TO CALCULATE METHYL BROMIDE QUANTITY NOMINATED FOR EACH REGION:

The amount of methyl bromide nominated by the U.S. was calculated as follows:

- The percent of regional hectares in the applicant's request was divided by the total area planted in that crop in the region covered by the request. Values greater than 100 percent are due to the inclusion of additional varieties in the applicant's request that were not included in the USDA. National Agricultural Statistics Service surveys of the crop.
- Hectares counted in more than one application or rotated within one year of an application to a crop that also uses methyl bromide were subtracted. There was no double counting in this sector.
- Growth or increasing production (the amount of area requested by the applicant that is greater than that historically treated) was subtracted. The three applicants that included growth in their request had the growth amount removed.
- Quarantine and pre-shipment (QPS) hectares is the area in the applicant's request subject to QPS treatments. Not applicable in this sector.
- Only the acreage experiencing one or more of the following impacts were included in the nominated amount: moderate to heavy key pest pressure, regulatory impacts, karst geology, buffer zones, unsuitable terrain, and cold soil temperatures.

MICHIGAN - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE

MICHIGAN - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

MICHIGAN - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST

REGION WHERE METHYL BROMIDE USE IS REQUESTED	KEY DISEASE(S) AND WEED(S) TO GENUS AND, IF KNOWN, TO SPECIES LEVEL	SPECIFIC REASONS WHY METHYL BROMIDE IS NEEDED
Michigan	Crown and root rots caused by soil-borne fungus *Phytophthora capsici*.	Fumigation operations need to be completed by the first week of May to allow growers to plant early and capture the early market for premium prices, as well as ensuring demand for their crop during the entire growing season (especially during the mid and late season).

MICHIGAN - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE

MICHIGAN - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	MICHIGAN
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Pepper transplants for fruit production
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual; generally 1 year
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Pepper – usually followed by an eggplant or pepper crop
SOIL TYPES: *(Sand, loam, clay, etc.)*	Sandy loam; clay loam
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	1 time every 2 years
OTHER RELEVANT FACTORS:	Key marketing opportunities have been established with Michigan's vegetable crop diversification and aims toward stable demands in the late spring and through the summer for Midwestern markets.

MICHIGAN - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE FOR PEPPERS

	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
CLIMATIC ZONE	USDA Plant Hardiness zone 5b											
SOIL TEMP. *(℃)*	<10	10 - 15	15-20	20-25	20-25	20-25	20	10-15	<10	<10	<10	<10
RAINFALL *(mm)*	40	72	101	48	47	32	17	31	36	20	6	8
OUTSIDE TEMP. *(℃)*	0.2	7.4	12.1	17.5	20.6	20.9	18.1	8	2.4	-2.9	-8	-7
FUMIGATION SCHEDULE		X										
PLANTING SCHEDULE			X									
KEY MARKET WINDOW					X	X	X	X				

MICHIGAN– 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Michigan experiences heavy rainfall events across the entire state at any given moment of the growing season. Heavy rain events (over 25 mm) can trigger rapid root and crown rot development, and promote dissemination of *P. capsici* via irrigation sources (Gevens and Hausbeck 2003). Generally, there is no difference in the amount of infection depending on soil type. The pathogen is widespread and indigenous on almost all soil types in Michigan (Cortright 2003, Gevens and Hausbeck 2003).

Significant rainfall events (>25 mm) or cold soil temperatures (<4.4 °C) delay fumigation and planting with the MB alternatives 1, 3 D + chloropicrin and metam-sodium. Also, all fumigation practices need to be completed by the first week of May to allow growers to plant early and capture the early market (July-September).

MICHIGAN - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

Growers are using anti-drip valves to eliminate loss of MB at the end of rows when the machinery is removed from the ground. Michigan's use of MB for vegetable production has declined steadily since the mid-1990s, when growers switched to different application methods (i.e. from Flat Fumigation to tarped beds) and formulations (from 98 % MB to 67 % MB). Currently, all MB is applied to tarped beds, with 100% of low-density polyethylene sheeting and 95% of the acreage was treated with the 67:33 formulation. Since 2000, about 5% of the acreage has been treated with the 50:50 formulation of methyl bromide and chloropicrin.

Please see Table 12.1 for further information.

MICHIGAN - TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE ON PEPPERS

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	1998	1999	2000	2001	2002	2003
AREA TREATED *(hectares)*	96	98	117	126	135	128
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED USE IF STRIP TREATMENT IS USED	No pepper area in Michigan uses flat fumigation application.					
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED *(total kilograms)*	11,482	11,747	14,001	15,618	16,230	15,391
FORMULATIONS OF METHYL BROMIDE *(methyl bromide /chloropicrin)* [A]	67:33	67:33	67:33 or 50:50	67:33 or 50:50	67:33 or 50:50	67:33 or 50:50
METHODS BY WHICH METHYL BROMIDE APPLIED	Injected 20-25 cm	Injected 20-25 cm	Injected 20-25 cm	Injected 20-25 cm	Injected 20-25 cm	Injected 20-25 cm
DOSAGE RATE* (KG/HA) FOR THE ACTIVE INGREDIENT	12.0	12.0	12.0 or 8.9	12.0 or 8.9	12.0 or 8.9	12.0 or 8.9

[A] Growers have just started switching to the 50/50 formulation of MB/Chloropicrin since 2000 (about 5% of production acreage) to reduce cost per acre.

MICHIGAN – PART C: TECHNICAL VALIDATION -PEPPERS

MICHIGAN - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

MICHIGAN – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE
CHEMICAL ALTERNATIVES		
Metam-sodium or Metam-potassium	Pepper farmers requesting MB must plant by the first week of May to capture an early market window. Soil fumigation must therefore be completed by mid April to allow 14-21 days for aeration. However, metam labels recommend that applications be made when soil temperatures (at application depth) are above 4.4°C. Since soil temperatures in Michigan do not climb over 10°C until after mid to late May (Schaetzl and Tomczak, 2001), metam products cannot be used effectively for early pepper planting in Michigan. Metam products have the additional disadvantage that when the soil is wet and cold (below 15°C), the minimum recommended plant back period is 30 days, which would further move the crop beyond the early market window. In addition, control of the key pest is inconsistent (Locascio et al. 1997, Martin 2003). Gilreath et al. (1994) found that metam-sodium treatments did not match MB in terms of plant vigor at the end of the season; *P. capsici* was, however, not present. In the cool conditions of Michigan, metam-sodium is likely to be slow to transform into the active ingredient (methyl isothiocyanate), which also suggests that pest control will not be as effective as with MB (Ashley et al. 1963). In a recent study conducted in Oceana County, Michigan by Hausbeck and Cortright (2004), yields from pepper plots treated with metam potassium (K-Pam) were comparable to yields from control plots and plots treated with MB + chloropicrin, indicating e a very low pest (*P. capsici*) pressure at the test site.	No
NON CHEMICAL ALTERNATIVES		
Soil solarization	Michigan's climate is typically cool (often less than 11 °C through May) and cloudy, particularly early in the growing season when control of the key pests is especially important. In Michigan, the growing season is short (May to September), and the time needed to utilize solarization is likely to render the subsequent growing of crops impossible, even if it did somehow eliminate all fungal pathogens. Since solarization has shown promise in other crops and regions (e.g., tomatoes in Florida), the potential for adoption exists (Schneider et al. 2003). However, because of climate, solarization is not feasible in Michigan.	No
Steam	While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open field pepper crops in Michigan. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No

Name of Alternative	**Technical and regulatory* reasons for the alternative not being feasible or available**	**Is the alternative considered cost effective**
Biological Control	Biological control agents are not technically feasible alternatives to MB because they alone cannot control the soil pathogens that afflict peppers in Michigan. The bacterium *Burkholderiaia cepacia* and the fungus *Gliocladium virens* have shown some potential in controlling some fungal plant pathogens (Larkin and Fravel 1998). However, in a test conducted by the Michigan applicants, *P. capsici* was not controlled adequately in summer squash by either of these beneficial microorganisms.	No
Cover crops and mulching	There is no evidence these practices effectively substitute for the control MB provides against *P. capsici*. Control of *P.capsici* is imperative for pepper production in Michigan. Plastic mulch is already in widespread use in Michigan vegetables, and regional crop experts state that it is not an adequate protectant when used without MB. The longevity and resistance of *P. capsici* oospores renders cover crops ineffective as a management alternative to MB.	No
Crop rotation and fallow land	The crop rotations available to growers in Michigan region are also susceptible to these fungi, particularly to *P. capsici*. Fallow land can still harbor *P. capsici* oospores (Lamour and Hausbeck 2003). Thus fungi would persist and attack peppers if crop rotation/fallow land was the main management regime.	No
Endophytes	Though these organisms (bacteria and fungi that grow symbiotically or as parasites within plants) have been shown to suppress some plant pathogens in cucumber, there is no such information for the other pepper crops grown in Michigan. Furthermore, the pathogens involved did not include *Phytophthora* species, which are arguably the greatest single threat to Michigan peppers.	No
Flooding/Water management	Flooding is not technically feasible as an alternative because it does not have any suppressive effect on *P. capsici* (Allen et al. 1999), and is likely to be impractical for Michigan pepper growers. It is unclear whether irrigation methods in this region could be adapted to incorporate flooding or alter water management for pepper fields. In any case, there appears to be no supporting evidence for its use against the hardy oospores of *P. capsici*.	No
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/plug plants.	Due to the paucity of scientific information on the utility of these alternatives as MB replacements in peppers, they have been grouped together for discussion in this document. There are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major pepper pests. Grafting and plant breeding are thus also rendered technically infeasible as MB alternatives for control of *Phytophthora* fungi. Soilless culture, organic production, and substrates/plug plants are also not technically viable alternatives to MB for fungi. One of the fungal pests listed by Michigan can spread through water (Gevens and Hausbeck 2003), making it difficult to keep any sort of area (with or without soil) disease free. Various aspects of organic production - e.g., cover crops, fallow land, and steam sterilization - have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
Combinations of Alternatives		

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE
Metam sodium or metam potassium + Chloropicrin	Pepper farmers requesting MB must plant by the first week of May to capture an early market window. Soil fumigation must therefore be completed by mid April to allow 14-21 days for aeration. However, metam labels recommend that applications be made when soil temperatures (at application depth) are above 4.4°C. Since soil temperatures in Michigan do not climb over 10°C until after mid to late May (Schaetzl and Tomczak, 2001), metam products cannot be used effectively for early pepper planting in Michigan. Metam products have the additional disadvantage that when the soil is wet and cold (below 15°C), the minimum recommended plant back period is 30 days, which would further move the crop beyond the early market window. In addition, trials in tomato have shown inconsistent efficacy of this formulation against fungal pests, though it is generally better than metam-sodium alone (Locascio and Dickson 1998, Csinos et al. 1999). These studies apparently did not measure yield impacts, and did not involve peppers. Hausbeck and Cortright (2004) evaluated several soil fumigants for control of *P. capsici* on several vegetable crops, including peppers, in Michigan. Results show that yields from pepper plots treated with metam potassium + chloropicrin were comparable to yields from control plots and from plots treated with MB + chloropicrin. These results point to a very low pest pressure in the study area. Further studies are necessary to clearly identify MB alternatives.	No
1,3 dichloropropene + chloropicrin	Regulatory restrictions and Michigan's cool and wet soils may result in a delay of up to 28 days in planting after treatment with this combination. This delay could result in growers missing key market windows, with consequent negative economic impacts (detailed in other sections below). In a small plot study conducted in Michigan by Hausbeck and Cortright (2004) pepper yields from plots treated with 1,3-D + chloropicrin were comparable to yields from control plots and plots treated with MB + chloropicrin. These results seem to indicate a very low pest (*P. capsici*) pressure at the test site. Further studies are necessary to clearly identify MB alternatives.	No
1,3 dichloropropene + Metam-sodium	Trials in tomato have shown inconsistent efficacy of this combination against fungal pests, though it is generally better than metam-sodium alone (Csinos et al. 1999). Low efficacy in even small-plot trials indicates that this is not a technically feasible alternative for commercially produced peppers in Michigan at this time. These studies apparently did not measure yield impacts, and did not involve peppers.	No

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

MICHIGAN - 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

Table 14.1 Technically Infeasible Alternatives Discussion.

NAME OF ALTERNATIVE	DISCUSSION
None	Other than those options discussed elsewhere, no alternatives exist for the control of the key pests when they are present in the soil and/or afflict the belowground portions of pepper plants. A number of effective fungicides are available for treatment of these fungi when they infect aerial portions of crops. However, these infections are not the focus of MB use, which is meant to keep newly planted transplants free of these fungi.

Michigan 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

MICHIGAN – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Methyl iodide	Not registered in the U.S. for peppers, although registration is being pursued for tomatoes, strawberries, peppers, and ornamental crops.	Yes	Unknown
Furfural	Not registered in the U.S. for peppers. Registration is currently being pursued only for non-food greenhouse uses.	No (for peppers)	Unknown
Sodium azide	Not registered. No registration requests submitted to U.S.	No (for any crop/commodity)	Unknown
Propargyl bromide	Not registered. No registration requests submitted to U.S.	No (for any crop/commodity)	Unknown

MICHIGAN - 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED:

Michigan pepper farmers requesting MB must plant by the first week of May to capture an early market window. Soil fumigation must therefore be completed by mid April to allow 14-21 days for aeration. However, 1,3-D and metam labels recommend that applications be made when soil temperatures (at application depth) are above 4.4°C. Furthermore, optimum soil temperatures for 1,3-D are in the 10°C - 25°C range (University of California, Davis, undated). Since soil temperatures in Michigan do not climb over 10°C until after mid to late May (Schaetzl and Tomczak, 2001), neither 1,3-D nor metam products can be used effectively for early pepper planting in Michigan. Metam products have the additional disadvantage that when the soil is wet and cold (below 15°C), the minimum recommended plant back period is 30 days, which would push the crop beyond the early market window.

Few studies have focused on peppers in Michigan's growing conditions. A recent study, conducted in Oceana County, Michigan by Hausbeck and Cortright (2004), was undertaken to evaluate soil fumigants for managing *P. capsici* on several solanaceous and cruciferous crops. Results, however, show that yields from pepper plots treated with metam potassium (K-Pam), alone or in combination with chloropicrin, and from plots treated with 1,3-D + chloropicrin (Telone C35) were comparable to yields from plots treated with MB + chloropicrin and to yields from control plots. These results seem to indicate a very low pest pressure in treated and control plots. However, with the best available MB alternative, revenue losses would be possible from planting delays and missing of key market windows.

In studies with other vegetable crops, 1,3 D + chloropicrin has generally shown better control of fungi than metam-sodium formulations, although still not as good as control with MB. For example, in a study using a bell pepper/squash rotation in small plots - conducted in the much warmer conditions of Georgia and without *P. capsici* as a component of the pest complex - Webster et al. (2001) found significantly lower fungal populations with 1,3 D + 35 % chloropicrin (drip irrigated or chisel injected, 146 kg/ha of 1,3 D), as compared to the untreated control. However, MB (440 kg/ha, shank-injected) lowered fungal populations even more. Methyl iodide had no significant suppressive effect, as compared to the untreated control. In another study, conducted on tomatoes in Florida, Gilreath et al. (1994) found that metam-sodium treatments did not match MB in terms of plant vigor at the end of the season. *P. capsici* was not present.

MICHIGAN – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 dichloropropene + Chloropicrin	*P. capsici*	0 – 6 % PLUS loss of revenue due to planting delays	6 % loss of revenue due to planting delays
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**6 % likely with the best alternative (1,3 D + chloropicrin)**

MICHIGAN - 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?

The critical use exemption applicant states that 1,3 D + chloropicrin, metam-sodium, methyl iodide, chloropicrin, and chloropicrin/metam sodium will continue to be subjects of field studies of utilization and efficacy enhancement where *P. capsici* fungi are the target pests. Most of these alternatives are not currently registered for peppers, and there are presently no commercial entities pursuing registration in the United States. The regulatory restrictions on 1,3-D discussed elsewhere will adversely influences the economics of this MB alternative. The timeline for developing the above-mentioned MB alternatives in Michigan is as follows:
2003 – 2005: Test for efficacy of identified alternatives.
2005 – 2007: Establish on-farm demonstration plots for effective MB alternatives.
2008 – 2010: Work with growers to implement widespread commercial use of effective alternatives.

Research is also under way to optimize the use of a 50 % MB: 50 % chloropicrin formulation to replace the currently used 67:33 formulation. In addition, field research is being conducted to optimize a combination of crop rotation, raised crop beds, black plastic, and foliar fungicides. Use of virtually impermeable film (VIF) will also be investigated as a replacement for the currently used low-density polyethylene (LDPE).

MICHIGAN - 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?

No. Soilless systems and greenhouse production are not in use for peppers in this region, and quick adoption is probably economically infeasible. Growers apply MB on fields with a history of fungal contamination, but it appears that most growing acreage in this region has moderate to severe infestations of *P. capsici* and other soil borne fungi, which thrive in cool and moist climates.

MICHIGAN - SUMMARY OF TECHNICAL FEASIBILITY

Based on the new trials conducted in vegetable crops in Michigan in 2003 (described above in Section 16), EPA has determined that only 1,3 D + chloropicrin has some technical feasibility against the key pest of peppers in this region.

Available studies in vegetable crops in the U.S. indicate that 1,3 D + chloropicrin has some technical feasibility against the key pest of peppers in this region. However, no large-plot studies have yet been performed to show commercial feasibility. Demonstration studies are planned (see Section 17 above). Important regulatory constraints on 1,3 D must also be kept in mind: a 7- 28 day planting delay, mandatory 30 m buffers near inhabited structures – both of which will cause negative economic impacts that make the use of these MB alternatives infeasible. There is also potentially lower dissipation (and thus efficacy) of these compounds in the cool, wet soils of this region. These planting restrictions may thus be important factors inhibiting widespread grower adoption of this MB alternative. Potential yield losses associated with plant restrictions could be exacerbated because fumigation practices need to be completed by the first week of May to allow growers to plant early and capture the early market (July – September) and have their product available for premium prices, as well as ensuring demand for their crop during the entire growing season (especially during the mid and late season). Key marketing opportunities have been established with Michigan's vegetable crop diversification and aims toward stable demands in the late spring and through the summer for Midwestern markets.

Currently unregistered alternatives, such as furfural and sodium azide, have shown good efficacy against the key pests involved (Cortright, personal communication). However, even if registration is pursued soon, these options would require additional research focusing on their adaptation to commercial pepper production in Michigan.

There are also no non-chemical alternatives that are currently viable for MB replacement for commercial pepper growers. In sum, while the potential exists for a combination of chemical and non-chemical alternatives to replace MB use in Michigan pepper, this goal appears be at least a few years away.

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE ON PEPPERS

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA [U.S. States of Alabama, Arkansas, Kentucky*, Louisiana*, North Carolina, South Carolina, Tennessee and Virginia; *States added for 2005-2007] - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST FOR PEPPERS

REGION WHERE METHYL BROMIDE USE IS REQUESTED	TARGET PESTS (WEED & PLANT-PARASITIC NEMATODES) PATHOGENS, AND [% DEGREE OF INFESTATION, IF REPORTED]	SPECIFIC REASONS WHY METHYL BROMIDE IS NEEDED
Southeast U.S. Peppers Consortium excluding Florida and Georgia	Yellow and purple nutsedge (*Cyperus esculentus, C. rotundus*), [30%]; plant-parasitic nematodes (*Meloidogyne incognita; Pratylenchus sp.);* pythium root and collar rots (*P.irregulare, P. myriotylum, P. ultimum, P. aphanidermatum*); crown and root rot (*Phytophthora capsici*)	Only MB can effectively control the target pests found in the southeastern United States where pest pressures commonly exist at moderate to severe levels. Most, if not all of these states, are limited in the use of the alternative 1,3-D because of underlying karst topography throughout the region. Halosulfuron, while effective against nutsedge, is only registered for use on row middles in peppers. Metam-sodium has limited pest control capabilities and should never be used as a stand-alone fumigant (Noling, 2003).

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE FOR PEPPERS

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Pepper transplants for fruit production
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual; generally 1 year
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Pepper – usually double-cropped with a high-value cucurbit crop (muskmelon, cucumber, or squash).
SOIL TYPES: *(Sand, loam, clay, etc.)*	Sandy loam; clay loam
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	1 time per year; (either in spring or fall)
OTHER RELEVANT FACTORS:	There are two distinct pepper-growing systems: 1) a spring crop (fumigation cycle begins in January) and a fall crop (fumigation cycle begins in May). Methyl bromide is applied 1 time per year on an individual field. Pepper does not follow pepper in this rotation; peppers are rotated with another crop, often a high-value cucurbit, which also depends on MB fumigation.

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE – JANUARY FUMIGATION (SPRING, EARLY SUMMER HARVEST)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
CLIMATIC ZONE	U.S. Plant Hardiness Zones 6b, 7a, 7b, 8a, 8b											
FUMIGATION SCHEDULE	X	X	X									
PLANTING SCHEDULE		X	X	X								
KEY HARVEST WINDOW				X	X	X	X					

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - TABLE 11.3 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE – SPRING FUMIGATION (FALL HARVEST)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
CLIMATIC ZONE	U.S. Plant Hardiness Zones 6b, 7a, 7b, 8a, 8b											
FUMIGATION SCHEDULE					X	X						
PLANTING SCHEDULE						X	X					
KEY HARVEST WINDOW								X	X	X	X	

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Peppers are generally produced using mechanized practices that involve deep soil injection (20 – 25 cm) of methyl bromide. Weeds, especially nutsedge, are the most serious concern precipitating MB use in both transplant beds and the field. Nutsedge species grow even under adverse conditions, resist traditional and modern methods of weed control, and are endemic to large tracts of pepper producing area in the Southeastern United States. Although herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds, there are no registered herbicides that can be used to control nutsedges on the beds. In addition to weeds, soil-borne fungal pathogens and plant-parasitic nematodes are endemic to the region, and nearly all production areas have severe infestations, thereby necessitating annual treatment with a broad-spectrum soil fumigant.

Alternatives like 1,3-dichloropropene and metam sodium require, respectively, a 7-28 day interval and a 14-30 day interval before planting, compared to 14 days for MB. This interval may cause delays and adjustments in production schedules that could lead to missing specific market windows, thus reducing profits for pepper growers (Kelley, 2003).

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE ON PEPPERS, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE ON PEPPERS

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	1998	1999	2000	2001	2002	2003
AREA TREATED *(hectares)*[A]	830	880	809	809	991	1,153
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED	Not available					
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED [A] *(total kilograms)*	182,253	132,199	121,563	121,563	148,914	173,227
FORMULATIONS OF METHYL BROMIDE *(methyl bromide /chloropicrin)*	No definitive/substantiated information available			67:33	67:33	67:33
METHODS BY WHICH METHYL BROMIDE APPLIED	No information available			Injected 15 to 25 cm deep	Injected 15 to 25 cm deep	Injected 15 to 25 cm deep
APPLICATION RATE (KG/HA) FOR THE FORMULATION	No information available					
DOSAGE RATE* (G/HA) FOR THE ACTIVE INGREDIENT	22.0	15.0	15.0	1.50	15.0	15.0

[A] An increase in the acreage of peppers produced in the Southeastern U.S. is projected from 2003 through 2007. Although reasons vary from state to state; they include shifts in acreage from tobacco and peanut production to the production of peppers and other high-value vegetable crops. This nomination package also includes two new states (added since 2001): Kentucky and Louisiana.
[B] Based on estimated area: 2,023 to 2,415 m^2 (Lewis, 2003, personal communication).

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - PART C: TECHNICAL VALIDATION FOR PEPPERS

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
CHEMICAL ALTERNATIVES		
Metam Sodium	Metam sodium provides limited and erratic performance at suppressing all major pepper pathogens and pests. In addition, there is a 14-30 day waiting period at the time of application until planting, compared to 14 days for MB. Such a delay could cause the higher-end market windows to be missed, particularly for the spring plantings (i.e., fall harvests). Beginning the application cycle earlier is not an option since crops from the previous fumigation cycle must be cleaned up prior to metam application. (Georgia CUE # 03-0049; Kelley, 2003). Repeated applications of MITC (the breakdown product of metam sodium) are known to enhance its biodegradation and reduce efficacy as a result of increased populations of adapted microorganisms (Dungan and Yates, 2003).	No
NON CHEMICAL ALTERNATIVES		
Soil solarization	For nutsedge control in the southeastern United States, solarization is not technically feasible as a methyl bromide alternative. Response of *Cyperus* species to solarization is sporadic and not well understood; data show solarization to provide, at best, suppression of nutsedge populations (Chase et al. 1999). Research indicates that the lethal temperature for nutsedge tubers is 50^{o}C or higher. Trials conducted in mid-summer in Georgia resulted in maximum soil temperatures of 43 ^{o}C at 5 cm depth (Chase et al. 1999). Thus, solarization, even in the warmer months in southern states, did not result in temperatures high enough to destroy nutsedge tubers. Also, tubers lodged deeper in the soil would be completely unaffected. In addition, solarization would take fields out of production since it would be needed during the spring and into the summer months, which are optimal for pepper production.	No
Steam	Steam is not a technically feasible alternative for open field pepper production because it requires sustained heat over a required period of time (UNEP 1998). While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open field pepper crops. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No

NAME OF ALTERNATIVE	**TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE**	**IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?**
Biological Control	Biological control agents alone cannot control nutsedge and/or the soil pathogens that afflict peppers. The bacterium *Burkholderia cepacia* and the fungus *Gliocladium virens* have shown some potential in controlling some fungal plant pathogens (Larkin and Fravel 1998). However, no biological control agent has been identified to effectively control nutsedge or *Phytophthora.* Therefore, biological control is not a stand-along replacement for methyl bromide in pepper crops. Only a limited number of biological organisms are effectively used to manage soil borne diseases and pests. Biocontrol agents are usually very specific regarding the organisms they control and their successful establishment is highly dependent on environmental conditions.	No
Cover crops and mulching	Cover crops and mulches have been integrated into solanaceous crop production systems. However there is no evidence these practices effectively substitute for the control methyl bromide provides against nutsedges (Burgos and Talbert 1996). Some cover crops that have been shown to reduce weed populations also reduced or delayed crop maturity and/or emergence, as well as yields (Burgos and Talbert 1996, Galloway and Weston 1996). Mulching has also been shown to be ineffective in controlling nutsedges, which are able to penetrate through both organic and plastic mulches (Munn 1992, Patterson 1998).	No
Crop rotation and fallow land	Crop rotation/fallow is not a technically feasible alternative to methyl bromide because it does not provide adequate control of nutsedges or fungal pathogens. The crop rotations available to growers are also susceptible to fungi; fallow land can still harbor fungal oospores (Lamour and Hausbeck 2003). Tubers of the perennial nutsedges provide new plants with larger energy reserves than annual weeds that can be more easily controlled by crop rotations and fallow. (Thullen and Keeley 1975). Furthermore, nutsedge plants can produce tubers within 2 weeks after emergence (Wilen et al. 2003). This enhances their survival across different cropping regimes that can disrupt other plants that rely on a longer undisturbed growing period to produce seeds to propagate the next generation.	No
Flooding/Water management	Flooding has been used effectively to manage various soil borne pest and diseases, especially nematodes and some weeds. However, nutsedges have shown tolerance to this treatment. Submerging nutsedge tubers for 8 days to 4 weeks showed no effect on the sprouting capabilities of the tubers (Horowitz, 1972). Studies in Florida showed ineffective nematode, disease, and nutsedge control after flooding (Allen, 1999). Regulatory issues concerning water management, as well as economic feasibility, also preclude its viability as an alternative to methyl bromide. Land structure, frequent and severe droughts, and the economics of developing and managing flood capabilities prevent flooding from being a viable, cost effective alternative in the Southeastern United States.	No

Name of Alternative	**Technical and regulatory* reasons for the alternative not being feasible or available**	**Is the alternative considered cost effective?**
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/plug plants.	Due to the paucity of scientific information on the utility of these alternatives as methyl bromide replacements in peppers, they have been grouped together for discussion in this document. The U.S. EPA was unable to locate any studies showing any potential for grafting, resistant rootstock or plant breeding as technically feasible alternatives to methyl bromide control of nutsedges. Plug plants are extensively used on high value vegetable crops like pepper but they do not control competition from nutsedges. There are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major pepper pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives for control of *Phytophthora* and *Fusarium* fungi. Soilless culture, organic production, and substrates/plug plants are also not technically viable alternatives to methyl bromide for fungi. Various aspects of organic production – e.g., cover crops, fallow land, and steam sterilization - have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
Combinations of Alternatives		
Metam sodium + Chloropicrin	Although this combination would likely be more effective than metam-sodium alone where fungal pests are the only concern, it may not prevent yield losses due to nutsedges, particularly where weed pressure is high. In a study with vegetables it provided control of yellow nutsedge, but weed pressure in that small plot test was low, according to the authors (Csinos et al. 1999).	No
1,3 dichloropropene (Telone II) + metam-sodium	This combination controls nematodes but not nutsedges. In a study with vegetables, it provided control of yellow nutsedge, but weed pressure in that small plot test was low, according to the authors (Csinos et al. 1999). It is inconsistently effective against fungal pests (see Michigan sections for more discussion). 1,3-D is also subject to regulatory prohibition of use on Karst geology.	No
1,3 dichloropropene (Telone II) followed by chloropicrin	Culpepper and Langston (2004) tested the effectiveness of several soil fumigant combinations for the management of nutsedges and nematodes affecting peppers in Tifton, Georgia. Results show that 1,3-D, followed by chloropicrin, was significantly less effective than MB for the control of both purple and yellow nutsedge, but as effective as MB for the control soil nematodes. In terms of spring and fall crop yield, however, this combination performed as well as MB. This treatment is promising and will require further testing and validation in commercial fields.	No, but shows promise

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
1,3 dichloropropene + chloropicrin	This combination does not adequately control nutsedge. Because of ground water contamination concerns, 1,3-D cannot be used in pepper growing areas of the U.S. where karst topography exists. Where 1,3-D use is allowed, set back restrictions (~ 100 meters from occupied structures; ~ 30 meters for emulsified formulations applied via chemigation) may limit the portion of a field that can be treated. In addition, because of a 28-day waiting period between application and planting (compared to 14 days for MB), growers could lose half of the harvest season and miss higher-end market windows, mainly for spring fumigations (i.e., fall harvests).	No
1,3 dichloropropene + chloropicrin (Telone C35) followed by chloropicrin	Culpepper and Langston (2004) have tested the effectiveness of several soil fumigant combinations for the management of nutsedges and nematodes affecting peppers in Tifton, Georgia. In this study, 1,3-D + chloropicrin, followed by more chloropicrin, was more effective than MB for the control of yellow nutsedge, but less effective against purple nutsedge. This treatment performed as well as MB in terms of spring crop yield, but poorly in terms of fall yield. This combination does not appear to show promise as a MB alternative.	No
1,3 dichloropropene + chloropicrin (Telone C35) followed by metam sodium	Culpepper and Langston (2004) have tested the effectiveness of several soil fumigant combinations for the management of nutsedges and nematodes affecting peppers in Tifton, Georgia. In this study, 1,3-D + chloropicrin, followed by metam sodium was 36% less effective than MB for the control of purple nutsedge, but as effective as MB for the control of yellow nutsedge and soil nematodes. In terms of spring and fall crop yield, this treatment performed as well as MB. This combination is promising and will require further testing and validation in commercial fields.	No, but shows promise
Fumigant combination + herbicide partners	Current research suggests that in areas of low pest pressure this combination may be suitable for some growers as an alternative for methyl bromide. In these situations growers may employ a marginal strategy without major economic dislocation if given a reasonable time frame for the transition.	Yes

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA- 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – TABLE 14.1: TECHNICALLY INFEASIBLE ALTERNATIVES DISCUSSION

NAME OF ALTERNATIVE	DISCUSSION
Halosulfuron-methyl	Is a non-selective herbicide. Causes potential crop injury; has plant back restrictions. Efficacy is lowered in rainy conditions (common during the period of initial planting of these crops). Also, a 24-month plant back restriction may cause significant economic disruption if growers must rely on this option. Since halosulfuron can only be applied to the row middles, nutsedges would survive on the pepper beds, close to crop plants. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.
Glyphosate	Is a non-selective herbicide. As halosulfuron, it will not control nutsedge within the plant rows and does not provide residual control. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been studied.
Paraquat	Is a non-selective herbicide that will not control nutsedge in the plant rows. It does not provide residual control. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.

Other than those options discussed elsewhere, no alternative exists for the control of the key weeds, nematodes, and pathogens affecting pepper production. Non-chemical alternatives and chemical alternatives to methyl bromide have been or are being investigated and when suitable, are incorporated into current pepper production practices.

Nutsedge management has proven to be difficult due to the perennial growth habit of nutsedge and tubers as primary means of propagation. There are no herbicides which control nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041.) Research suggests that metam sodium can, in some situations, provide effective pest management for certain diseases and weeds. However, even though there have been nearly 50 years experience with metam sodium, (which breaks down to methyl isothiocyanate) nutsedge control results have been unpredictable.

Since methyl bromide has been used effectively to manage minor crop production, there are limited pesticide alternatives due primarily to the small market share and the high cost associated with pesticide registration. Labeling of these products in minor crops could be more expensive than returns from potential sales, and therefore pesticide manufacturers have been reluctant to register pesticides for minor crop uses. Methyl bromide will be needed until a cost-effective alternative regimen is in place.

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES FOR PEPPERS

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Methyl iodide	Not registered	Yes	Unknown
Furfural	Not registered.	No	Unknown
Sodium azide	Not registered. No registration application received.	No	Unknown
Propargyl bromide	Not registered. No registration application received.	No	Unknown

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED:

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - TABLE 16.1. FUMIGANT ALTERNATIVES TO METHYL BROMIDE FOR POLYETHYLENE-MULCHED TOMATO (LOCASCIO ET AL. 1997)

Chemicals	Rate (kg/ha)	Average Nutsedge Density (#/m^2)	Average Marketable Yield (ton/ha)	% Yield Loss (compared to MB)
Untreated (control)	-	300 [ab]	20.1 [a]	59.1
MB + Pic (67-33), chisel-injected	390 kg	90 [c]	49.1 [b]	---
1,3 D + Pic (83-17), chisel-injected	327 l	340 [a]	34.6 [c]	29.5
Metam Na, Flat Fumigation	300 l	320 [a]	22.6 [a]	54.0
Metam Na, drip irrigated	300 l	220 [b]	32.3 [c]	34.2

***Notes*:** (1) Numbers followed by the same letter (within a column) are not significantly different at the 0.05 level of probability, using Duncan's multiple range test.
(2) Data shown are from the Gainesville/Horticultural Unit site, 1994 season (this was one of three sites included in this study). This site had relatively high nutsedge pressure, and data for both pest pressure and marketable yields for all treatments shown.

Locascio et al. (1997) studied MB alternatives on tomatoes grown in small plots at two Florida locations with high nutsedge infestation. The data from this tomato study are being cited because comparable pepper data are not available. Various treatments were tested on plots that had multiple pests. At the Bradenton site there was moderate to heavy *Fusarium* infestation; heavy purple nutsedge infestation and light root-knot nematode pressure. At Gainesville there was heavy infestation of yellow and purple nutsedge and moderate infestation of root-knot nematode. The treatments at both locations included MB (67%) + chloropicrin (33%) chisel-injected at 390 kg/ha; metam-sodium (chisel-injected) at 300L/ha; metam-sodium drip-irrigated at 300L/ha; and 1,3-D + 17% chloropicrin chisel-injected at 327L/ha. In pairwise statistical comparisons, the yield was significantly lower in metam-sodium treatments compared to MB at both sites. At Bradenton, the average yield from both metam-sodium treatments was 33% of the MB yields, suggesting a 67% yield loss from not using MB. At Gainesville the average yield of the two metam-sodium treatments was 56% of the MB yield, suggesting a 44% yield loss from not using MB. The yield of the 1,3-D treatment at Gainesville was 71% of the MB standard suggesting a 29% loss by not using MB (yield data for 1,3-D were not reported for Bradenton). In considering1,3 D results, one must keep in mind that this MB alternative cannot be used in areas where karst geology exists which is approximately 40% of the Florida pepper production area.

For **root knot nematodes**, both metam-sodium and 1,3 D + 35 % chloropicrin have shown good efficacy in trials with tomato and pepper. For example, Locascio and Dickson (1998) reported that metam-sodium + 35 % chloropicrin (295 l/ha of metam-sodium, shank-injected) reduced nematode galls significantly over untreated control plots, though not as much as did MB + 35 % chloropicrin treatments (500kg MB/ha, shank-injected), in Florida tomatoes. Analysis of 35 tomato and 5 pepper trials conducted from 1993 – 1995 indicated that 1,3 D (with either 17 % or 35 % chloropicrin) provided control of nematodes that was equal or superior to that seen with MB, in 95 % of the tomato and 100 % of pepper trials (Eger 2000). However, it is not clear whether yields were also comparable to those obtained with MB. Noling et al (2000) also studied the effects of metam-sodium (115 l/ha, syringe-injected), 1,3 D + 17 % chloropicrin (53.6 l/ha, soil-injected), and 1,3 D + 35 % chloropicrin (39.8 l/ha), among other treatments, in tomato plots. Galls inflicted by root knot nematodes were reduced significantly by all these MB alternatives, as compared to untreated control plots. Yields were also significantly higher as compared to the control plots; all MB alternatives resulted in similar high yields. However, the effects of MB formulations were not reported in this study. Further, it is the opinion of some U.S. crop experts that metam sodium, in particular, is inconsistent as a nematode control agent (Dr. S. Culpeper, University of Georgia, personal communication).

SOUTHEAST U.S. PEPPER CONSORTIUM - TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 dichloropropene + chloropicrin	Nutsedges, fungal pathogens	20 - 100	29%
Metam-sodium (with or without chloropicrin)	Nutsedges, fungal pathogens	30 - 55	44%
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**29 % if 1,3 D + pic is used; 44 % if metam-sodium is used**

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?:

Future plans to minimize MB use include:

1) Optimizing use of plastic (VIF) tarps and drip irrigation equipment for applying at-plant herbicides.
2) Conducting studies on tomato, pepper, and cucurbit crops with combinations of fumigants and herbicides including halosulfuron, metolachlor, rimsulfuron, and dimethenamid. Telone C-35 will be used as a fumigant because of nematode and disease problems.
3) Changing MB:chloropicrin formulations from 98:2 to 67:33

Trials using the alternative fumigants Telone C-35, iodomethane, metam sodium, chloropicrin, and at least two reduced-risk products (Propozone, PlantPro45, DiTera, Deny) are also planned. These trials will incorporate screening of pepper varieties for tolerance/resistance to *Phytophthora capsici*. The applicant noted that a program to evaluate host resistance to Phytophthora root and crown rot has been implemented. Growers are starting to deploy lines identified with genetic resistance and acceptable horticultural qualities.

In addition, the following new long-term studies have been initiated at the Coastal Plain Experiment Station in Tifton, Georgia, with funding provided by USDA-CSREES, Methyl Bromide Transitions Grant:

- Evaluation of the effects of soil conditions, particularly soil temperature and moisture, on nutsedge species efficacy from several fumigants.

- Investigation of the impact of multiple-season adoption of methyl bromide alternatives in terms of pest species composition, including weeds, diseases, and nematodes.

- Integration of multiple tactics as alternatives to methyl bromide for management of weeds, diseases, and nematodes in pepper and eggplant.

- Evaluation of vegetable crop response to herbicides applied under plastic prior to crop transplants and characterize herbicide fate when applied in a plasticulture system between summer and fall crops.

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA - 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?:

No. Soilless systems and greenhouse production are not in use for peppers and quick adoption is probably economically infeasible. Grafting has not been evaluated for vegetable production due to the high cost and the large number of plants that would be needed. In addition this alternative is primarily used for nematode and disease management, but there is no evidence that it applies to competition from weeds. Plug plants are extensively used on high value vegetable crops like pepper but they do not control competition from nutsedges.

SOUTHEAST U.S. PEPPERS CONSORTIUM EXCLUDING FLORIDA AND GEORGIA – SUMMARY OF TECHNICAL FEASIBILITY

There has been extensive research on alternatives for solanaceous crops, and methyl bromide minimizing practices have been incorporated into pepper production systems where possible. However, the effectiveness of chemical and non-chemical alternatives designed to fully replace methyl bromide must still be characterized as preliminary. These alternatives have not been shown to be stand-alone replacements for methyl bromide, and no combination has been shown to provide effective, economical pest control. Methyl bromide is believed to be the only treatment currently available that consistently provides reliable control of nutsedge species and the disease complex affecting pepper production. (Locascio et al., 1997) Nutsedges resist traditional and modern methods of weed control and are endemic to large tracts of pepper producing area in the Southeastern United States. Herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds, but there are no currently registered herbicides to address sedge weed pests. Nematodes, especially root knot nematodes (*Meloidogyne* spp.), and fungal diseases (such as *Phytophthora* blight) are also of concern. Fungal pests are expected to become serious problems for pepper production if MB were not available for pre-plant fumigation.

The 1,3-dichloropropene and chloropicrin combination does not effectively control nutsedges. Lack of an effective registered herbicide for control of nutsedge impairs adoption of methyl bromide alternatives in pepper (Banks, 2002). In addition, labeling of 1,3-dichloropropene products restricts its use in key pepper growing areas of the United States where karst topography exists due to ground-water contamination concerns. In areas where 1,3-dichloropropene use is allowed, set back restrictions and 7-28 day waiting periods between application and planting cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops. For example, peppers produced during the winter return a higher price than peppers produced during warmer months, and many growers rely on this price premium to maintain profitability.

Metam sodium provides limited and erratic performance at suppressing all major solanaceous pathogens and pests. Data indicate that metam sodium is not an effective alternative to methyl bromide for nutsedge control in bell pepper fields Webster et al., (2002). A 14-30 day planting delay is also recommended for this chemical. In addition there is evidence that both 1,3-dichloropropene and methyl isothiocyanate (the breakdown product of metam sodium) levels decline more rapidly, thus further compromising efficacy, in areas where these are repeatedly applied (Smelt et al. 1989, Ou et al. 1995, Gamliel et al. 2003). This is due to enhanced degradation of these chemicals by soil microbes (Dungan and Yates 2003).

Culpepper and Langston (2004) recently compared the effectiveness of several soil fumigants in managing soil pests affecting peppers in Tifton, Georgia. Results show that 1,3-D followed by chloropicrin was significantly less effective than methyl bromide for the control of both purple and yellow nutsedge, but as effective as MB for the control soil nematodes. In terms of spring and fall crop yield, this treatment performed as well as MB. 1,3-D + chloropicrin, followed by more chloropicrin was more effective than MB for the control of yellow nutsedge, but less effective against purple nutsedge. This treatment performed as well as MB in terms of spring crop yield, but poorly in terms of fall yield. 1,3-D + chloropicrin, followed by metam sodium was 36% less effective than methyl bromide for the control of purple nutsedge, but as effective as MB for the control of yellow nutsedge. This combination was as effective as MB against soil nematodes. In terms of spring and fall crop yield, this treatment performed as well as MB. These treatments are showing promise and will require further testing and validation in commercial fields.

Research on the effectiveness of non-chemical alternatives to methyl bromide is still in a preliminary stage, particularly for high value, minor-use crops such as peppers.

GEORGIA - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE ON PEPPERS

GEORGIA - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

GEORGIA - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST FOR PEPPERS

REGION WHERE METHYL BROMIDE USE IS REQUESTED	TARGET PESTS (WEED & PLANT-PARASITIC NEMATODES) PATHOGENS, AND [% DEGREE OF INFESTATION, IF REPORTED]	SPECIFIC REASONS WHY METHYL BROMIDE IS NEEDED
Georgia	Yellow and purple nutsedge (*Cyperus esculentus, C. rotundus*) *[100%];* crown and Root rot (*Phytophthora capsici*) *[40%];* plant-parasitic nematodes (*Meloidogyne incognita; Pratylenchus sp) [70%];* southern blight (*Sclerotium rolfsii*) *[70%];* Pythium root and collar rots (*P.irregulare, P. myriotylum, P. ultimum, P. aphanidermatum*) *[100%]*	Only MB can effectively control the target pests found in the southeast U.S. where pest pressures commonly exist at moderate to severe levels. Most, if not all of these states are limited in the use of the alternative 1,3-D because of underlying karst geology throughout the region. Halosulfuron, which is registered only for middle-of-row use, does not control nutsedge near pepper plants where most competition occurs. Metam-sodium has limited pest control capabilities and should never be used as a stand-alone fumigant (Noling, 2003). Refer to Item 13 for additional detail.

GEORGIA - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE FOR PEPPERS

GEORGIA - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	GEORGIA
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Pepper transplants for fruit production
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual; generally 1 year
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Pepper – usually followed by a cucurbit crop (cucumbers or squash). Occasionally eggplants follow pepper crops.
SOIL TYPES: *(Sand, loam, clay, etc.)*	Sandy loam; clay loam
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	1 time per year; (either in spring or fall)
OTHER RELEVANT FACTORS:	Actual frequency may be between 12 and 15 months depending on the number of crops grown per fumigation cycle.

Georgia - Table 11.2 Characteristics of Climate and Crop Schedule – July Fumigation Event, Pepper Crop is Harvested in Fall.

	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Climatic Zone	U.S. Plant Hardiness Zones 7a, 7b, 8a, 8b											
Soil Temp. *(° F)*	64.1	72.5	80.8	85.9	87.8	86.8	82.2	73.9	34.0	54.0	51.1	55.5
Rainfall *(inches)*	5.0	3.8	3.5	4.5	5.6	4.8	3.4	2.3	2.3	4.5	4.5	4.2
Average Air Temp. *(℃)*	69.8	77.7	84.7	89.4	90.7	90.5	87.3	79.3	69.8	63.1	61.5	64.0
Fumigation Schedule					X							
Planting Schedule	**2C**				**P**							
Key Harvest Windows			**2C**	**2C**	**2C**		**P**	**P**	**P**			

Methyl bromide applied in July allows the grower to economically produce at least two crops from one annual fumigation event. **P** = planting or harvest of pepper crop; **2C** = planting and/or harvest of 2^{nd} crop.

Georgia - Table 11.3. Characteristics of Climate and Crop Schedule – Spring (Late February - March) Fumigation Event, Pepper Crop is Harvested in Early Summer

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Climatic Zone	U.S. Plant Hardiness Zones 7a, 7b, 8a, 8b											
Soil Temp. *(℃)*	Same as above- Table 11.2											
Rainfall *(mm)*	Same as above- Table 11.2											
Air Temp. *(℃)*	Same as above- Table 11.2											
Fumigation Schedule[A]	X											
Planting Schedule[A,]		**P**				**2C**						
Key harvest Window[A,]				**P**	**P**	**P**		**2C**	**2C**	**2C**		

[A]Fumigation is an early spring event. Two crops are shown as being produced from one fumigation event.
P = planting and/or harvest of pepper crop; **2C** = planting and/or harvest of second crop.

GEORGIA – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Peppers are generally produced using mechanized practices that involve deep injection of methyl bromide. Methyl bromide is being requested only for moderate to severe pest infestations. Approximately 81% of the Georgia pepper area is considered to have moderate to severe infestations of nutsedge (Culpepper, 2004).

Weeds, especially nutsedge, are the most serious concern precipitating methyl bromide use in both transplant beds and in the field. Nutsedge species grow even under adverse conditions, resist traditional and modern methods of weed control, and are endemic to large tracts of pepper producing area in the Southeastern United States. Herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds - but there are no currently registered herbicides that control nutsedges near pepper plants. Weeds, when present in crops such as pepper, tomato, and cucurbits for 40 to 60 days may reduce yields by 10 to 50%. In addition to weeds, soil-borne fungal pathogens and plant-parasitic nematodes are endemic to the region and nearly all production areas have severe infestations, thus necessitating annual treatment with a broad-spectrum soil fumigant.

Alternatives like 1,3-dichloropropene and metam sodium require, respectively, a 14-28 day interval and a 14-30 day interval before planting, compared to 14 days for MB. This interval can cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops (Kelley, 2003).

Georgia - 12. Historic Pattern of Use of Methyl Bromide on Peppers, and/or Mixtures Containing Methyl Bromide, for which an Exemption Is Requested

Georgia - Table 12.1 Historic Pattern of Use of Methyl Bromide on Peppers

For as many years as possible as shown specify:	1998	1999	2000	2001	2002	2003
Area Treated *(hectares)*	1,267	1,767	2,263	2,252	2,312	2,117
Ratio of Flat Fumigation methyl bromide use to strip/bed use if strip treatment is used	All production acreage is strip/bed fumigation and tarped with LDPE films. Approximately 58% of the field is treated with MB and covered with plastic mulch.					
Amount of methyl bromide active ingredient used *(total kilograms)*	313,053	337,163	347,944	338,248	347,183	317,886
Formulations of methyl bromide *(methyl bromide /chloropicrin)*	98:2	98:2 (15% acreage) 67:33 (85% Of acreage)	67:33	67:33	67:33	67:33
Methods by which methyl bromide applied	Injected, 20.3 to 30.5 cm, under tarp	Injected, 20.3 to 30.5 cm, under tarp	Injected, 20.3 to 30.5 cm, under tarp	Injected, 20.3 to 30.5 cm, under tarp	Injected, 20.3 to 30.5 cm, under tarp	Injected, 20.3 to 30.5 cm, under tarp
Dosage rate*(g/m^2) of Active Ingredient	24.7	18.1	15.0	15.0	15.0	15.0

GEORGIA - PART C: TECHNICAL VALIDATION FOR PEPPERS

GEORGIA - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

GEORGIA – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
CHEMICAL ALTERNATIVES		
Metam Sodium	Metam sodium provides limited and erratic performance at suppressing all nutsedge weed species and pepper pathogens. Also, there is a 14-30 day waiting period at the time of application until planting compared to 14 days for MB. Such a delay may cause the higher-end market windows to be missed—particularly for the spring plantings (i.e., fall harvests). Beginning the application cycle earlier is not an option since crops from the previous fumigation cycle must be cleaned up prior to metam application. (Georgia CUE # 03-0049; Kelley, 2003). Repeated applications of MITC (the breakdown product of metam sodium) are known to enhance its biodegradation (and reduce efficacy) as a result of increased populations of adapted microorganisms (Dungan and Yates, 2003).	No
NON CHEMICAL ALTERNATIVES		
Soil solarization	For nutsedge control in the southeastern United States, solarization is not technically feasible as a methyl bromide alternative. Response of *Cyperus* species to solarization is sporadic and not well understood; data show solarization to provide, at best, suppression of nutsedge populations (Chase et al. 1999). Research indicates that the lethal temperature for nutsedge tubers is 50 ^{o}C or higher (Chase et al. 1999). Trials conducted in mid-summer in Georgia resulted in maximum soil temperatures of 43 ^{o}C at 5 cm depth. Thus, solarization, even in the warmer months in southern states, did not result in temperatures high enough to destroy nutsedge tubers. Also, tubers lodged deeper in the soil would be completely unaffected. In addition, solarization would take fields out of production since it would be needed during the spring and into the summer months, which are optimal for pepper production.	No
Steam	Steam is not a technically feasible alternative for open field pepper production because it requires sustained heat over a required period of time (UNEP 1998). While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open field pepper crops. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No

Name of Alternative	Technical and regulatory* reasons for the alternative not being feasible or available	Is the alternative considered cost effective?
Biological Control	Biological control agents alone cannot control nutsedge and/or the soil pathogens that afflict peppers. The bacterium *Burkholderia cepacia* and the fungus *Gliocladium virens* have shown some potential in controlling some fungal plant pathogens (Larkin and Fravel 1998). However, no biological control agent has been identified to effectively control nutsedge or *Phytophthora.* Therefore, biological control is not a stand-along replacement for methyl bromide in pepper crops. Only a limited number of biological organisms are effectively used to manage soil borne plant pathogens and pests. Biocontrol agents are usually very specific regarding the organisms they control and their successful establishment is highly dependent on environmental conditions.	No
Cover crops and mulching	Cover crops and mulches have been integrated into solanaceous crop production systems. However there is no evidence these practices effectively substitute for the control methyl bromide provides against nutsedges (Burgos and Talbert 1996). Some cover crops that have been shown to reduce weed populations also reduced or delayed crop maturity and/or emergence, as well as yields (Burgos and Talbert 1996, Galloway and Weston 1996). Mulching has also been shown to be ineffective in controlling nutsedges, which are able to penetrate through both organic and plastic mulches (Munn 1992, Patterson 1998).	No
Crop rotation and fallow land	Crop rotation/fallow is not a technically feasible alternative to methyl bromide because it does not provide adequate control of nutsedges or fungal pathogens. The crop rotations available to growers are also susceptible to fungi; fallow land can still harbor fungal oospores (Lamour and Hausbeck 2003). Tubers of the perennial nutsedges provide new plants with larger energy reserves than annual weeds that can be more easily controlled by crop rotations and fallow. (Thullen and Keeley 1975). Furthermore, nutsedge plants can produce tubers within 2 weeks after emergence (Wilen et al. 2003). This enhances their survival across different cropping regimes that can disrupt other plants that rely on a longer undisturbed growing period to produce seeds to propagate the next generation.	No
Flooding/Water management	Flooding has been used effectively to manage various soil borne pest and plant pathogens, especially nematodes and some weeds. However, nutsedges have shown tolerance to this treatment. Submerging nutsedge tubers for 8 days to 4 weeks showed no effect on the sprouting capabilities of the tubers (Horowitz, 1972). Studies in Florida showed ineffective nematode, plant pathogen, and nutsedge control after flooding (Allen, 1999). Regulatory issues concerning water management, as well as economic feasibility, also preclude its viability as an alternative to methyl bromide. Land structure, frequent and severe droughts, and the economics of developing and managing flood capabilities prevent flooding from being a viable, cost effective alternative in the Southeastern United States.	No

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates /plug plants.	Due to the paucity of scientific information on the utility of these alternatives as methyl bromide replacements in peppers, they have been grouped together for discussion in this document. The United States was unable to locate any studies showing any potential for grafting, resistant rootstock or plant breeding as technically feasible alternatives to methyl bromide control of nutsedges. Plug plants are extensively used on high value vegetable crops like pepper but they do not control competition from nutsedges. There are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major pepper pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives for control of *Phytophthora* and *Fusarium* fungi. Soilless culture, organic production, and substrates/plug plants are also not technically viable alternatives to methyl bromide for fungi. Various aspects of organic production – e.g., cover crops, fallow land, and steam sterilization - have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
COMBINATIONS OF ALTERNATIVES		
Metam sodium + Chloropicrin	Would possibly be more effective than metam-sodium alone where fungal pests are the only concern (see Michigan sections for more discussion), but this combination may not prevent yield losses due to nutsedges, particularly where the weed pressure is high. U.S. EPA is aware of one vegetable study that showed control of yellow nutsedge with this chemical combination, but weed pressure in that small plot test was low, according to the authors (Csinos et al. 1999).	No
1,3 dichloropropene + Metam-sodium	Controls nematodes but not nutsedges. U.S. EPA is aware of one vegetable study that showed control of yellow nutsedge with this chemical combination, but weed pressure in that small plot test was low, according to the authors (Csinos et al. 1999). Inconsistently effective against fungal pests (see Michigan sections for more discussion). 1,3-D also subject to regulatory prohibition of use on Karst geology.	No
1,3 dichloropropene (Telone II) followed by chloropicrin	Culpepper and Langston (2004) have tested the effectiveness of several soil fumigant combinations for the management of nutsedges and nematodes affecting peppers in Tifton, Georgia. Results show that 1,3-D followed by chloropicrin was significantly less effective than MB for the control of both purple and yellow nutsedge, but as effective as MB for the control soil nematodes. In terms of spring and fall crop yield, however, this combination performed as well as MB. This treatment is promising and will require further testing and validation in commercial fields.	No, but shows some promise

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
1,3 dichloropropene + chloropicrin	This combination does not adequately control nutsedge. Due to ground-water contamination concerns, 1,3-D cannot be used in pepper growing areas of the U.S. where karst topography exists. Where 1,3-dichloropropene use is allowed, set back restrictions (~ 100 meters from occupied structures; ~ 30 meters for emulsified formulations applied via chemigation) may limit the proportion of the field that can be treated. In addition, because of a 28-day waiting period between application and planting (compared to 14 days for MB), growers could lose half of the harvest season and miss higher-end market windows, mainly for spring fumigations (i.e., fall harvests). (SE Pepper Consortium, CUE # 03-0041).	No
1,3 dichloropropene + chloropicrin (Telone C35) followed by chloropicrin	Culpepper and Langston (2004) have tested the effectiveness of several soil fumigant combinations for the management of nutsedges and nematodes affecting peppers in Tifton, Georgia. In this study, 1,3-D + chloropicrin, followed by more chloropicrin was more effective than MB for the control of yellow nutsedge, but less effective against purple nutsedge. This treatment performed as well as MB in terms of spring crop yield, but poorly in terms of fall yield. This combination does not appear to show promise as a MB alternative.	No
1,3 dichloropropene + chloropicrin (Telone C35) followed by metam sodium	Culpepper and Langston (2004) have tested the effectiveness of several soil fumigant combinations for the management of nutsedges and nematodes affecting peppers in Tifton, Georgia. In this study, 1,3-D + chloropicrin, followed by metam sodium was 36% less effective than MB for the control of purple nutsedge, but as effective as MB for the control of yellow nutsedge and soil nematodes. In terms of spring and fall crop yield, this treatment performed as well as MB. This combination is promising and will require further testing and validation in commercial fields.	No, but shows promise
Fumigant combination + herbicide partners	Current research suggests that in areas of low pest pressure this combination may be suitable for some growers as an alternative for methyl bromide. In these situations growers may employ a marginal strategy without major economic dislocation if given a reasonable time frame for the transition.	Yes

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

GEORGIA- 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

GEORGIA – TABLE 14.1: TECHNICALLY INFEASIBLE ALTERNATIVES DISCUSSION

NAME OF ALTERNATIVE	DISCUSSION
Halosulfuron-methyl	For nutsedges: potential crop injury; plant back restrictions. Efficacy is lowered in rainy conditions (which are common in this region). Also, a 24 month plant back restriction may cause significant economic disruption if growers must rely on this control option.
Glyphosate	For nutsedges: Non-selective; will not control nutsedge in the plant rows; does not provide residual control. Repeated applications are required for control even in row middles.
Paraquat	For nutsedges: Non-selective; will not control nutsedge in the plant rows; does not provide residual control

Other than those options discussed in Table 13.1 and elsewhere in this document, no alternative exists for the control of the key pests and fungi affecting pepper production. Non-chemical alternatives and chemical alternatives to methyl bromide have been or are being investigated and when suitable, are incorporated into current pepper production practices.

Nutsedge management has proven to be difficult due to the perennial growth habit of nutsedge and tubers as primary means of propagation. There are no herbicides which control nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041). Research suggests that metam sodium can, in some situations, provide effective pest management for certain plant pathogens and weeds. However, even though there have been nearly 50 years experience with metam sodium, (which breaks down to methyl isothiocyanate) nutsedge control results have been unpredictable.

Since methyl bromide has been used effectively to manage minor crop production, there are limited pesticide alternatives due primarily to the small market share and the high cost associated with pesticide registration. Labeling of these products in minor crops could be more expensive than returns from potential sales, and therefore pesticide manufacturers have been reluctant to register pesticides for minor crop uses. Methyl bromide will be needed until a cost-effective alternative regimen is in place.

The applicant supplied information indicating pepper yield in fields treated with 1,3-D was 43% below MB-treated fields, though these results are as yet unpublished.

GEORGIA 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

GEORGIA – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES FOR PEPPERS

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Iodomethane	Not registered	Yes	Unknown
Furfural (Multigard™)	Not registered	No	Unknown
Sodium azide	Not registered. No registration application received.	No	Unknown
Propargyl bromide	Not registered. No registration application received.	No	Unknown

GEORGIA - 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED:

GEORGIA - TABLE 16.1. FUMIGANT ALTERNATIVES TO METHYL BROMIDE FOR POLYETHYLENE-MULCHED TOMATO (LOCASCIO ET AL. 1997)

Chemicals	Rate (kg/ha)	Average Nutsedge Density (#/m^2)	Average Marketable Yield (ton/ha)	% Yield Loss (compared to MB)
UNTREATED (CONTROL)	-	300 [ab]	20.1 [a]	59.1
MB + Pic (67-33), chisel-injected	390 kg	90 [c]	49.1 [b]	---
1,3 D + Pic (83-17), chisel-injected	327 l	340 [a]	34.6 [c]	29.5
Metam Na, Flat Fumigation	300 l	320 [a]	22.6 [a]	54.0
Metam Na, drip irrigated	300 l	220 [b]	32.3 [c]	34.2

***Notes*:** (1) Numbers followed by the same letter (within a column) are not significantly different at the 0.05 level of probability, using Duncan's multiple range test.
(2) Data shown are from the Gainesville/Horticultural Unit site, 1994 season (this was one of three sites included in this study). This site had relatively high nutsedge pressure, and data for both pest pressure and marketable yields for all treatments shown.

Locascio et al. (1997) studied MB alternatives on tomatoes grown in small plots at two Florida locations with high nutsedge infestation. The data from the tomato study are being cited because pepper data are not available.

Various treatments were tested on plots that had multiple pests. At the Bradenton site there was moderate to heavy *Fusarium* infestation; heavy purple nutsedge infestation and light root-knot nematode pressure. At Gainesville there was heavy infestation of yellow and purple nutsedge and moderate infestation of root-knot nematode. The treatments at both locations included MB (67%) + chloropicrin (33%) chisel-injected at 390 kg/ha; metam-sodium (chisel-injected) at 300L/ha; metam-sodium drip-irrigated at 300L/ha; and 1,3-D + 17% chloropicrin chisel-injected at 327L/ha. In pairwise statistical comparisons, the yield was significantly lower in metam-sodium treatments compared to MB at both sites. At Bradenton, the average yield from both metam-sodium treatments was 33% of the MB yields, suggesting a 67% yield loss from not using MB. At Gainesville, the average yield of the two metam-sodium treatments was 56% of the MB yield, suggesting a 44% yield loss from not using MB. The yield of the 1,3-D treatment at Gainesville was 71% of the MB standard suggesting a 29% loss by not using MB (yield data for 1,3-D were not reported for Bradenton). { In considering 1,3 D results, one must keep in mind that this MB alternative cannot be used in areas where karst geology exists.}

GEORGIA – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 D + chloropicrin	Nutsedges, fungal pathogens	20 – 100	29
Metam-sodium (with or without chloropicrin)	Nutsedges, fungal pathogens	30 – 55	44
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**29 % if 1,3 D + pic is used; 44 % if metam-sodium is used**

GEORGIA - 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?

There are plans to conduct studies on tomato, pepper, and cucurbit crops with combinations of fumigants and herbicides including halosulfuron, metolachlor, rimsulfuron, and dimethenamid. Telone C-35 will be used as a fumigant because of nematode and plant pathogen problems.

Trials using the alternative fumigants Telone C-35, iodomethane, metam sodium, chloropicrin, and at least two low risk products (Propozone, PlantPro45, DiTera, Deny) are also planned. These trials will incorporate screening of pepper varieties for tolerance/resistance to *P. capsici*. The applicant noted that a program to evaluate host resistance to *Phytophthora* root and crown rot has been implemented. Growers are starting to deploy lines identified with genetic resistance and acceptable horticultural qualities.

In addition, the following new long-term studies have been initiated at the Coastal Plain Experiment Station in Tifton, Georgia, with funding provided by USDA-CSREES, Methyl Bromide Transitions Grant:

- Evaluation of the effects of soil conditions, particularly soil temperature and moisture, on nutsedge species efficacy from several fumigants.

- Investigation of the impact of multiple-season adoption of methyl bromide alternatives in terms of pest species composition, including weeds, diseases, and nematodes.

- Integration of multiple tactics as alternatives to methyl bromide for management of weeds, diseases, and nematodes in pepper and eggplant.

Evaluation of vegetable crop response to herbicides applied under plastic prior to crop transplants and characterize herbicide fate when applied in a plasticulture system between summer and fall crops.

GEORGIA - 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?

No. Soilless systems and greenhouse production are not in use for peppers and quick adoption is probably economically infeasible. Grafting has not been evaluated for vegetable production due to the high cost and the large number of plants that would be needed. In addition this alternative is primarily used for nematode and plant pathogen management, but there is no evidence that it applies to competition from weeds. Plug plants are extensively used on high value vegetable crops like pepper but they do not control competition from nutsedges.

GEORGIA - SUMMARY OF TECHNICAL FEASIBILITY

There has been extensive research on alternatives for solanaceous crops, and methyl bromide minimizing practices have been incorporated into pepper production systems where possible. However, the effectiveness of chemical and non-chemical alternatives designed to fully replace methyl bromide must still be characterized as preliminary. These alternatives have not been shown to be stand-alone replacements for methyl bromide, and no combination has been shown to provide effective, economical pest control. Methyl bromide is believed to be the only treatment currently available that consistently provides reliable control of nutsedge species and the plant pathogen complex affecting pepper production. Nutsedges resist traditional and modern methods of weed control and are endemic to large tracts of pepper producing area in the Southeastern United States. Herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds, but there are no currently registered herbicides to address nutsedges in the row. Nematodes, especially root knot nematodes (*Meloidogyne* spp.), and fungal diseases (such as Phytophthora blight) are also of concern. These pests are expected to become serious problems for pepper production if methyl bromide were not available for pre-plant fumigation.

The 1,3-dichloropropene and chloropicrin combination does not effectively control nutsedges. Lack of an effective registered herbicide for control of nutsedge impairs adoption of methyl bromide alternatives in pepper (Banks, 2002). In addition, labeling of 1,3-dichloropropene products restricts its use in key pepper growing areas of the U.S. where karst topography exists, due to ground-water contamination concerns. In areas where 1,3-dichloropropene use is allowed, set back restrictions, and 7-28 day waiting periods between application and planting cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops. For example, peppers produced during the winter fetch a higher price than peppers produced during warmer months, and many growers rely on this price premium to maintain profitability.

Metam sodium provides limited and erratic performance at suppressing all major solanaceous pathogens and pests. Data indicate that metam sodium is not an effective alternative to methyl bromide for nutsedge control in bell pepper fields Webster et al., (2002 a). A 14-30 day planting delay is also recommended for this chemical. In addition there is evidence that both 1,3-dichloropropene and methyl isothiocyanate (the breakdown product of metam sodium) levels decline more rapidly, thus further compromising efficacy, in areas where these are repeatedly applied (Smelt et al. 1989, Ou et al. 1995, Gamliel et al. 2003). This is due to enhanced degradation of these chemicals by soil microbes (Dungan and Yates 2003).

Culpepper and Langston (2004) recently compared the effectiveness of several soil fumigants in managing soil pests affecting peppers in Tifton, Georgia. Results show that 1,3-D followed by chloropicrin was significantly less effective than methyl bromide for the control of both purple and yellow nutsedge, but as effective as MB for the control soil nematodes. In terms of spring and fall crop yield, this treatment performed as well as MB. 1,3-D + chloropicrin, followed by more chloropicrin was more effective than MB for the control of yellow nutsedge, but less effective against purple nutsedge. This treatment performed as well as MB in terms of spring crop yield, but poorly in terms of fall yield. 1,3-D + chloropicrin, followed by metam sodium was 36% less effective than methyl bromide for the control of purple nutsedge, but as effective as MB for the control of yellow nutsedge. This combination was as effective as MB against soil nematodes. In terms of spring and fall crop yield, this treatment performed as well as MB. These treatments are showing promise and will require further testing and validation in commercial fields.

Research on the effectiveness of non-chemical alternatives to methyl bromide is still in a preliminary stage, particularly for high value, minor-use crops.

PART B: FLORIDA -CROP CHARACTERISTICS AND METHYL BROMIDE USE ON PEPPERS

FLORIDA - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

FLORIDA- TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST

REGION WHERE METHYL BROMIDE USE IS REQUESTED	TARGET PATHOGENS, NEMATODES AND/OR WEED(S) TO GENUS AND, IF KNOWN, TO SPECIES LEVEL	SPECIFIC REASONS WHY METHYL BROMIDE IS NEEDED
Florida	Weeds: yellow & purple nutsedges (*Cyperus rotundus & C. esculentus*), nightshade (*Solanum* spp.), white clover (*Trifollium repens*), ragweed (*Ambrosia artemisifolia*) Plant diseases: phytophthora blight (*Phytophthora* spp.), damping-off (*Rhizoctonia solani*, *Pythium* spp.), white mold (*Sclerotinia sclerotiorum*) Nematodes: root-knot nematodes (*Meloidogyne* spp.),	Only MB can effectively control the target pests found in Florida, where pest pressures commonly exist at moderate to severe levels. Use of 1,3-D is restricted in key pepper growing areas of Florida underlain by karst geology and sandy (porous) sub-soils, geological features that could lead to ground-water contamination. Approximately 40% of Florida's pepper production land has these soil constraints. For instance, 1,3-D is prohibited in Dade County, where 100% of the pepper growing area is affected (U.S. EPA, 2002, Noling, 2003). Metam-sodium has limited pest control capabilities and is not useful as a stand-alone fumigant (Noling, 2003). Halosulfuron, which is effective against nutsedge, is only registered for use in row middles in peppers.

FLORIDA - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE

FLORIDA - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	FLORIDA
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Pepper transplants for fruit production
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual (usually 1 yr)
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Eggplants or cucurbits
SOIL TYPES: *(Sand, loam, clay, etc.)*	Sandy and sandy-loam soils
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	1time per year
OTHER RELEVANT FACTORS:	Double-cropped with cucurbits

FLORIDA - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE

	MAR	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**Sept**	**Oct**	**NOV**	**DEC**	**JAN**	**FEB**
CLIMATIC ZONES	Plant Hardiness Zones 9a; 9b; 10a, 10.											
RAINFALL *(mm)*, TAMPA, FL	65.5	50.0	72.5	134.1	175.8	193.3	152.7	65.0	42.7	158.8	62.0	66.8,
OUTSIDE TEMP. *(℃);* TAMPA, FL	19.4	22.1	25.3	27.6	28.2	28.2	27.3	24.1	19.2	17.3	16.0	16.9
FUMIGATION SCHEDULE[A]						X	X	X	X	X	X	
TRANSPLANTING SCHEDULE; ' NON DOUBLE-CROPPED[B]	X						X	X	X	X	X	X
KEY HARVEST WINDOW; NON DOUBLE-CROPPED[C]	X	X	X	X					X	X	X	X

[A] Non-double cropped: earliest start date: August 15; cells marked with an "x" represent variation in fumigation initiation amongst pepper growers.

[B] For Non-Double cropped pepper production, transplanting peppers is usually initiated around September 1; cells marked with an "x" represent variation in transplanting dates amongst pepper growers.

.[C] For Non-Double Cropped Peppers: Harvest Period usually begins as early as Nov. 15, and may continue until June 15, depending on when planted and weather conditions.

FLORIDA - TABLE 11.3 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE – PEPPERS DOUBLE CROPPED WITH ANOTHER VEGETABLE (USUALLY CUCURBITS)

	MAR	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEPT**	**Oct**	**NOV**	**DEC**	**JAN**	**FEB**
CLIMATIC ZONES	Plant Hardiness Zones 9a; 9b; 10a, 10.											
RAINFALL *(mm)*, TAMPA, FL	65.5	50.0	72.5	134.1	175.8	193.3	152.7	65.0	42.7	158.8	62.0	66.8,
OUTSIDE TEMP. *(℃);* TAMPA, FL	19.4	22.1	25.3	27.6	28.2	28.2	27.3	24.1	19.2	17.3	16.0	16.9
FUMIGATION SCHEDULE'; DOUBLE-CROPPED[A]						X	X					
TRANSPLANTING SCHEDULE; DOUBLE-CROPPED[B]	**2C**	**2C**					**P**	**P**				**2C**
KEY HARVEST WINDOW; DOUBLE-CROPPED[C]	**P**	**P**	**2C**	**2C**	**2C**				**P**	**P**	**P**	**P**

[A]Double-cropped; assumed to be with cucurbits; earliest start date is August 15; shaded cells represent variation in fumigation initiation among pepper growers who double-crop.

[B]For Double-Cropped pepper production, transplanting (**P**) is typically initiated on September 1; variance can be until October 31. The second crop of cucurbits (usually) transplants (indicated by "**2C**") would typically be initiated around Feb 15, and may vary until April 30

[C] For Double Cropped peppers, Harvest Period usually begins as early as Nov. 15, (**P**), may continue until April 15, depending on when planted and weather conditions; Harvesting of second crop (**2C**) may start around May and continue until mid-July.

Climate Zone designation (http://www.usna.usda.gov/Hardzone)

FLORIDA – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

The sandy soils of Florida are a contributing factor to the erratic performance suppressing weeds, nematodes, and plant pathogens of the metam sodium + chloropicrin combination, the most promising alternative to methyl bromide currently available for use in Dade County (because of label restrictions for 1,3-D). Methyl bromide has higher vapor pressure than metam sodium, therefore can penetrate and diffuse throughout the soil more effectively than metam sodium.

Several climatic factors appeared to contribute to increases in plant pathogens, e.g., Southern stem blight, caused by the soil-borne fungus (*Sclerotium rolfsii*) across the production area, even with methyl bromide. Variations in rainfall and soil and air temperatures may predispose developing plants to diseases caused by plant-pathogenic fungi. Furthermore, in the fall, temperature and rainfall patterns favor high levels of nematode infestation.

FLORIDA - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

FLORIDA - TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	1998	1999	2000	2001	2002	2003
AREA TREATED *(hectares)*	8,903	8,903	8,741	8,741 ha	8,195 ha	8,417
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED USE	100% strip treatments are used in this region					
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED *(total kilograms)*	1,630,376	1,644,501	1,431,639	1,406,135	1,285,199	1,320,860
FORMULATIONS OF METHYL BROMIDE *(methyl bromide /chloropicrin)*[A]	98:2 & 67:33	98:2 & 67:33	67:33	67:33	67:33	67:33
METHOD BY WHICH METHYL BROMIDE APPLIED [A]	Sweptback chisel-shank, 25-30.5 cm.deep	Sweptback chisel-shank, 25-30.5 cm.deep	Sweptback chisel-shank, 25-30.5 cm.deep	Sweptback chisel-shank, 25-30.5 cm.deep	Sweptback chisel-shank, 25-30.5 cm.deep	Sweptback chisel-shank, 25-30.5 cm.deep
DOSAGE RATE OF STRIP/ BED, G MB/M^2	18.3	18.5	16.4	16.1	15.7	15.7

[A] Sources: personal communication, Professor J.W. Noling, November 25, 2003; M. Aerts, December 2, 2003.

Florida - PART C: TECHNICAL VALIDATION

FLORIDA - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

FLORIDA – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
CHEMICAL ALTERNATIVES		
1,3 dichloropropene	1,3-D provides control of nematode populations, but poor control of plant pathogens and weeds. Control of nematodes is erratic, due to poor distribution of the fumigant in the sandy soils of Florida. 1,3-D's use is prohibited due to groundwater contamination in key pepper growing areas with karst geology, which is estimated to be about 40% in of FL pepper area in 2002. In Dade County, a major pepper production area, 100% of pepper acreage is affected by a label prohibition that addresses groundwater contamination concerns. In areas where 1,3-D use is allowed, set back restrictions (~ 100 meters from occupied structures; ~ 30 meters for emulsified formulations applied via chemigation) may limit the portion of a field that can be treated. In addition, the 28-day waiting period between application and planting can cause delays/adjustments in production schedules that could lead to missing specific higher-end market windows.	No
Metam-sodium/potassium	Provides limited and erratic performance for suppressing major pepper pathogens and pests. Does not work under high pest pressure. This soil fumigant is considered the best available alternative for Dade County only, where 1,3 D use is prohibited (Aerts, 2003). This is at best a treatment that complements other fumigants and herbicides, and is not a stand-alone option (Noling, 2003). Metam sodium has a lower vapor pressure than methyl bromide, and therefore cannot penetrate and diffuse throughout the soil as effectively as MB. In addition, the effectiveness of metam sodium is dependent on the organic matter and moisture content of the soil. Metam sodium tends to degrade rapidly in warm soils where it has been previously used.	No

Name of Alternative	Technical and regulatory* reasons for the alternative not being feasible or available	Is the alternative considered cost effective?
Non Chemical Alternatives		
Solarization	Solarization is not technically feasible as a methyl bromide alternative for control of nutsedges. Research indicates that the lethal temperature for nutsedge tubers is 50 ^{o}C or higher (Chase et al. 1999. Trials conducted in mid-summer in Georgia resulted in maximal soil temperatures of 43 ^{o}C at 5 cm depth. Thus, solarization, even in the warmer months in southern states, did not result in temperatures reliably high enough to destroy nutsedge tubers, and tubers lodged deeper in the soil would be completely unaffected. Response of *Cyperus* species to solarization is sporadic and not well understood and data show solarization to provide, at best, suppression of nutsedge populations (Chase et al. 1999). In addition, solarization will take fields out of production since it would be needed during the spring and into the summer months, which are optimal for pepper production.	No
Steam	Steam is not a technically feasible alternative for open field pepper production because it requires sustained heat over a required period of time (UNEP 1998). While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open field pepper crops. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No
Biological Control	Biological control agents alone cannot control nutsedge and/or the soil pathogens that afflict peppers. The bacterium *Burkholderia cepacia* and the fungus *Gliocladium virens* have shown some potential in controlling some fungal plant pathogens (Larkin and Fravel 1998). However, no biological control agent has been identified to effectively control nutsedge or *Phytophthora.* Therefore, biological control is not a stand-along replacement for methyl bromide in pepper crops. Only a limited number of biological organisms are effectively used to manage soil borne plant pathogens and pests.	No
Cover crops and mulching	Cover crops and mulches have been integrated to solanaceous crop production management. However there is no evidence these practices effectively substitute for the control methyl bromide provides against nutsedges (Burgos and Talbert 1996). Some cover crops that have been shown to reduce weed populations also reduced or delayed crop maturity and/or emergence, as well as yields (Burgos and Talbert 1996, Galloway and Weston 1996). Mulching has also been shown to be ineffective in controlling nutsedges, since these plants are able to penetrate through both organic and plastic mulches (Munn 1992, Patterson 1998).	No

Name of Alternative	**Technical and regulatory* reasons for the alternative not being feasible or available**	**Is the alternative considered cost effective?**
Crop rotation and fallow land	Crop rotation/fallow is not a technically feasible alternative to methyl bromide because it does not provide adequate control of nutsedges or fungal pathogens. The crop rotations available to growers are also susceptible to fungi; fallow land can still harbor fungal oospores (Lamour and Hausbeck 2003). As regards to nutsedges, tubers of these perennial species provide new plants with larger energy reserves than the annual weeds that can be frequently controlled by crop rotations and fallow land (Thullen and Keeley 1975). Furthermore, nutsedge plants can produce tubers within 2 weeks after emergence (Wilen et al. 2003). This enhances their survival across different cropping regimes that can disrupt other plants that rely on a longer undisturbed growing period to produce seeds to propagate the next generation.	No
Flooding/Water management	South Florida is generally subject to natural flooding during summer months, but other areas cannot be flooded because of lack of a shallow, impermeable layer. Although flooding is a pest management tool that has been used effectively to manage various soil borne pest and plant pathogens, nutsedges have shown tolerance to this treatment. Submergence of nutsedge tubers for periods of 8 days to 4 weeks showed no effect on the sprouting capabilities of the tubers (Horowitz, 1972). Studies in Florida (Allen, 1999) showed ineffective nematode, plant pathogen, and nutsedge control. Regulatory issues concerning water management, as well as economic feasibility, also preclude its viability as an alternative to methyl bromide. Land structure, frequent and severe droughts, and the economics of developing and managing flood capabilities will prevent flooding from being a viable, cost effective alternative in the Southeastern states.	No
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/ plug plants.	Due to the paucity of scientific information on the utility of these alternatives as methyl bromide replacements in peppers, they have been grouped together for discussion in this document. The U.S. was unable to locate any studies showing any potential for grafting, resistant rootstock or plant breeding as technically feasible alternatives to methyl bromide control of nutsedges. Plug plants are extensively used on high value vegetable crops like pepper but they do not control competition from nutsedges. There are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major pepper pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives for control of *Phytophthora* and *Fusarium* fungi. Soilless culture, organic production, and substrates/plug plants are also not technically viable alternatives to methyl bromide for fungi. Various aspects of organic production – e.g., cover crops, fallow land, and steam sterilization - have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
Combinations of Alternatives		

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Metam sodium + Chloropicrin	This combination has been used in Florida since the 1970s. It is being tested as a leading alternative to MB in Dade County because of label restrictions for 1,3-D, which do not allow its use in that county. However, it has shown erratic performance suppressing weeds, nematodes, and plant pathogens in the sandy soils of Florida. MB has higher vapor pressure than metam sodium and can penetrate and diffuse throughout the soil more effectively. Trials in tomato have shown inconsistent efficacy of this combination against soil pathogens, though it is generally better than metam-sodium alone (Locascio and Dickson 1998, Csinos et al. 1999). This alternative will require further testing and validation on commercial fields.	No, but shows promise
1,3 dichloropropene + chloropicrin (Telone C35)	Although this combination, by itself, is not effective in areas with moderate to high nutsedge pressure, it can provide season long control when coupled with herbicides (Chellemi et al. 2001; Gilreath and Santos, 2003). Trials comparing Flat Fumigation applications with standard in-row applications indicated the need to increase the amount of chloropicrin to compensate for the potential decrease in efficacy of 1,3-D applied via Flat Fumigation. Applications via micro-irrigation systems have yielded mixed results, probably due to poor lateral distribution of the chemical in the soil (Martin 2003; Dungan and Yates, 2003). In addition, 1,3-D's use is prohibited due to groundwater contamination in areas with karst geology, estimated to be about 40% in of FL pepper area in 2002. In Dade County this combination is not allowed at all. A Telone C35 application, along with a herbicide mix (e.g. clomazone + metolachlor) applied at bed formation, has been identified by the Florida Fruit and Vegetable Association as the recommended best MB alternative outside karst geology areas. Although promising, this alternative will require further testing and validation on commercial fields.	No, but shows promise for non-karst geology areas.
1,3 dichloropropene + Metam-sodium	Trials in tomato have shown inconsistent efficacy of this formulation against fungal pests, though it is generally better than metam-sodium alone (Csinos et al. 1999). Low efficacy in even small-plot trials indicates that this is not a technically feasible alternative for commercially produced peppers at this time. In addition, 1,3-D's use is prohibited due to groundwater contamination in all pepper growing areas with karst geology, estimated to be about 40% in of FL pepper area in 2002. In Dade County 100% of pepper acreage is affected by this limitation.	No
Fumigant combination + herbicide partners	Current research suggests that in areas of low pest pressure this combination may be suitable for some growers as an alternative for methyl bromide. In these situations growers may employ a marginal strategy without major economic dislocation if given a reasonable time frame for the transition	Yes

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

FLORIDA - 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

FLORIDA – TABLE 14.1: TECHNICALLY INFEASIBLE ALTERNATIVES DISCUSSION

NAME OF ALTERNATIVE	DISCUSSION
Halosulfuron-methyl	For nutsedges: potential crop injury; plant back restrictions. Efficacy is lowered in rainy conditions (which are common in this region). Also, a 24-month plant back restriction may cause significant economic disruption if growers must rely on this control option. Halosulfuron is registered for use in row middles only.
Glyphosate	For nutsedges: Non-selective; will not control nutsedge in the plant rows; does not provide residual control
Paraquat	For nutsedges: Non-selective; will not control nutsedge in the plant rows; does not provide residual control. Another weed, nightshade, has shown resistance to paraquat, a dangerous development since this plant serves as a reservoir for many insects (e.g., whiteflies), that are vectors of pepper diseases (Aerts, 2004)

Other than those options discussed in Table 13.1 and elsewhere in this document, no alternative exists for the control of the key pests and fungi affecting pepper production. Non-chemical alternatives and chemical alternatives to methyl bromide have been or are being investigated and when suitable, incorporated into current pepper production practices.

Nutsedge management has proven to be difficult due to the perennial growth habit of nutsedge and tubers as primary means of propagation. There are no herbicides which control nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041). Research suggests that metam sodium can, in some situations, provide effective pest management for certain plant pathogens and weeds. However, even though there have been nearly 50 years experience with metam sodium, (which breaks down to methyl isothiocyanate) nutsedge control results have been unpredictable.

Since methyl bromide has been used effectively to manage minor crop production, there are limited pesticide alternatives due primarily to the small market share and the high cost associated with pesticide registration. Labeling of these products in minor crops could be more expensive than returns from potential sales, and therefore pesticide manufactures have been reluctant to register pesticides for minor crop uses. Methyl bromide will be needed until a cost-effective alternative regimen is in place.

FLORIDA - 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

FLORIDA – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Iodomethane	Pre-plant soil fumigant. Not registered yet	Yes	Unknown
Trifloxysulfuron sodium	Herbicide - recently registered for tomato in FL only. Crop injury potential exist	No	Unknown
Fosthiazate	Not registered on peppers	No	Unknown
Furfural (Multigard™)	Not registered	No	Unknown
Sodium azide	Not registered. No registration application received.	No	Unknown
Propargyl bromide	Not registered. No registration application received.	No	Unknown
Paecilomyces lilacinus	Biological nematicide; not registered	Yes	Unknown

FLORIDA - 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED:

FLORIDA - TABLE 16.1. FUMIGANT ALTERNATIVES TO METHYL BROMIDE FOR POLYETHYLENE-MULCHED TOMATO (LOCASCIO ET AL. 1997)-)

Chemicals	Rate (kg/ha)	Average Nutsedge Density (#/m^2)	Average Marketable Yield (ton/ha)	% Yield Loss (compared to MB)
Untreated (control)	-	300 [ab]	20.1 [a]	59.1
MB + Pic (67-33), chisel-injected	390 kg	90 [c]	49.1 [b]	---
1,3 D + Pic (83-17), chisel-injected	327 l	340 [a]	34.6 [c]	29.5
Metam Na, Flat Fumigation	300 l	320 [a]	22.6 [a]	54.0
Metam Na, drip irrigated	300 l	220 [b]	32.3 [c]	34.2

***Notes*:** (1) Numbers followed by the same letter (within a column) are not significantly different at the 0.05 level of probability, using Duncan's multiple range test.

(2) Data shown are from the Gainesville/Horticultural Unit site, 1994 season (this was one of three sites included in this study). This site had relatively high nutsedge pressure, and data for both pest pressure and marketable yields for all treatments shown.

All fumigants were injected 15-20 cm deep, with three chisels per bed, 30 cm apart

Locascio et al. (1997) studied MB alternatives on tomatoes grown in small plots at two Florida locations with high nutsedge infestation. The data from the tomato study are being cited because pepper data are not available.

Various treatments were tested on plots that had multiple pests. At the Bradenton site there was moderate to heavy *Fusarium* infestation; heavy purple nutsedge infestation and light root-knot nematode pressure. At Gainesville there was heavy infestation of yellow and purple nutsedge and moderate infestation of root-knot nematode. The treatments at both locations included MB (67%) + chloropicrin (33%) chisel-injected at 390 kg/ha; metam-sodium (chisel-injected) at 300L/ha; metam-sodium drip-irrigated at 300L/ha; and 1,3-D + 17% chloropicrin chisel-injected at 327L/ha. In pairwise statistical comparisons, the yield was significantly lower in metam-sodium treatments compared to MB at both sites. At Bradenton, the average yield from both metam-sodium treatments was 33% of the MB yields, suggesting a 67% yield loss from not using MB. At Gainesville, the average yield of the two metam-sodium treatments was 56% of the MB yield, suggesting a 44% yield loss from not using MB. The yield of the 1,3-D treatment at Gainesville was 71% of the MB standard suggesting a 29% loss by not using MB (yield data for 1,3-D were not reported for Bradenton). In considering 1,3 D results, one must keep in mind that this MB alternative cannot be used in areas where karst geology exists, or anywhere in Dade county, a major production area.

FLORIDA – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 dichloropropene + chloropicrin	Nutsedges, fungal pathogens	20 - 100	29
Metam-sodium (with or without chloropicrin)	Nutsedges, fungal pathogens	30 - 55	44
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**29 % if 1,3 D + pic is used; 44 % if metam-sodium is used**

FLORIDA - 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?

Iodomethane is being considered for registration as a methyl bromide replacement. Its registration date is not known. Please refer to Table 15.1 for details.

FLORIDA- 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?

The U.S. EPA is unaware of large- scale, commercial greenhouse operations for peppers or other technologies that could reduce methyl bromide use. There may be local or small community organic or hothouse pepper production that targets fresh market and/or temporal (seasonal) sectors.

Grafting has not been evaluated for vegetable production due to the high cost and the large number of plants that would be needed. In addition this alternative is primarily used for nematode and plant pathogen management, but there is no evidence that it applies to competition from weeds. Plug plants are extensively used on high value vegetable crops like pepper but they do not control competition from nutsedges.

FLORIDA - SUMMARY OF TECHNICAL FEASIBILITY

There has been extensive research on alternatives for solanaceous crops, and methyl bromide minimizing practices have been incorporated into pepper production systems where possible. However, the effectiveness of chemical and non-chemical alternatives designed to fully replace methyl bromide must still be characterized as preliminary. Weeds, particularly nutsedge, are the major pests of Florida peppers that drive the need for methyl bromide. There are no registered herbicides compatible with pepper production. Although s-metolachlor (Dual Magnum) and napropamide (Devrinol) were cited as herbicides with some potential to control nutsedges, their efficacy in sub-tropical Florida is inconsistent (Noling, 2003). Furthermore, s-metolachlor's effectiveness is restricted to yellow nutsedge. When nutsedge pressure is moderate to severe, 1,3-D + chloropicrin is not technically feasible because it needs to be coupled with an effective herbicide to provide control for the entire growing season (U.S. EPA, 2002). Frank et al (1992) reported that weeds in pepper for 40 to 60 days could reduce yields by 10 to 50 percent. Stall and Morales-Payan reported that tomato must be nutsedge-free for 2 to10 weeks to keep yield reductions below 5 percent. There are no herbicides which control purple nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041).

In addition, labeling of 1,3-dichloropropene products restricts its use in key pepper growing areas of the U.S. where karst geology exists due to ground-water contamination concerns. In areas where 1,3-dichloropropene use is allowed, set back restrictions and a 28 day waiting periods, at the maximum label rate, between application and planting cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops. For example, peppers produced during the winter fetch a higher price than peppers produced during warmer months, and many growers rely on this price premium to maintain profitability.

Metam sodium provides limited and erratic performance at suppressing all major solanaceous pathogens and pests. Data indicate that metam sodium is not an effective alternative to methyl bromide for nutsedge control in bell pepper fields (Webster et al. (2002). A 14-30 day planting delay is also recommended for this chemical. In addition there is evidence that both 1,3-dichloropropene and methyl isothiocynate (the breakdown product of metam sodium) levels decline more rapidly, thus further compromising efficacy, in areas where these are repeatedly applied (Smelt et al. 1989, Ou et al. 1995, Gamliel et al. 2003). This is due to enhanced degradation of these chemicals by soil microbes (Dungan and Yates 2003).

Diseases caused by soil-borne plant pathogenic fungi, (e.g., *Sclerotinia*, *Phytophthora* spp., *Verticillium* spp., *Pythium* spp. and *Rhizoctonia solani*) commonly reside in many production areas, since many pepper production areas are old tomato production fields. Fungicides such as chlorothalonil, and azoxystrobin are considered to be only prophylactic, and may not offer sufficient pest management. Resistance of *Phytophthora* spp to metalaxyl and mefanoxem (Ridomil and Ridomil Gold, respectively) has been reported in tomato crop areas, and most recently pepper (Lamour and Hausbeck 2003).

Nematodes, such as the root knot nematode species of *Meloidogyne* were third, following weeds and fungal pathogens, in order of causing yield and economic losses in Florida peppers. Pre-plant control of nematodes is very important because root feeding and damage may predispose the plant tissues to fungal pathogens or bacterial wilt which can lead to significant yield loss. Fumigant alternatives such as metam-sodium (Vapam, K-pam) have proven inconsistent. (Noling, 2003; CUE #03-0017).

Research on the effectiveness of non-chemical alternatives to methyl bromide is still in a preliminary stage, particularly for high value, minor-use crops.

CALIFORNIA - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE

CALIFORNIA - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

CALIFORNIA - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST

REGION WHERE METHYL BROMIDE USE IS REQUESTED	KEY DISEASE(S) AND WEED(S) TO GENUS AND, IF KNOWN, TO SPECIES LEVEL)	SPECIFIC REASONS WHY METHYL BROMIDE IS NEEDED
California	Crown and root rots caused by soil-borne fungi – particularly *Phytophthora capsici;* plant-parasitic nematodes, primarily root knot (*Meloidogyne* spp.)	Registered alternative fumigants, fungicides, and nematicides are not as cost-effective and do not provide the same level of pest control as methyl bromide. One application of methyl bromide can last more than a year (within a particular field), whereas alternative chemicals must be applied annually.

CALIFORNIA - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE

CALIFORNIA- TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	CALIFORNIA
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Pepper transplants for fruit production
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual; generally 1 year
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Pepper may be followed by pepper, celery, broccoli or leafy vegetables
SOIL TYPES: *(Sand, loam, clay, etc.)*	Sandy loam; clay loam
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	1 time every 2 years
OTHER RELEVANT FACTORS:	High land costs and urban encroachment increasing near production areas. Very few crops can be rotated with peppers that will provide an economic return.

CALIFORNIA - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE

	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
CLIMATIC ZONE	USDA Plant Hardiness Zone 9b											
RAINFALL (*mm*)[A,B]	16.0 29.7	72.1 112.3	17.3 16.0	0 0	T 17.2	1.0 T	T 0	0 T	44.7 74.9	56.9 273.1	9.9 36.3	30.5 62.2
OUTSIDE TEMP. (℃)[A]	14.4 13.2	14.8 12.4	20.8 14.9	25.7 17.1	30.3 17.2	27.4 19.1	25.1 18.2	18.4 16.3	13.4 14.2	9.6 11.4	10.3 2.1	10.6 11.2
FUMIGATION SCHEDULE[C]								X*	X*	X*		
PLANTING SCHEDULE[C]											X	X
KEY MARKET WINDOW				X	X	X	X	X				

Notes:
* Fumigation occurs in these months, but only every other year, typically.
[A] Air temperatures and rainfall data were collected from weather stations in Fresno (top number) and at the San Francisco Airport (bottom number) from September to December 2002 and January to August, 2003.
[B] A "T" in the column denotes trace amount of rainfall recorded
[C] The above cycle is if another pepper crop followed the first planting of peppers. If other crops follow pepper, then planting of the other crops (e.g., a leafy vegetable) would begin in October and harvest would be in December, January and February.

CALIFORNIA – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Urban encroachment and concomitant buffer zones and local (township) caps restrict the use of the MB alternative 1,3 D (with or without chloropicrin). This prevents the use of this alternative on approximately 10 % of the pepper growing area in California, according to the applicant. The applicant is requesting MB only for this proportion of their total pepper acreage.

CALIFORNIA - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

In California, the soil injection of MB under tarps has increased from approximately 68% of the area using this fumigant in 1997 to 93% in 2003. The depth of methyl bromide application varies from 15 to 36 cm centimeters below tarps. The low MB dosage rate is due in large part to a shift by all growers to formulations lower than the 98:2 ratio that was used in the mid-1990s. The formulations most commonly in use currently are 75:25 or 67:33 mixture of methyl bromide: chloropicrin. (Melban 2003). Please see Table 12.1 for further information.

CALIFORNIA- TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	1998	1999	2000	2001	2002	2003
AREA TREATED *(hectares)*	864	1,226	995	447	121	Not available
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED USE IF STRIP TREATMENT IS USED	Ratio of Flat Fumigation treatments versus bed applications is not known. Two methods of application are used: Flat-fumed type, and methyl bromide is injected, and sealed with plastic ground cover. If buffer zones are strict (e.g., in southern Santa Clara County), then almost all applications are flat-fumed, Flat Fumigation. The second type of application involves bed-fumed (~0.67 A, or 29,000 sq. ft)					
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED *(total kilograms)*	182,834	247,191	170,830	63,558	25,929	Not available
FORMULATIONS OF METHYL BROMIDE *(methyl bromide /chloropicrin)*	75:25 or 67:33	75:25 or 67:33	75:25 or 67:33	75:25 or 67:33	75:25 or 67:33	75:25 or 67:33
METHODS BY WHICH METHYL BROMIDE APPLIED	Flat-fumed or bed fumed, injected 16-36 cm deep	Flat-fumed or bed fumed, injected 16-36 cm deep	Flat-fumed or bed fumed, injected 16-36 cm deep	Flat-fumed or bed fumed, injected 16-36 cm deep	Flat-fumed or bed fumed, injected 16-36 cm deep	Flat-fumed or bed fumed, injected 16-36 cm deep
APPLICATION RATE OF FLAT FUMIGATION ; FLAT-FUMED; KG A.I./ha*	212	202	172	142	214	Not available
DOSAGE RATE*(G/M^2) OF FORMULATION USED TO CALCULATE REQUESTED KILOGRAMS OF METHYL BROMIDE	27.4	27.4	27.4	27.4	27.4	Not available

California - Part C: Technical Validation

California - 13. Reason for Alternatives Not Being Feasible

California– Table 13.1: Reason for Alternatives Not Being Feasible

Name of Alternative	Technical and regulatory* reasons for the alternative not being feasible or available	Is the alternative considered cost effective?
Chemical Alternatives		
Metam Sodium	Control of key fungal pest is inconsistent at best (Martin 2003). The use of metam-sodium also creates a 14-30 day planting delay (waiting period from application to planting) to avoid risk of phytotoxic injury to crops compared to a 14-day delay for MB. Gilreath et al. (1994) found that metam-sodium treatments did not match MB in terms of plant vigor at the end of the season; *Fusarium* was one of several pests present	No
1,3 dichloropropene	I, 3-D controls nematodes, but performs poorly with soil pathogens and weeds. Furthermore, California has township caps limiting the amount of 1, 3 D that can be used near urban areas and a mandatory buffer (approx. 100 m) around treated areas. The use of 1,3-D also requires a 28-day waiting period between application and planting.	No
Non Chemical Alternatives		
Soil solarization	California's coastal climate is typically cool (less than 16 ^{o}C frequently through December), rainy, and cloudy, particularly early in the pepper-growing season when control of the key pests is particularly important. Since solarization has shown some potential in other crops and regions (e.g., tomatoes in Florida), the potential for adoption exists (Schneider et al. 2003). However, at this time it is technically infeasible for California coastal peppers.	No
Steam	While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open field pepper crops in California. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No
Biological Control	Biological control agents are not technically feasible alternatives to methyl bromide because they alone cannot control the soil pathogens that afflict peppers in California. The bacterium *Burkholderia cepacia* and the fungus *Gliocladium virens* have shown some potential in controlling some fungal plant pathogens (Larkin and Fravel 1998). However, in a test conducted in Michigan, *P. capsici* was not controlled adequately in summer squash by either of these beneficial microorganisms. Tests in California peppers have apparently not been conducted.	No

NAME OF ALTERNATIVE	**TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE**	**IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?**
Cover crops and mulching	There is no evidence these practices effectively substitute for the control methyl bromide provides against *P. capsici*. Plastic mulch is already in widespread use in California vegetables, and regional crop experts state that it is not an adequate protectant when used without methyl bromide. The longevity and resistance of *P. capsici* oospores renders cover crops ineffective as a stand-alone management alternative to methyl bromide.	No
Crop rotation and fallow land	The crop rotations available to growers in the coastal California region are also susceptible to these fungi, particularly to *P. capsici*. Fallow land can still harbor *P. capsici* oospores (Lamour and Hausbeck 2003). Thus fungi would persist and attack peppers if crop rotation/fallow land was the main management regime. The same phenomenon applies to nematodes, another important soil pest in this region.	No
Endophytes	Though these organisms (fungi that grow symbiotically or as parasites within plants) have been shown to suppress some plant pathogens in cucumber, there is no such information for the pepper crops grown in California. Furthermore, the pathogens involved did not include *Phytophthora* species, which are arguably the greatest single threat to California peppers.	No
Flooding/Water management	Flooding is not technically feasible as an alternative because it does not have any suppressive effect on *P. capsici* (Allen et al. 1999), and is likely to be impractical for California pepper growers. It is unclear whether irrigation methods in this region could be adapted to incorporate flooding or alter water management for pepper fields. In any case, there appears to be no supporting evidence for its use against the hardy oospores of *P. capsici*.	No
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/plug plants.	Due to the paucity of scientific information on the utility of these alternatives as methyl bromide replacements in peppers, they have been grouped together for discussion in this document. There are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major pepper pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives for control of *Phytophthora* and *Fusarium* fungi. Soilless culture, organic production, and substrates/plug plants are also not technically viable alternatives to methyl bromide for fungi. *P.capsici* can spread through water (Gevens and Hausbeck 2003), making it difficult to keep any sort of area (with or without soil) plant pathogen free. Various aspects of organic production – e.g., cover crops, fallow land, and steam sterilization - have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
COMBINATIONS OF ALTERNATIVES		

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Metam sodium + Chloropicrin	Trials in tomato have shown inconsistent efficacy of this formulation against fungal pests, though it is generally better than metam-sodium alone (Locascio and Dickson 1998, Csinos et al. 1999). Low efficacy in even small-plot trials indicates that this is not a technically feasible alternative for commercially produced cucurbits at this time. These studies apparently did not measure yield impacts, and did not involve cucurbits. The use of metam-sodium requires a 21-day waiting period from application to planting to avoid risk of phytotoxic injury to crops.	No
1,3 dichloropropene + metam-sodium	Trials in tomato have shown inconsistent efficacy of this formulation against fungal pests, though it is generally better than metam-sodium alone (Csinos et al. 1999). Furthermore, the use of metam-sodium requires a 21-day waiting period from application to planting, while 1,2-D has a 28-day waiting period.	No
1,3 dichloropropene + chloropicrin	This combination has shown effectiveness equivalent to that of MB against nematodes (Eger 2000). However, California has township caps on the amount of 1,3-D and chloropicrin that can be used near urban areas and a mandatory buffer (approx. 100 m) around treated areas, factors that may result in significant areas remaining untreated. The use of 1,3-D requires a 28 day waiting period between application and planting.	No
Fumigant combination + herbicide partners	Current research suggests that in areas of low pest pressure this combination may be suitable for some growers as an alternative for methyl bromide. In these situations growers may employ a marginal strategy without major economic dislocation if given a reasonable time frame for the transition.	Yes

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

CALIFORNIA - 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

NAME OF ALTERNATIVE	DISCUSSION
	Other than those options discussed elsewhere, no alternatives exist for the control of the key pests when they are present in the soil and/or afflict the belowground portions of pepper plants. A number of effective fungicides are available for treatment of these fungi when they infect aerial portions of crops. However, these infections are not the focus of MB use, which is meant to keep newly planted transplants free of these fungi.

California 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES

CALIFORNIA – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS *State if registered for this crop, registered for crop but use restricted, registered for other crops but not target crop, or not registered*	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Methyl iodide	Not registered	Yes	Unknown
Furfural	Not registered	No	Unknown
Sodium azide	Not registered. No registration application received.	No	Unknown
Propargyl bromide	Not registered. No registration application received.	No	Unknown

CALIFORNIA- 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED:

1,3-D + chloropicrin has shown effectiveness equivalent to that of MB against nematodes (Eger 2000). In studies with other vegetable crops, this combination has generally shown better control of soil-borne fungi than metam-sodium formulations (though still not as good as control with MB). For example, in a study using a bell pepper/squash rotation in small plots - conducted in the much warmer conditions of Georgia and without *P. capsici* as a component of the pest complex - Webster et al. (2001) found significantly lower fungal populations with 1,3 D + 35 % chloropicrin (drip irrigated or chisel injected, 146 kg/ha of 1,3 D), as compared to the untreated control. However, MB (440 kg/ha, shank-injected) lowered fungal populations even more. Methyl iodide had no significant suppressive effect, as compared to the untreated control. In another study, conducted on tomatoes in Florida, Gilreath et al. (1994) found that metam-sodium treatments did not match MB in terms of plant vigor at the end of the season; *Fusarium* was one of several pests present. However, California has township caps on the amount of 1,3-D and chloropicrin that can be used near urban areas and a mandatory buffer (approx. 100 m) around treated areas, factors that may result in significant areas remaining untreated. The use of 1,3-D also requires a 28 day waiting period between application and planting.

CALIFORNIA – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 dichloropropene + Chloropicrin	Soil borne plant pathogens and nematodes	0 – 6 % PLUS loss of revenue due to planting delays	6 % loss of revenue due to planting delays
Metam sodium (with or without chloropicrin)	Soil borne plant pathogens and nematodes	0 – 6 % PLUS loss of revenue due to planting delays	6 % loss of revenue due to planting delays
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**6 % likely with the best alternative (1,3 D + chloropicrin)**

California - 17. Are There Any Other Potential Alternatives Under Development which Are Being Considered to Replace Methyl Bromide?

The critical use exemption applicant states that chloropicrin, 1,3 D, metam-sodium, water management, and plant varieties will continue to be tested for efficacy against *P. capsici* and other key soil-borne pathogens.

California - 18. Are There Technologies Being Used to Produce the Crop which Avoid the Need for Methyl Bromide?

No. Soilless systems and greenhouse production are not in use for peppers in this region, and quick adoption is probably economically infeasible. Growers apply MB on fields with a history of pest contamination, but it appears that most growing acreage in this region has moderate to severe infestations, particularly of *P. capsici* and other soil borne fungi, which thrive in cool and moist climates.

California - Summary of Technical Feasibility

Without MB, pepper producers in cool weather climates of Ventura and Santa Clara Counties would most likely use a mixture of 1,3-D and chloropicrin (Telone C-35) to manage nematode and fungal pathogen populations prior to transplanting pepper. There is evidence from numerous small plot and large-scale trials to indicate that these MB alternatives, in combination, will control nematodes to the extent that MB does nematodes (e.g. Eger 2000). However fungal pests, particularly *P. capsici*, may not be controlled to a similar extent. No large-plot studies have yet been performed to show commercial feasibility against fungal pests in coastal California peppers. Regulatory constraints on 1,3 D and chloropicrin must also be kept in mind: township caps on the amounts used (which may affect the use rate, and hence efficacy), and mandatory 100 m buffers near inhabited structures, both of which could cause negative economic impacts on the pepper industry. These planting restrictions may inhibit widespread grower adoption of this MB alternative.

Currently unregistered alternatives, such as furfural and sodium azide, have shown good efficacy against the key pests involved. However, even if registration is pursued soon (and there is no indication of plans to do so) these options will need more validation and adaptation research specific to commercial pepper production in California. There are no non-chemical alternatives that are currently viable for MB replacement for commercial pepper growers. In sum, while the potential exists for a combination of chemical and non-chemical alternatives to replace MB use in California pepper, this goal still is a few years away.

PART D: EMISSION CONTROL

19. TECHNIQUES THAT HAVE AND WILL BE USED TO MINIMIZE METHYL BROMIDE USE AND EMISSIONS IN THE PARTICULAR USE:

TABLE 19.1: TECHNIQUES TO MINIMIZE METHYL BROMIDE USE AND EMISSIONS

TECHNIQUE OR STEP TAKEN	VIF OR HIGH BARRIER FILMS	METHYL BROMIDE DOSAGE REDUCTION	INCREASED % CHLOROPICRIN IN METHYL BROMIDE FORMULATION	LESS FREQUENT APPLICATION
WHAT USE/EMISSION REDUCTION METHODS ARE PRESENTLY ADOPTED?	Currently some growers use HDPE tarps.	Growers have switched from a 98% MB formulation to a 67 % formulation. Between 1997 and 2001, the U.S. has achieved a 36 % reduction in use rates.	From 2 % to 33 %	No
WHAT FURTHER USE/EMISSION REDUCTION STEPS WILL BE TAKEN FOR THE METHYL BROMIDE USED FOR CRITICAL USES?	Research is underway to develop use in commercial production systems	A 50 % MB formulation is being tested in Michigan pepper fields. A similar formulation was tested in Florida and found to be ineffective.	A 50 % MB formulation is being tested in Michigan pepper fields. A similar formulation was tested in Florida and found to be ineffective.	The U.S. anticipates that the decreasing supply of methyl bromide will motivate growers to try less frequent applications.
OTHER MEASURES *(please describe)*	Examination of promising but presently unregistered alternative fumigants and herbicides, alone or in combination with non-chemical methods, is planned in all regions (Please see Section 17 for each region for details)	Measures adopted in Michigan will likely be used in the other regions when fungi are the only key pests involved	Measures adopted in Michigan will likely be used in the other regions when fungi are the only key pests involved	Unknown

20. IF METHYL BROMIDE EMISSION REDUCTION TECHNIQUES ARE NOT BEING USED, OR ARE NOT PLANNED FOR THE CIRCUMSTANCES OF THE NOMINATION, STATE REASONS

In accordance with the criteria of the critical use exemption, each party is required to describe ways in which it strives to minimize use and emissions of MB. The use of MB in the growing of peppers in the United States is minimized in several ways. First, because of its toxicity, MB has, for the last 40 years, been regulated as a restricted use pesticide in the United States. As a consequence, MB can only be used by certified applicators who are trained at handling these hazardous pesticides. In practice, this means that MB is applied by a limited number of very experienced applicators with the knowledge and expertise to minimize dosage to the lowest level possible to achieve the needed results. In keeping with both local requirements to avoid "drift" of methyl bromide into inhabited areas, as well as to preserve MB and keep related emissions to the lowest level possible, MB application for cucurbits is most often machine injected into soil to specific depths.

As MB has become scarce, users in the United States have, where possible, experimented with different mixes of MB and chloropicrin. Specifically, in the early 1990s, MB was typically sold and used in MB mixtures made up of 92% MB and 2% chloropicrin, with the chloropicrin being included solely to give the chemical a smell enabling those in the area to be alerted if there was a risk. However, with the outset of very significant controls on MB, users have been experimenting with significant increases in the level of chloropicrin and reductions in the level of MB. While these new mixtures have generally been effective at controlling target pests, at low to moderate levels of infestation, it must be stressed that the long-term efficacy of these mixtures is unknown.

Tarpaulin (high density polyethylene) is also used to minimize use and emissions of MB. In addition, pepper growers utilize cultural practices.

Reduced MB concentrations in mixtures, cultural practices, and the extensive use of tarpaulins to cover land treated with MB has resulted in reduced emissions and an application rate that we believe is among the lowest in the world for the uses described in this nomination.

PART E: ECONOMIC ASSESSMENT

Economic data from the 2004 submission for all applicants were not substantially different from those in 2003 (greater or less than a 10% change in costs and revenue). Given these insignificant differences, the economic analyses were not updated for any applicants other than Michigan, which was updated to reflect a change in the requested pounds of MeBr.

The following economic assessment is organized by MeBr critical use application. Cost of MeBr and alternatives are given first in table 21.1. This is followed in table 22.1 by a listing of net and gross revenues by applicant. Expected losses when using MeBr alternatives are then further decomposed in tables E1 through E5.

Reader please note that in this study net revenue is calculated as gross revenue minus operating costs. This is a good measure as to the direct losses of income that may be suffered by the users. It should be noted that net revenue does not represent net income to the users. Net income, which indicates profitability of an operation of an enterprise, is gross revenue minus the sum of operating and fixed costs. Net income should be smaller than the net revenue measured in this study. We did not include fixed costs because it is often difficult to measure and verify.

21. OPERATING COSTS OF ALTERNATIVES COMPARED TO METHYL BROMIDE OVER 3-YEAR PERIOD:

TABLE 21.1: PEPPERS – OPERATING COSTS OF ALTERNATIVES COMPARED TO METHYL BROMIDE OVER 3-YEAR PERIOD

ALTERNATIVE	YIELD*	COST IN YEAR 1 *(US$/ha)*	COST IN YEAR 2 *(US$/ha)*	COST IN YEAR 3 *(US$/ha)*
California				
Methyl Bromide	100%	$17,246	$17,246	$17,246
1,3-D + Chloropicrin	94%	$17,160	$17,160	$17,160
Florida				
Methyl Bromide	100%	$20,341	$20,341	$20,341
1,3-D + Chloropicrin	71%	$18,510	$18,510	$18,510
Metam-Sodium	56%	$16,999	$16,999	$16,999
Georgia				
Methyl Bromide	100%	$28,623	$28,623	$28,623
1,3-D + Chloropicrin	71%	$25,790	$25,790	$25,790
Metam-Sodium	56%	$23,598	$23,598	$23,598
Michigan				
Methyl Bromide	100%	$23,938	$23,938	$23,938
1,3-D + Chloropicrin	94%	$25,607	$25,607	$25,607
Southeast USA				
Methyl Bromide	100%	$18,758	$18,758	$18,758
1,3-D + Chloropicrin	71%	$18,844	$18,844	$18,844
Metam-Sodium	56%	$16,731	$16,731	$16,731

** As percentage of typical or 3-year average yield, compared to methyl bromide e.g. 10% more yield, write 110.*

22. GROSS AND NET REVENUE:

TABLE 22.1: PEPPERS – YEAR 1, 2, AND 3 GROSS AND NET REVENUES

YEAR 1, 2, AND 3		
ALTERNATIVES *(as shown in question 21)*	**GROSS REVENUE FOR LAST REPORTED YEAR** *(US$/ha)*	**NET REVENUE FOR LAST REPORTED YEAR** *(US$/ha)*
California		
Methyl Bromide	$21,344	$4,098
1,3-D + Chloropicrin	$20,063	$2,903
Florida		
Methyl Bromide	$29,498	$9,158
1,3-D + Chloropicrin	$20,944	$2,433
Metam-Sodium	$16,519	$(479)
Georgia		
Methyl Bromide	$35,176	$6,553
1,3-D + Chloropicrin	$24,975	$(816)
Metam-Sodium	$19,698	$(3,900)
Michigan		
Methyl Bromide	$24,056	$118
1,3-D + Chloropicrin	$20,916	$(2,994)
Southeastern USA		
Methyl Bromide	$30,579	$11,822
1,3-D + Chloropicrin	$21,711	$2,867
Metam-Sodium	$17,124	$393

NOTE: Year 1 equals year 2 and 3.

MEASURES OF ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

CALIFORNIA PEPPER - TABLE E1: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

CALIFORNIA PEPPER	METHYL BROMIDE	1, 3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	787	739
* PRICE PER UNIT (US$)	$27	$27
= GROSS REVENUE PER HECTARE (US$)	$21,344	$20,063
- OPERATING COSTS PER HECTARE (US$)	$17,246	$17,160
= NET REVENUE PER HECTARE (US$)	$4,098	$2,903
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$1,194
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$8
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	6%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	29%
5. PROFIT MARGIN (%)	19%	14%

FLORIDA PEPPER - TABLE E.2: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

FLORIDA PEPPER	METHYL BROMIDE	1, 3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	2,922	2,074	1,636
* PRICE PER UNIT (US$)	$10	$10	$10
= GROSS REVENUE PER HECTARE (US$)	$29,498	$20,944	$16,519
- OPERATING COSTS PER HECTARE (US$)	$20,341	$18,510	$16,999
= NET REVENUE PER HECTARE (US$)	$9,158	$2,433	$(479)
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$6,724	$9,637
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$45	$64
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	23%	33%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	73%	105%
5. PROFIT MARGIN (%)	31%	12%	-3%

GEORGIA PEPPER - TABLE E.3: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

GEORGIA PEPPER	METHYL BROMIDE	1, 3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	4,440	3,152	2,486
* PRICE PER UNIT (US$)	$8	$8	$8
= GROSS REVENUE PER HECTARE (US$)	$35,176	$24,975	$19,698
- OPERATING COSTS PER HECTARE (US$)	$28,623	$25,790	$23,598
= NET REVENUE PER HECTARE (US$)	$6,553	$(816)	$(3,900)
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$7,368	$10,453
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$49	$70
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	21%	30%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	112%	160%
5. PROFIT MARGIN (%)	19%	-3%	-20%

MICHIGAN PEPPER- TABLE E.4: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

MICHIGAN PEPPER	METHYL BROMIDE	1, 3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	4,530	4,258
* PRICE PER UNIT (US$)	$5	$5
= GROSS REVENUE PER HECTARE (US$)	$24,056	$20,916
- OPERATING COSTS PER HECTARE (US$)	$23,938	$25,607
= NET REVENUE PER HECTARE (US$)	$118	$(4,690)
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$4,808
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$40
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	20%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	100%
5. PROFIT MARGIN (%)	0%	-22%

SOUTHEASTERN USA (EXCEPT GEORGIA) PEPPER - TABLE E.5: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

SOUTHEASTERN USA (EXCEPT GEORGIA) PEPPER	METHYL BROMIDE	1, 3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	3,707	2,632	2,076
* PRICE PER UNIT (US$)	$8	$8	$8
= GROSS REVENUE PER HECTARE (US$)	$30,579	$21,711	$17,124
- OPERATING COSTS PER HECTARE (US$)	$18,758	$18,844	$16,731
= NET REVENUE PER HECTARE (US$)	$11,822	$2,867	$393
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$8,954	$11,429
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$60	$76
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	29%	37%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	76%	97%
5. PROFIT MARGIN (%)	39%	13%	2%

SUMMARY OF ECONOMIC FEASIBILITY

There are currently few alternatives to methyl bromide for use in peppers. Furthermore, there are factors that limit existing alternatives' usability and efficacy from place to place. These include pest complex, climate, and regulatory restrictions. As described above, the two most promising alternatives to methyl bromide in Florida, Georgia, and the Southeastern USA for control of nut-sedge in peppers (1,3-D + chloropicrin and metam-sodium) are considered not technically feasible. This derives from regulatory restrictions and the magnitude of expected yield losses when they are used. Economic data representing the Florida, Georgia, and Southeastern USA pepper growing conditions are included in this section as a supplement to the biological review to illustrate the impacts of using MeBr alternatives, not to gauge them with respect to economic feasibility. However, in California and Michigan 1,3-D + chloropicrin is considered technically feasible.

California

Yield loss in California pepper production is expected to be 6% when using MeBr alternatives. Growers will experience loss on a per hectare basis of approximately $1,200 and 6% and 29% losses in gross and net revenues, respectively. However, these measures do not clearly indicate that 1,3-D + chloropicrin is an economically infeasible alternative to MeBr.

The economic conditions facing pepper growers were quantified as best as possible but, primarily due to limited data availability, every aspect of the economic picture was not included in the numeric assessment. Factors not accounted for are distribution of yield loss across individual growers and the yield risk associated with using MeBr alternatives.

Michigan

The US concludes that, at present, no economically feasible alternatives to MeBr exist for use in Michigan pepper production. Two factors have proven most important in this conclusion. These are yield loss and missed market windows, which are discussed individually below.

1. Yield Loss

Expected yield losses of 6% are anticipated throughout Michigan pepper production.

2. Missed Market Windows

The US agrees with Michigan's assertion that growers will likely receive significantly lower prices for their produce if they switch to 1,3-D + chloropicrin. This is due to changes in the harvest schedule caused by the above described soil temperature complications and extended plant back intervals when using 1,3-D + chloropicrin.

The analysis of this effect is based on the fact that prices farmers receive for their peppers vary widely over the course of the growing season. Driving these fluctuations are the forces of supply and demand. Early in the growing season, when relatively few peppers are harvested, the supply is at is lowest and the market price is at its highest. As harvested quantities increase, the price declines. In order to maximize their revenues, pepper growers manage their production systems with the goal of harvesting the largest possible quantity of peppers when the prices are at their highs. The ability to sell produce at these higher prices makes a significant contribution toward the profitability of pepper operations.

To describe these conditions in Michigan pepper production, weekly pepper sales data from the US Department of Agriculture for the previous three years was used to gauge the impact of early season price fluctuations on gross revenues. Though data availability is limiting, it is assumed that if pepper growers adjust the timing of their production system, as required when using 1,3-D + Chloropicrin, that they will, over the course of the growing season, receive gross revenues reduced by approximately 7.5%. The season average price was reduced by 7.5% in the analysis of the alternatives to reflect this. Based on currently available information, the US believes this reduction in gross revenues serves as a reasonable indicator of the typical effect of planting delays resulting when MeBr alternatives are used in Michigan pepper production.

Florida

No technically (and thus economically) feasible alternatives to MeBr are presently available to the effected pepper growers. As such, the US concludes that use of MeBr is critical in Florida pepper production.

Georgia

No technically (and thus economically) feasible alternatives to MeBr are presently available to the effected pepper growers. As such, the US concludes that use of MeBr is critical in Georgia pepper production.

Southeastern USA Except Georgia

No technically (and thus economically) feasible alternatives to MeBr are presently available to the effected pepper growers. As such, the US concludes that use of MeBr is critical in Southeastern USA pepper production.

PART F. FUTURE PLANS

23. WHAT ACTIONS WILL BE TAKEN TO RAPIDLY DEVELOP AND DEPLOY ALTERNATIVES FOR THIS CROP?

Since 1997, the United States EPA has made the registration of alternatives to methyl bromide a high registration priority. Because the EPA currently has more applications pending in its registration review queue than the resources to evaluate them, EPA prioritizes the applications. By virtue of being a top registration priority, methyl bromide alternatives enter the science review process as soon as U.S. EPA receives the application and supporting data rather than waiting in turn for the EPA to initiate its review.

As one incentive for the pesticide industry to develop alternatives to methyl bromide, the Agency has worked to reduce the burdens on data generation, to the extent feasible while still ensuring that the Agency's registration decisions meet the Federal statutory safety standards. Where appropriate from a scientific standpoint, the Agency has refined the data requirements for a given pesticide application, allowing a shortening of the research and development process for the methyl bromide alternative. Furthermore, Agency scientists routinely meet with prospective methyl bromide alternative applicants, counseling them through the preregistration process to increase the probability that the data is done right the first time and rework delays are minimized

The U.S. EPA has also co-chaired the U.S.DA/EPA Methyl Bromide Alternatives Work Group since 1993 to help coordinate research, development and the registration of viable alternatives. This coordination has resulted in key registration issues (such as worker and bystander exposure through volatilization, township caps and drinking water concerns) being directly addressed through USDA's Agricultural Research Service's U.S.$15 million per year research program conducted at more than 20 field evaluation facilities across the country. Also EPA's participation in the evaluation of research grant proposals each year for USDA's U.S. $2.5 million per year methyl bromide alternatives research has further ensured close coordination between the U.S. government and the research community.

The amount of methyl bromide requested for research purposes is considered critical for the development of effective alternatives. Without methyl bromide for use as a standard treatment, the research studies can never address the comparative performance of alternatives. This would be a serious impediment to the development of alternative strategies. The U.S. government estimates that peppers research will require 2844 kg per year of methyl bromide for 2005 and 2006. This amount of methyl bromide is necessary to conduct research on alternatives and is in addition to the amounts requested in the submitted CUE applications. One example of the research is a field study testing the comparative performance of methyl bromide, host resistance, cultural practices, pest management approaches for control of root-knot nematodes. Another example is a five year field study comparing methyl bromide to 1,3-D combined with biologically based materials including transplant treatments for control of weeds, root-knot nematodes and soil borne fungal pathogens.

24. HOW DO YOU PLAN TO MINIMIZE THE USE OF METHYL BROMIDE FOR THE CRITICAL USE IN THE FUTURE?

See Section 23 above.

25. ADDITIONAL COMMENTS ON THE NOMINATION?

New data used in this CUN

1. Southeastern states, including Georgia

New data on potential MB alternatives for use on peppers were submitted by the Georgia and Southeast U.S. Peppers Consortium. Results of a small plot field study conducted in Tifton, Georgia by Culpepper and Langston (2004) show that 1,3-D + chloropicrin, followed by more chloropicrin, was more effective than MB against yellow nutsedge, but less effective against purple nutsedge. Although this treatment performed as well as MB in terms of spring crop yield, its fall yield performance was inferior to that of MB. In a second treatment, 1,3-D by itself, followed by chloropicrin, was significantly less effective than methyl bromide for the control of both purple and yellow nutsedge, but as effective as MB for the control soil nematodes. In terms of spring and fall pepper yield, however, this treatment performed as well as MB. In a third treatment, 1,3-D + chloropicrin, followed by metam sodium, was as effective as MB against yellow nutsedge, 36% less effective than MB against purple nutsedge, and as effective as MB for the control of soil nematodes. This treatment also performed as well as MB in terms of both spring and fall pepper yield. Although these combinations are showing promise, they will require further testing and validation.

Ongoing research at University of Florida includes various techniques with existing chemical alternatives as well as the development of new chemistries, such as propargyl bromide, a compound with reduced risk. The efficacy of pre plant herbicides and soil-applied fumigants depends on the physical, chemical and biological properties of the soil. The depth of the incorporation could play a critical role in the efficacy of a given chemical alternative, because of the changes in soil humidity, microbial activity, and temperature. These changes could alter the chemistry of the applied chemicals.

In addition, the Florida Fruit and Vegetable Association has been screening, as stand-alone MB replacements, 1,3-D, chloropicrin, metam sodium, and dazomet evaluated against 98:2 and 67:33 MB + chloropicrin formulations at the maximum allowable label rate at multiple locations. Results indicate that the best alternatives will likely include a pre-plant application of 1,3-D + chloropicrin, followed by an application of chloropicrin injected into the raised bed and a herbicide mix applied to the raised bed at plastic laying.

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APPENDIX A. 2007 Methyl Bromide Usage Numerical Index (BUNI).

Methyl Bromide Critical Use Exemption Process — **Date:** 1/28/2005 — **Average Hectares in the US:** 37,557

2007 Methyl Bromide Usage Numerical Index (BUNI) — **Sector:** PEPPERS — **% of Average Hectares Requested:** 35%

REGION	2007 Amount of Request: Kilograms (kgs)	Hectares (ha)	Use Rate (kg/ha)	2001 & 2002 Average Use*: Kilograms (kgs)	Hectares (ha)	Use Rate (kg/ha)	Quarantine and Pre-Shipment	Regional Hectares: 2003 Hectares	% of 2001 & 2002 Avg	Requested %	Research Amount (kgs)
CALIFORNIA*	136,078	759	179	44,743	284	157	0%	10,659	3%	7%	2844
SOUTHEASTERN US	240,086	1,599	150	135,238	900	150	0%	5,806	16%	28%	
GEORGIA	347,183	2,312	150	342,716	2,282	150	0%	2,899	79%	80%	
FLORIDA	1,415,207	8,417	168	1,345,667	8,468	159	0%	7,893	107%	107%	
MICHIGAN	15,195	127	120	15,924	133	120	0%	816	16%	16%	
TOTAL OR AVERAGE	2,153,749	13,213	163	1,884,288	12,067	156	0%	28,074	43%	47%	

2007 Nomination Options	Subtractions from Requested Amounts (kgs)					Combined Impacts Adjustment (kgs)		Adoption Transition Adjustment (kgs)		MOST LIKELY IMPACT VALUE		
REGION	2007 Request	(-) Double Counting	(-) Growth	(-) Use Rate Adjustment	(-) QPS	HIGH	LOW	HIGH	LOW	Kilograms (kgs)	Hectares (ha)	Use Rate (kg/ha)
CALIFORNIA	136,078	-	91,334	-	-	33,558	8,949	28,524	7,606	12,522	80	157
SOUTHEASTERN US	240,086	-	104,848	-	-	108,191	63,562	96,560	56,729	66,089	440	150
GEORGIA	347,183	-	4,467	-	-	281,027	174,785	251,519	156,432	178,778	1,190	150
FLORIDA	1,415,207	-	69,540	-	-	1,197,643	901,597	1,085,364	817,072	880,121	5,538	159
MICHIGAN	15,195	-	-	-	-	11,396	11,396	11,396	11,396	11,396	95	120
Nomination Amount	2,153,749	2,153,749	1,883,560	1,883,560	1,883,560	1,631,815	1,160,289	1,473,364	1,049,237	1,148,907	7,343	156
% Reduction from Initial Request	0%	0%	13%	13%	13%	24%	46%	32%	51%	47%	44%	4%

Adjustments to Requested Amounts	Use Rate (kg/ha)		(%) Karst (Telone)		(%) 100 ft Buffer Zones		(%) Key Pest Distribution		Regulatory Issues (%)		Unsuitable Terrain (%)		Cold Soil Temp (%)		Combined Impacts (%)		Adoption / Transition	
REGION	Low	EPA	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	HIGH	LOW	% adopt	% per year
CALIFORNIA	157	157	0	0	0	0	100	100	26	17	0	0	0	0	75%	20%	75%	15%
SOUTHEASTERN US	150	150	0	0	0	0	80	47	0	0	0	0	0	0	80%	47%	86%	11%
GEORGIA	150	150	8	8	0	0	80	47	0	0	0	0	0	0	82%	51%	84%	11%
FLORIDA	159	159	40	40	1	1	80	47	0	0	0	0	0	0	89%	67%	75%	9%
MICHIGAN ***	120	120	0	0	0	0	75	75	0	0	0	0	75	75	75%	75%	0%	0%

Other Considerations	Dichotomous Variables (Y/N)						Other Issues			Economic Analysis					
REGION	Strip Bed Treatment	Currently Use Alternatives?	Research / Transition Plans	Tarps/ Deep Injection Used	Pest-free Cert. Requirement	Adopt New Fumigants	Change from Prior CUE Request (+/-)	Verified Historic MeBr Use / State	Frequency of Treatment	Loss per Hectare (US$/ha)	Loss per Kilogram of MeBr (US$/kg)	Loss as a % of Gross Revenue	Loss as a % of Net Revenue	Quality/ Time/ Market Window/ Yield Loss (%)	
CALIFORNIA	Yes	Yes	Yes	Tarp	No	Yes	0	Yes	1/year	$ 1,194	$ 8	6%	29%	6%	1,3-D + Pic
SOUTHEASTERN US	Yes	Yes	Yes	Tarp	No	Yes	+	Yes	1/year	$ 8,954	$ 60	29%	76%	29%	1,3-D + Pic
	Yes	Yes	Yes	Tarp	No	Yes	+	Yes	1/year	$ 11,429	$ 76	37%	97%	44%	Metam-Sodium
GEORGIA	Yes	Yes	Yes	Tarp	No	Yes	+	Yes	1/year	$ 7,368	$ 49	21%	112%	29%	1,3-D + Pic
	Yes	Yes	Yes	Tarp	No	Yes	+	Yes	1/year	$ 10,453	$ 70	30%	160%	44%	Metam-Sodium
FLORIDA	Yes	Yes	Yes	Tarp	No	Yes	-	Yes	1/year	$ 6,724	$ 45	23%	73%	29%	1,3-D + Pic
	Yes	Yes	Yes	Tarp	No	Yes	-	Yes	1/year	$ 9,637	$ 64	33%	105%	44%	Metam-Sodium
MICHIGAN	Yes	Yes	Yes	Tarp	No	No	N/A	Yes	1/year	$ 4,808	$ 40	20%	100%	22% -6 yield + 16 planting delay	1,3-D + Pic

Pest Distribution GA used Stanley Culpepper, UGA survey. GA figures were used for FL and SE US

High estimate adds moderate and severe, Low estimate add 1/2 of moderate and all severe

*Georgia rotates crops with solanaceous crops therefore we had to balance the distribution with the other sectors in Georgia's application.

**Georgia Acreage estimates verified at http://www.caed.uga.edu/2003gafgveg.pdf

***Michigan rates are higher for 2007 based on more current information.

Conversion Units:
1 Pound = 0.453592 Kilograms
1 Acre = 0.404686 Hectares

Most Likely Impact Value: High 24% Low 77%

Footnotes for Appendix A:

Values may not sum exactly due to rounding.

1. **Average Hectares in the US** – Average Hectares in the US is the average of 2001 and 2002 total hectares in the US in this crop when available. These figures were obtained from the USDA National Agricultural Statistics Service.
2. **% of Average Hectares Requested** - Percent (%) of Average Hectares Requested is the total area in the sector's request divided by the Average Hectares in the US. Note, however, that the NASS categories do not always correspond one to one with the sector nominations in the U.S. CUE nomination (e.g., roma and cherry tomatoes were included in the applicant's request, but were not included in NASS surveys). Values greater than 100 percent are due to the inclusion of these varieties in the U.S. CUE request that were not included in the USDA NASS: nevertheless, these numbers are often instructive in assessing the requested coverage of applications received from growers.
3. **2007 Amount of Request** – The 2007 amount of request is the actual amount requested by applicants given in total pounds active ingredient of methyl bromide, total acres of methyl bromide use, and application rate in pounds active ingredient of methyl bromide per acre. U.S. units of measure were used to describe the initial request and then were converted to metric units to calculate the amount of the US nomination.
4. **2001 & 2002 Average Use** – The 2001 & 2002 Average Use is the average of the 2001 and 2002 historical usage figures provided by the applicants given in total pounds active ingredient of methyl bromide, total acres of methyl bromide use, and application rate in pounds active ingredient of methyl bromide per acre. Adjustments are made when necessary due in part to unavailable 2002 estimates in which case only the 2001 average use figure is used.
5. **Quarantine and Pre-Shipment** – Quarantine and pre-shipment (QPS) hectares is the percentage (%) of the applicant's request subject to QPS treatments.
6. **Regional Hectares, 2001 & 2002 Average Hectares** – Regional Hectares, 2001 & 2002 Average Hectares is the 2001 and 2002 average estimate of hectares within the defined region. These figures are taken from various sources to ensure an accurate estimate. The sources are from the USDA National Agricultural Statistics Service and from other governmental sources such as the Georgia Acreage estimates.
7. **Regional Hectares, Requested Acreage %** - Regional Hectares, Requested Acreage % is the area in the applicant's request divided by the total area planted in that crop in the region covered by the request as found in the USDA National Agricultural Statistics Service (NASS). Note, however, that the NASS categories do not always correspond one to one with the sector nominations in the U.S. CUE nomination (e.g., roma and cherry tomatoes were included in the applicant's request, but were not included in NASS surveys). Values greater than 100 percent are due to the inclusion of these varieties in the U.S. CUE request that were not included in the USDA NASS: nevertheless, these numbers are often instructive in assessing the requested coverage of applications received from growers.
8. **2007 Nomination Options** – 2007 Nomination Options are the options of the inclusion of various factors used to adjust the initial applicant request into the nomination figure.
9. **Subtractions from Requested Amounts** – Subtractions from Requested Amounts are the elements that were subtracted from the initial request amount.
10. **Subtractions from Requested Amounts, 2007 Request** – Subtractions from Requested Amounts, 2007 Request is the starting point for all calculations. This is the amount of the applicant request in kilograms.
11. **Subtractions from Requested Amounts, Double Counting** - Subtractions from Requested Amounts, Double Counting is the estimate measured in kilograms in situations where an applicant has made a request for a CUE with an individual application while their consortium has also made a request for a CUE on their behalf in the consortium application. In these cases the double counting is removed from the consortium application and the individual application takes precedence.
12. **Subtractions from Requested Amounts, Growth or 2002 CUE Comparison** - Subtractions from Requested Amounts, Growth or 2002 CUE Comparison is the greatest reduction of the estimate measured in kilograms of either the difference in the amount of methyl bromide requested by the applicant that is greater than that historically used or treated at a higher use rate or the difference in the 2007 request from an applicant's 2002 CUE application compared with the 2007 request from the applicant's 2003 CUE application.
13. **Subtractions from Requested Amounts, QPS** - Subtractions from Requested Amounts, QPS is the estimate measured in kilograms of the request subject to QPS treatments. This subtraction estimate is calculated as the 2007 Request minus Double Counting, minus Growth or 2002 CUE Comparison then

multiplied by the percentage subject to QPS treatments. *Subtraction from Requested Amounts, QPS = (2007 Request – Double Counting – Growth)*(QPS %)*

14. **Subtraction from Requested Amounts, Use Rate Difference** – Subtractions from requested amounts, use rate difference is the estimate measured in kilograms of the lower of the historic use rate or the requested use rate. The subtraction estimate is calculated as the 2007 Request minus Double Counting, minus Growth or 2002 CUE Comparison, minus the QPS amount, if applicable, minus the difference between the requested use rate and the lowest use rate applied to the remaining hectares.
15. **Adjustments to Requested Amounts** – Adjustments to requested amounts were factors that reduced to total amount of methyl bromide requested by factoring in the specific situations were the applicant could use alternatives to methyl bromide. These are calculated as proportions of the total request. We have tried to make the adjustment to the requested amounts in the most appropriate category when the adjustment could fall into more than one category.
16. **(%) Karst topography** – Percent karst topography is the proportion of the land area in a nomination that is characterized by karst formations. In these areas, the groundwater can easily become contaminated by pesticides or their residues. Regulations are often in place to control the use of pesticide of concern. Dade County, Florida, has a ban on the use of 1,3D due to its karst topography.
17. **(%) 100 ft Buffer Zones** – Percentage of the acreage of a field where certain alternatives to methyl bromide cannot be used due the requirement that a 100 foot buffer be maintained between the application site and any inhabited structure.
18. **(%) Key Pest Impacts** - Percent (%) of the requested area with moderate to severe pest problems. Key pests are those that are not adequately controlled by MB alternatives. For example, the key pest in Michigan peppers, *Phytophthora* spp. infests approximately 30% of the vegetable growing area. In southern states the key pest in peppers is nutsedge.
19. **Regulatory Issues (%)** - Regulatory issues (%) is the percent (%) of the requested area where alternatives cannot be legally used (e.g., township caps) pursuant to state and local limits on their use.
20. **Unsuitable Terrain (%)** – Unsuitable terrain (%) is the percent (%) of the requested area where alternatives cannot be used due to soil type (e.g., heavy clay soils may not show adequate performance) or terrain configuration, such as hilly terrain. Where the use of alternatives poses application and coverage problems.
21. **Cold Soil Temperatures** – Cold soil temperatures is the proportion of the requested acreage where soil temperatures remain too low to enable the use of methyl bromide alternatives and still have sufficient time to produce the normal (one or two) number of crops per season or to allow harvest sufficiently early to obtain the high prices prevailing in the local market at the beginning of the season.
22. **Combined Impacts (%)** - Total combined impacts are the percent (%) of the requested area where alternatives cannot be used due to key pest, regulatory, soil impacts, temperature, etc. In each case the total area impacted is the conjoined area that is impacted by any individual impact. The effects were assumed to be independently distributed unless contrary evidence was available (e.g., affects are known to be mutually exclusive). For example, if 50% of the requested area had moderate to severe key pest pressure and 50% of the requested area had karst topography, then 75% of the area was assumed to require methyl bromide rather than the alternative. This was calculated as follows: 50% affected by key pests and an additional 25% (50% of 50%) affected by karst topography.
23. **Adaptation / Transition** - Estimate of the percentage of the weighted usage that can be transitioned to a marginal strategy. This estimate is for areas of low to moderate pest pressure, where some growers may employ a marginal strategy without major economic dislocation if given a reasonable time frame for the transition.
24. **Qualifying Area** - Qualifying area (ha) is calculated by multiplying the adjusted hectares by the combined impacts.
25. **Use Rate** - Use rate is the lower of requested use rate for 2007 or the historic average use rate.
26. **CUE Nominated amount** - CUE nominated amount is calculated by multiplying the qualifying area by the use rate.
27. **Percent Reduction** - Percent reduction from initial request is the percentage of the initial request that did not qualify for the CUE nomination.
28. **Sum of CUE Nominations in Sector** - Self-explanatory.
29. **Total US Sector Nomination** - Total U.S. sector nomination is the most likely estimate of the amount needed in that sector.

30. **Dichotomous Variables** – dichotomous variables are those which take one of two values, for example, 0 or 1, yes or no. These variables were used to categorize the uses during the preparation of the nomination.
31. **Strip Bed Treatment** – Strip bed treatment is 'yes' if the applicant uses such treatment, no otherwise.
32. **Currently Use Alternatives** – Currently use alternatives is 'yes' if the applicant uses alternatives for some portion of pesticide use on the crop for which an application to use methyl bromide is made.
33. **Research/ Transition Plans** – Research/ Transition Plans is 'yes' when the applicant has indicated that there is research underway to test alternatives or if applicant has a plan to transition to alternatives.
34. **Tarps/ Deep Injection Used** – Because all pre-plant methyl bromide use in the US is either with tarps or by deep injection, this variable takes on the value 'tarp' when tarps are used and 'deep' when deep injection is used.
35. **Pest-free cert. Required** - This variable is a 'yes' when the product must be certified as 'pest-free' in order to be sold
36. **Other Issues**.- Other issues is a short reminder of other elements of an application that were checked
37. **Change from Prior CUE Request**- This variable takes a '+' if the current request is larger than the previous request, a '0' if the current request is equal to the previous request, and a '-' if the current request is smaller that the previous request.
38. **Verified Historic Use/ State**- This item indicates whether the amounts requested by administrative area have been compared to records of historic use in that area.
39. **Frequency of Treatment** – This indicates how often methyl bromide is applied in the sector. Frequency varies from multiple times per year to once in several decades.
40. **Economic Analysis** – provides summary economic information for the applications.
41. **Loss per Hectare** – This measures the total loss per hectare when a specific alternative is used in place of methyl bromide. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars.
42. **Loss per Kilogram of Methyl Bromide** – This measures the total loss per kilogram of methyl bromide when it is replaced with an alternative. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars.
43. **Loss as a % of Gross revenue** – This measures the loss as a proportion of gross (total) revenue. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars.
44. **Loss as a % of Net Operating Revenue** -This measures loss as a proportion of total revenue minus operating costs. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars. This item is also called net cash returns.
45. **Quality/ Time/ Market Window/Yield Loss (%)** – When this measure is available it measures the sum of losses including quality losses, non-productive time, missed market windows and other yield losses when using the marginal strategy.
46. **Marginal Strategy** -This is the strategy that a particular methyl bromide user would use if not permitted to use methyl bromide.

APPENDIX B. 2006 Methyl Bromide Reconsideration for Peppers.

Overview of the U.S. Nomination

The U.S. requested 1,498.53 metric tons of methyl bromide for use on pepper crops in the U.S. for 2006. This amount was requested for California (59.659 metric tons), Florida (1,006.074 metric tons), Georgia (242.761 metric tons), Michigan (9.482 metric tons), and a group of States in the southeastern part of the U.S. (77.711 metric tons).[1]

The U.S. nomination is only for those areas where the alternatives are not suitable. In U.S. pepper production there are several factors that make the potential alternatives to methyl bromide unsuitable. These include:

- pest control efficacy of alternatives: the efficacy of alternatives may not be comparable to methyl bromide in some areas, making these alternatives technically and/or economically infeasible for use in pepper production.
- geographic distribution of key target pests[2]: i.e., some alternatives may be comparable to methyl bromide as long as key pests occur at low pressure, and in such cases the U.S. is only nominating a CUE for peppers where the key pest pressure is moderate to high. An example is areas of moderate to high nutsedge infestation in the Southeastern U.S.
- regulatory constraints: e.g., 1,3 D use is limited in Georgia and Florida due to the presence of karst geology and in California due to township caps.
- delay in planting and harvesting: e.g., the plant-back interval for 1,3 D + chloropicrin is two weeks longer than methyl bromide + chloropicrin, and in Michigan an additional delay would occur because soil temperature must be higher to fumigate with alternatives (this is a regulatory requirement). Delays in planting and harvesting result in users missing key market windows, and adversely affect revenues through lower prices. In addition, delay in planting and harvesting may preclude the planting and harvesting of an additional crop on the treated acreage, causing an additional economic loss.
- cold soil temperatures: some alternatives cannot be used effectively and are precluded from such uses by the label until the soil temperatures is above 40° F (approximately 5° C.)

MBTOC recommended 804.033 tons of methyl bromide for this use distributed as follows: 9.482 tons for Michigan; 172.629 tons for Georgia; 525.121 tons for Florida; 55.261 tons for the southeastern US; and 41.511 tons for California.

MBTOC does not appear to have accounted for the new information regarding the extent of nutsedge infestation affecting this crop. MBTOC suggests that alternatives are available in California, that growers are using more than 200kg/ha, and that alternatives are both technically and economically feasible in non-karst areas of the southeastern U.S. (including Georgia and Florida) so that 20% is deducted for that phasing of alternatives. We will address each of these issues separately.

[1] These states are: Alabama, Arkansas, Kentucky, Louisiana, North Carolina, South Carolina, Tennessee, and Virginia. These States have similar climate and terrain and face similar pests.
[2] Key target pasts are those pests that cannot be controlled by available alternatives to methyl bromide.

a. MBTOC used their own numbers for nutgrass (nutsedge) rather than the numbers provided by the U.S.

In 2003, Dr. Stanley Culpepper of the University of Georgia conducted a survey of land under cultivation with various crops to determine the proportion of land (by crop) that was infested with various levels of nutsedge. The values selected were those used in published literature and characterized as 'none' (no plants per square yard[3]), 'light' (fewer than five plants per square yard), 'moderate' (five to thirty plants per square yard), and 'severe' (more than thirty plants per square yard). This information was used to estimate nutsedge information for the entire southeastern region (including the State of Florida) because the entire region has similar climate, soils and rainfall. In the judgment of U.S. government experts, familiar with U.S. agriculture and with the southeastern growing regions in particular, nutsedge infestations are similar throughout the region[4]. For the previous year's estimates of nutsedge infestation (those used in the 2005 nomination), similar estimates were used throughout the southeastern growing region. These estimates were the fruit of a half dozen phone calls to growers with large tomato operations in one or more of the southeastern states. The estimates derived were applied to all crops in all of the southeastern states. The new data represented a significant improvement in accuracy over the previous estimates, in the judgment of U.S. experts familiar with the circumstances of the nomination. The USG is requesting restoration of the amount deducted for this factor.[5]

Information used for the 2005 nomination was developed by asking some large tomato operations (growers with large tomato acreages in several states) to 'guestimate' the proportion of tomato-growing acreage impacted by 'none', 'light', 'moderate' and 'heavy' nutsedge infestations and to compare these across that various states in which the growers have operations. Information on the proportion of impacted tomato area was then used for other crops throughout the southeastern growing region.

The effort to gather more refined and reliable estimates of the prevalence of this key pest was one of many improvements in estimating the amount of methyl bromide critically needed by U.S. agriculture, which was undertaken to provide MBTOC with the best information possible. Replacing U.S.-provided survey values with MBTOC-derived values with no explanation of how MBTOC is better able to make this judgment than are the U.S. officials familiar with actual conditions casts doubt on the integrity of the MBTOC deliberative process.

[3] One square yard is approximately 9/10 of a square meter.

[4] Conversations with officials in the State of Florida regarding the extent of nutsedge infestation indicate that these officials believe that the infestation in Florida is more severe that in Georgia. They are currently investigating whether a survey of cultivated land in Florida for nutsedge infestation can be undertaken.

[5] The U.S. is unable to exactly determine how that various factors that MBTOC used were reflected in the final amounts. The U.S. technical experts had been promised a spreadsheet so that the amounts could be disaggregated but were not provided with one.

b. Alternatives are technically and economically feasible so a 20% reduction for phase-in of alternatives such as 1,3D/Pic or metam sodium was used: alternatives can be used in areas where 1,3-D use is not appropriate

MBTOC disagrees with the U.S. assessments of yield loss, which is the basis for the MBTOC recommendation of economic feasibility.

The U.S. assessments of yield loss were developed from technically appropriate studies relevant to the specific circumstances of the U.S. situation. Technically appropriate studies are those which:

- Included an untreated control for comparison purposes
- Included information on the (key) pests present in the treated area
- Give estimates of yield changes (differences)
- Include methyl bromide as a standard

The U.S. nomination was restricted to those situations where the presence and prevalence of pests ('key' pests) that could not be controlled by alternatives to methyl bromide was moderate to severe[6] and would result in yield loss.

The U.S. technical experts asked MBTOC to explain the basis for their decision[7] and were told that in some cases a meta analysis served as the basis, and in other cases the basis was 'experience'. The procedure MBTOC used, as we understand it, was not a meta analysis. A meta analysis includes a statistical analysis of the information, and compares only those studies which are similar enough from a statistical standpoint that they can be combined and analyzed as if they comprised one study. Further, the studies need to be identified, appraised and summarized according to an explicit and reproducible methodology that is designed to answer a specific research question. In this case, the appropriate research question would be the performance of alternatives to methyl bromide under the conditions of the U.S. nomination (i.e. with moderate to severe pressure from key pests). The studies used in the meta analysis are not listed and no indication is given of the criteria used to include or exclude a study from the analysis, which presents a serious problem in applying the results. Our understanding is that this analysis does include some studies conducted under circumstances that are not similar to the limited conditions included in the U.S. nomination, such as the presence of moderate to severe pest pressure.

The null hypothesis would be that alternatives work as well as methyl bromide in the conditions of the U.S. nomination. The U.S. nomination is specifically for the use of methyl bromide where key pests (pests not adequately controlled by alternatives to methyl bromide) are present at moderate to severe levels and/or soil, climate, terrain, or regulatory conditions are such that alternatives to methyl bromide either cannot be used or result in significant economic losses

[6] In the judgment of U.S. experts pressure was such that yield losses of the magnitude of those used in the economic assessment would be sustained.
[7] MBTOC asserted that alternatives were both technically and economically feasible for the pre-plant sectors of field grown peppers, strawberries, and tomatoes.

when used. These economic losses must be of sufficient magnitude that they render the alternative not economically feasible.

When asked for references, USG experts were directed to "the Porter paper in press". USG experts have examined a "Porter paper in press"[8] and find a number of concerns with respect to its application to the specific circumstances of the U.S. nomination. Although it is difficult to be certain how the MBTOC analysis was conducted and what it includes because it has not been reviewed and published and was not provided to the U.S. experts to evaluate[9], U.S. experts were able to make some educated guesses about the analysis[10].

A version of the paper was presented by Dr. Ian Porter at the Methyl Bromide Alternatives Organization meeting in San Diego, November 2003 and was the subject of some controversy and concern among a number of participants. Dr. Porter's paper included a number of papers, which U.S. experts believe are not appropriate for use in determining the usefulness of alternatives because the research was carried out under conditions of no pest pressure, and are therefore not relevant to the specific circumstances of our nomination[11]. If few or no pests are present, any alternative, or indeed not using any pesticide at all, will all work equally well. By including situations where there is no pest pressure one in effect adds (many) "100" to the equation[12] describing the differences in yield between crops grown using methyl bromide and those grown using an alternative. This has the effect of lowering the average difference between yields using methyl bromide and yields using an alternative. If a sufficient number of "100" are added, the result will be to (falsely) eliminate the yield differences between methyl bromide and the alternatives.

In other papers, pests were present but they were not the pests present in all of the U.S. circumstances. Taking the case of the southeastern US, for example, weeds, diseases, fungi, and nematodes all afflict the crops. Some of these pests can be controlled with alternatives, but some of the weeds, in particular nutsedges (nut grasses), nightshades, and some hard coated seeds, cannot. Situations without weeds will show small or no yield losses when alternatives are used while the true situation when (key) weeds are present is that there are relatively large yield

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[8] Porter,I., S. Mattner, R. Mann, R. Gounder, J. Banks, and P. Fraser. 1994. Strawberry Fruit Production and results from trials in Different Geographic Regions. A Presentation to the Methyl Bromide Alternatives Conference, Lisbon, September 1994.

[9] U.S. experts requested references from some of the authors of the studyso that the studies included could be evaluated against the circumstances of the U.S. nomination, but they have not been provided.

[10] Some of this material had been previously presented at the Methyl Bromide Alternatives Organization 2003 meeting (San Diego). At that time U.S. experts expressed their view that many if not most of the studies were not an appropriate application of the information.

[11] For example, some trials are used for residue tests. These tests are likely to be carried out in conditions of little or no pest pressure in order to have enough harvested fruit to to test for residue. The Porter paper does not indicate which of the studies used (but not cited) where for the purposes of examining pesticide residues.

[12] The actual procedure was to add in yields expressed as a percentage of (anticipated) yield using methyl bromide. How this yield was estimated is puzzling as many of the studies did not include a methyl bromide control. Because there was no indication of pest pressure in many instances, many of the entries indicated yields of approximately 100%, obviating the differences between methyl bromide and the alternatives.

losses. Including these factors again has the effect of adding "100" yield difference as many times as there are these papers.

If the issue in question was to average all papers, describing some "average" worldwide situation, the procedure would be correct. However, The U.S. submitted requests for continued methyl bromide use only in instances of sufficiently high pest pressure (not 'average' conditions) for pests which cannot be controlled by alternatives to methyl bromide.

In the case of crops other than strawberries, the basis for MBTOC's suggestion of no differences in yields between methyl bromide treatments and treatments with the alternatives is more difficult to assess. MBTOC indicated to us in recent meetings at MOP-16 that their expert judgment was the basis for the finding that alternatives were technically and economically feasible. It is impossible to determine from this statement whether the conditions used by the experts to make their findings are similar to the particular conditions of the U.S. nomination. Given what we already know about the applicability of the meta analysis for strawberries to the U.S. circumstances, we are concerned that MBTOC may not be limiting their evaluation to experience accrued in situations similar to those prevailing in the portions of the U.S. for which methyl bromide is requested, but rather relying on more generalized experience to make these judgments for which references have been provided.The U.S. disagrees with the MBTOC assessment of yield loss in the circumstances of the U.S. nomination.

Turning now to the component of economic loss that is a consequence of market timing we find that MBTOC has not accounted for losses arising from missing market windows, and other losses due to timing, such as shorter harvesting periods and loss of the opportunity to plant a 'follow-on' or second crop.

Experts are familiar with high prices for fresh produce early in the season, prices which decline as the produce becomes abundant (and more familiar) later in the season. The U.S. has provided marketing data documenting the existence of these market windows and their effects on the revenue and profits earned by farmers. Anecdotally, farmers tell us that virtually al of their net revenue (approximately 90%) above cost is earned during the short period of high prices. For some crops, 75% of the economic loss is due to missing a market window rather than through smaller crops, lower fruit quality, or higher costs of using alternatives

Many of the alternatives will cause farmers to miss the market window. In conditions of cold soil temperatures, such as in Michigan and coastal California, where the growing season is short, alternatives cannot be used until the soil temperatures reach at least 40 F. This temperature is reached 3-4 weeks into the growing season, delaying planting and consequently harvesting for that time. Because the Michigan growing season is already short due to the cold temperatures, even apart from missing the market window, delaying planting will result in a smaller harvestable amount. In other situations the "plant-back" interval is longer, by two weeks, relative to the methyl bromide plant back times. Requiring a longer interval before a crop can be planted will delay the harvesting, again causing a farmer to miss a market window. Some alternatives also require a different bed preparation, which will also delay the planting time. The strawberry crop in California is one example of this situation.

It is not clear that MBTOC considered the specific circumstances of the U.S. nomination, which are that methyl bromide is requested only for situations where regulatory concerns preclude use of an alternative or where there are ‘key’ pests present at moderate to severe levels, or where terrain conditions (temperature, topography) result in no alternative being technically and economically feasible. MBTOC has not referenced research findings to support their view that alternatives are both technically and economically feasible, while the U.S. has presented extensive results in the circumstances of the nomination to support our request.

Georgia

Peppers are generally produced using mechanized practices that involve injection of methyl bromide to a depth of 20 – 25 cm. Weeds, especially nutsedge, are the most serious concern precipitating MB use in both transplant beds and the field although nightshade and hard coated seeds are also problems. Nutsedge species grow even under adverse conditions, resist traditional and modern methods of weed control, and are endemic to large tracts of pepper producing area in the Southeastern United States. Herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds. Most preemergence herbicides do not provide effective control of nutsedge for one crop cycle let alone multiple crop cycles. Many of the newer sulfonyl urea herbicides are not as effective preemergence as is necessary to be effective under the plastic tarps as postemergence (60 to 70 percent for one crop cycle versus 90% postemergence). In addition to weeds, soil-borne fungal pathogens (such as *Phytophthora* blight) and plant-parasitic nematodes (e.g. *Meloidogyne* spp.) are endemic to the region and nearly all production areas have severe infestations, thereby necessitating annual treatment with a broad-spectrum soil fumigant. Fungal pests are expected to become serious problems for pepper production if MB were not available for pre-plant fumigation. Methyl bromide is believed to be the only treatment currently available that consistently provides reliable control of nutsedge species and the disease complex affecting pepper production. (Locascio et al., 1997).

Alternatives like 1,3-dichloropropene and metam sodium require a 21 to 28-day interval before planting, compared to 14 days for MB or methyl bromide with Pic. This interval can cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops (Kelley, 2003

Nutsedge management has proven to be difficult due to the perennial growth habit of nutsedge and tubers as primary means of propagation. There are no herbicides which control nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041.) S-metolachlor can suppress yellow nutsedge for a single crop cycle but would need to be reapplied for multiple crops along with removing and replacing the existing plastic tarps. Approximately 81% of the Georgia pepper area is considered to have moderate to severe infestations of nutsedge (Culpepper, 2004). Research suggests that metam sodium can, in some situations, provide effective pest management for certain diseases and weeds. However, even though there have been nearly 50 years experience with metam sodium, (which breaks down to methyl isothiocyanate) nutsedge control results have been unpredictable.

Locascio et al. (1997) studied MB alternatives on tomatoes grown in small plots at two Florida locations with high nutsedge infestation. (The data from this tomato study are being cited because comparable pepper data are not available.)

Various treatments were tested on plots that had multiple pests. At the Bradenton site there was moderate to heavy *Fusarium* infestation; heavy purple nutsedge infestation and light root-knot nematode pressure. At Gainesville there was heavy infestation of yellow and purple nutsedge and moderate infestation of root-knot nematode. The treatments at both locations included MB (67%) + chloropicrin (33%) chisel-injected at 390 kg/ha; metam-sodium (chisel-injected) at 300L/ha; metam-sodium drip-irrigated at 300L/ha; and 1,3-D + 17% chloropicrin chisel-injected at 327L/ha. In pairwise statistical comparisons, the yield was significantly lower in metam-sodium treatments compared to MB at both sites. At Bradenton, the average yield from both metam-sodium treatments was 33% of the MB yields, suggesting a 67% yield loss from not using MB. At Gainesville the average yield of the two metam-sodium treatments was 56% of the MB yield, suggesting a 44% yield loss from not using MB. The yield of the 1,3-D treatment at Gainesville was 71% of the MB standard suggesting a 29% loss by not using MB (yield data for 1,3-D were not reported for Bradenton). In considering 1,3 D results, one must keep in mind that this MB alternative cannot be used in areas where karst geology exists

Further, due to regulatory restrictions resulting from groundwater contamination concerns, 1,3-D + chloropicrin cannot be used in large portions of the southeastern United States due to the presence of karst geology.

Furthermore, trials of metam-sodium and 1,3 D + chloropicrin (and various combinations thereof) are based on small plot research trials conducted in the Southeastern United States on crops other than peppers. For fungi and nutsedge, no on-farm, large-scale trials have yet been done. Some researchers have also reported that these MB alternatives degrade more rapidly in areas where they are applied repeatedly due to enhanced metabolism by soil microbes (Dungan and Yates 2003, Gamliel et al. 2003). This may compromise long-term efficacy of these compounds and appears to need further scientific scrutiny.

For the Southeastern United States, including Florida and Georgia, metam-sodium and 1,3 D + chloropicrin are alternatives for nutsedges and nematodes, respectively, the key target pests in these regions. However, peppers treated with metam-sodium, the best available alternative, have an estimated 44 percent yield decrease compared to MB. 1,3 D + chloropicrin is infeasible because it cannot used on karst geology or in Dade county, Florida, and because there is a 28-day planting delay.

There is also evidence that the efficacy of 1,3-D and metam-sodium declines in areas where it is repeatedly applied due to enhanced degradation of methyl isothiocyanate, the active ingredient, by soil microbes (Ashley et al. 1963, Ou et al. 1995, Verhagen et al. 1996, Gamliel et al. 2003).

In sum, neither of these MB alternatives is presently technically and economically feasible for control of key pests, and MB remains a critical use for peppers in the Southeastern United States.

The U.S. assessment that the alternatives are not technically and economically feasible rests on two kinds of losses[13]: changes in yields which result in a lesser amount harvested and therefore lower revenues to farmers, and later yields which resulted in further reduced revenues to farmers (missed market windows, shorter harvest periods, the inability to grow a second crop). The proportion of loss attributable to each component differs from sector to sector, and within sectors, depending on the local circumstances of the nomination. As an example, for tomatoes in both Michigan and the southeastern United States, approximately 70% to 75% of the loss is attributable to missing the high value market time and 25% to 30% of the loss is attributable to lower yield.

There are currently few alternatives to methyl bromide for use in peppers. Furthermore, there are factors that limit existing alternatives' usability and efficacy from place to place. These include pest complex, climate, and regulatory restrictions. As described above, the two most promising alternatives to methyl bromide in Georgia for control of nutsedge in peppers (1,3-D + chloropicrin and metam-sodium) are considered not technically feasible. This derives from regulatory restrictions and the magnitude of expected yield losses when they are used. MBTOC does not appear to have taken into account planting delays resulting from use of alternative pesticide treatments. These delays cause growers to lose all or part of a market window. In the case of peppers (in particular) missing the early part of the winter growing season causes hugely disproportionate losses in grower net revenues.

Florida

Peppers are generally produced using mechanized practices that involve injection of methyl bromide to a depth of 20 – 25 cm. Weeds, especially nutsedge, are the most serious concern precipitating MB use in both transplant beds and the field, although nightshade and hard coated seeds are also problems. Nutsedge species grow even under adverse conditions, resist traditional and modern methods of weed control, and are endemic to large tracts of pepper producing area in the Southeastern United States. Herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds - but there are no currently registered herbicides that control nutsedges near pepper plants. In addition to weeds, soil-borne fungal pathogens and plant-parasitic nematodes are endemic to the region and nearly all production areas have severe infestations, thereby necessitating annual treatment with a broad-spectrum soil fumigant.

[13] From a theoretical perspective there are additional losses that should be included: differences in costs between methyl bromide and the alternatives and changes in yield quality. Cost differences between methyl bromide and the alternatives can occur because the prices of the materials differ, amounts used differ, equipment needs differ, additional materials are needed, such as an additional herbicide, an additional application step, either of the alternative or of some ancillary material is required, or there are additional land preparation or other costs. In practice, cost differences between methyl bromide and alternatives are generally small and can usually be ignored.

Quality difference in the yield, such as smaller, scarred, less sweet, or other differences in fruit quality would also be factors in assessing economic loss. In practice quality differences have not been reported in the available literature and so losses from his source cannot be incorporated into the analysis.

There has been extensive research on alternatives for solanaceous crops, and methyl bromide minimizing practices have been incorporated into pepper production systems where possible. However, the effectiveness of chemical and non-chemical alternatives designed to fully replace methyl bromide must still be characterized as preliminary. These alternatives have not been shown to be stand-alone replacements for methyl bromide, and no combination has been shown to provide effective, economical pest control. Methyl bromide is believed to be the only treatment currently available that consistently provides reliable control of nutsedge species and the disease complex affecting pepper production. (Locascio et al., 1997) Nematodes, especially root knot nematodes (*Meloidogyne* spp.), and fungal diseases (such as *Phytophthora* blight) are also of concern. Fungal pests are expected to become serious problems for pepper production if MB were not available for pre-plant fumigation.

The sandy soils of Florida are a contributing factor to the erratic performance suppressing nematodes and plant pathogens of the metam sodium + chloropicrin combination, the most promising alternative to methyl bromide currently available for use in Dade County (because of label restrictions for 1,3-D)[14]. Methyl bromide has higher vapor pressure than metam sodium, therefore can penetrate and diffuse throughout the soil more effectively than metam sodium.

Several climatic factors appeared to contribute to increases in plant pathogens, e.g., Southern stem blight, caused by the soil-borne fungus (*Sclerotium rolfsii*) across the production area, even with methyl bromide. Variations in rainfall and soil and air temperatures may predispose developing plants to diseases caused by plant-pathogenic fungi. Furthermore, in the fall, temperature and rainfall patterns favor high levels of nematode infestation.

Alternatives like 1,3-dichloropropene and metam sodium require a 21 to 28-day interval before planting, compared to 14 days for MB. This interval can cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops (Kelley, 2003).

Weeds, particularly nutsedge, are the major pests of Florida peppers that drive the need for methyl bromide. There are no registered herbicides compatible with pepper production. Although s-metolachlor (Dual Magnum) and napropamide (Devrinol) were cited as herbicides with some potential to control nutsedges, the efficacy of these herbicides in sub-tropical Florida is inconsistent (Noling, 2003). When nutsedge pressure is moderate to severe, 1,3-D + chloropicrin is not technically feasible because it needs to be coupled with an effective herbicide to provide control for the entire growing season (U.S. EPA, 2002). Frank et al (1992) reported that weeds in pepper for 40 to 60 days could reduce yields by 10 to 50 percent. Stall and Morales-Payan reported that tomato must be nutsedge-free for 2 to10 weeks to keep yield reductions below 5 percent. There are no herbicides which control nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041).

Diseases caused by soil-borne plant pathogenic fungi, (e.g., *Phytophthora* spp., *Verticillium* spp., *Pythium* spp. and *Rhizoctonia solani*) commonly reside in many production areas, since many

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[14] By law 1,3-D cannot be used anywhere in Dade county, Florida, where the majority of that region's peppers are grown

pepper production areas are old tomato production fields. Fungicides such as chlorothalonil, and azoxystrobin are considered to be only prophylactic, and may not offer sufficient pest management. Resistance of *Phytophthora* spp to metalaxyl and mefanoxem (Ridomil and Ridomil Gold, respectively) has been reported in tomato crop areas, and most recently pepper (Lamour and Hausbeck 2003).

Nematodes, such as the root knot nematode species of *Meloidogyne* were third, following weeds and fungal pathogens, in order of causing yield and economic losses in Florida peppers. Pre-plant control of nematodes is very important because root feeding and damage may predispose the plant tissues to fungal pathogens or bacterial wilt which can lead to significant yield loss. Fumigant alternatives such as metam-sodium (Vapam, K-pam) have proven inconsistent. (Noling, 2003; CUE #03-0017).

In addition, labeling of 1,3-dichloropropene products restricts its use in key pepper growing areas of the U.S. where karst topography exists due to ground-water contamination concerns. In areas where 1,3-dichloropropene use is allowed, set back restrictions and 28-day waiting periods between application and planting cause delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profits on pepper crops. For example, peppers produced during the winter fetch a higher price than peppers produced during warmer months, and many growers rely on this price premium to maintain profitability.

Nutsedge management has proven to be difficult due to the perennial growth habit of nutsedge and tubers as primary means of propagation. Research suggests that metam sodium can, in some situations, provide effective pest management for certain diseases and weeds. However, even though there have been nearly 50 years experience with metam sodium, (which breaks down to methyl isothiocyanate) nutsedge control results have been unpredictable.

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Various treatments were tested on plots that had multiple pests. At the Bradenton site there was moderate to heavy *Fusarium* infestation; heavy purple nutsedge infestation and light root-knot nematode pressure. At Gainesville there was heavy infestation of yellow and purple nutsedge and moderate infestation of root-knot nematode. The treatments at both locations included MB (67%) + chloropicrin (33%) chisel-injected at 390 kg/ha; metam-sodium (chisel-injected) at 300L/ha; metam-sodium drip-irrigated at 300L/ha; and 1,3-D + 17% chloropicrin chisel-injected at 327L/ha. In pairwise statistical comparisons, the yield was significantly lower in metam-sodium treatments compared to MB at both sites. At Bradenton, the average yield from both metam-sodium treatments was 33% of the MB yields, suggesting a 67% yield loss from not using MB. At Gainesville the average yield of the two metam-sodium treatments was 56% of the MB yield, suggesting a 44% yield loss from not using MB. The yield of the 1,3-D treatment at Gainesville was 71% of the MB standard suggesting a 29% loss by not using MB (yield data for 1,3-D were not reported for Bradenton). In considering1,3 D results, one must keep in mind that this MB alternative cannot be used in areas where karst geology exists which is approximately 40% of the Florida pepper production area, including all of Dade country, a major pepper growing area.

Further, due to regulatory restrictions resulting from groundwater contamination concerns, 1,3-D + chloropicrin cannot be used in large portions of the southeastern United States due to the presence of karst geology. By law 1,3-D cannot be used anywhere in Dade county, Florida, where the majority of that region's peppers are grown. There is also a 28 day planting delay (vs. 14 days for MB) due to regulatory restrictions for 1,3-D + chloropicrin. In Florida particularly, growers are on a tight production schedule where buyers must place pepper transplants in fields at a certain time of the. Thus, if growers have only metam sodium for preplant pest control, they will be forced to fumigate earlier in their season, which in turn will force the fumigation schedule into rainy periods, an untenable situation since rain causes this and all other available fumigants to lose efficacy dramatically (Aerts, 2004).

Furthermore, trials of metam-sodium and 1,3 D + chloropicrin (and various combinations thereof) are based on small plot research trials conducted in the Southeastern United States on crops other than peppers. For fungi and nutsedge, no on-farm, large-scale trials have yet been done. Some researchers have also reported that these MB alternatives degrade more rapidly in areas where they are applied repeatedly due to enhanced metabolism by soil microbes (Dungan and Yates 2003, Gamliel et al. 2003). This may compromise long-term efficacy of these compounds and appears to need further scientific scrutiny.

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lower revenues to farmers, and later yields which resulted in further reduced revenues to farmers (missed market windows, shorter harvest periods, the inability to grow a second crop). The proportion of loss attributable to each component differs from sector to sector, and within sectors, depending on the local circumstances of the nomination. As an example, for tomatoes in both Michigan and the southeastern United States, approximately 70% to 75% of the loss is attributable to missing the high value market time and 25% to 30% of the loss is attributable to lower yield

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Southeastern US

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Nutsedge management has proven to be difficult due to the perennial growth habit of nutsedge and tubers as primary means of propagation. There are no herbicides which control nutsedge in the crop row. Paraquat and glyphosate will suppress emerged nutsedge, but cannot be used in the crop row because of potential crop injury (SE Pepper Consortium CUE 02-0041.) Research suggests that metam sodium can, in some situations, provide effective pest management for certain diseases and weeds. However, even though there have been nearly 50 years experience with metam sodium, (which breaks down to methyl isothiocyanate) nutsedge control results have been unpredictable.

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Further, due to regulatory restrictions resulting from groundwater contamination concerns, 1,3-D + chloropicrin cannot be used in large portions of the southeastern United States due to the presence of karst geology. There is also a 28 day planting delay (vs. 14 days for MB) due to regulatory restrictions for 1,3-D + chloropicrin. In many areas of the southeast growers are on a tight production schedule where buyers must place pepper transplants in fields at a certain time of the. Thus, if growers have only metam sodium for preplant pest control, they will be forced to fumigate earlier in their season, which in turn will force the fumigation schedule into rainy periods, an untenable situation since rain causes this and all other available fumigants to lose efficacy dramatically (Aerts, 2004).

Furthermore, trials of metam-sodium and 1,3 D + chloropicrin (and various combinations thereof) are based on small plot research trials conducted in the Southeastern United States on crops other than peppers. For fungi and nutsedge, no on-farm, large-scale trials have yet been done. Some researchers have also reported that these MB alternatives degrade more rapidly in areas where they are applied repeatedly due to enhanced metabolism by soil microbes (Dungan and Yates 2003, Gamliel et al. 2003). This may compromise long-term efficacy of these compounds and appears to need further scientific scrutiny.

For the Southeastern United States, including Florida and Georgia, metam-sodium and 1,3 D + chloropicrin are alternatives for nutsedges and nematodes, respectively, the key target pests in these regions. However, peppers treated with metam-sodium, the best available alternative, have an estimated 44 percent yield decrease compared to MB. 1,3 D + chloropicrin is infeasible because it cannot used on karst geology, and because there is a 28-day planting delay.

There is also evidence that the efficacy of 1,3-D and metam-sodium declines in areas where it is repeatedly applied due to enhanced degradation of methyl isothiocyanate, the active ingredient, by soil microbes (Ashley et al. 1963, Ou et al. 1995, Verhagen et al. 1996, Gamliel et al. 2003).

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The U.S. assessment that the alternatives are not technically AND economically feasible rests on two kinds of losses[16]: changes in yields which result in a lesser amount harvested and therefore lower revenues to farmers, and later yields which resulted in further reduced revenues to farmers (missed market windows, shorter harvest periods, the inability to grow a second crop). The proportion of loss attributable to each component differs from sector to sector, and within sectors, depending on the local circumstances of the nomination. As an example, for tomatoes in both Michigan and the southeastern United States, approximately 70% to 75% of the loss is attributable to missing the high value market time and 25% to 30% of the loss is attributable to lower yield

There are currently few alternatives to methyl bromide for use in peppers. Furthermore, there are factors that limit existing alternatives' usability and efficacy from place to place. These include pest complex, climate, and regulatory restrictions. As described above, the two most promising alternatives to methyl bromide in the Southeastern U.S. for control of nutsedge in

[16] From a theoretical perspective there are additional losses that should be included: differences in costs between methyl bromide and the alternatives and changes in yield quality. Cost differences between methyl bromide and the alternatives can occur because the prices of the materials differ, amounts used differ, equipment needs differ, additional materials are needed, such as an additional herbicide, an additional application step, either of the alternative or of some ancillary material is required, or there are additional land preparation or other costs. In practice, cost differences between methyl bromide and alternatives are generally small and can usually be ignored.

Quality difference in the yield, such as smaller, scarred, less sweet, or other differences in fruit quality would also be factors in assessing economic loss. In practice quality differences have not been reported in the available literature and so losses from his source cannot be incorporated into the analysis.

peppers (1,3-D + chloropicrin and metam-sodium) are considered not technically feasible. This derives from regulatory restrictions and the magnitude of expected yield losses when they are used. MBTOC does not appear to have taken into account planting delays resulting from use of alternative pesticide treatments. These delays cause growers to lose all or part of a market window. In the case of peppers (in particular) missing the early part of the winter growing season causes hugely disproportionate losses in grower net revenues.

California

Urban encroachment and concomitant buffer zones, and local (township) caps restrict the use of the MB alternative 1,3 D (with or without chloropicrin). Essentially this prevents the use of this alternative on approximately 10 % of the pepper growing area in California, according to the applicant. The applicant is requesting MB only for this proportion of their total pepper acreage

Peppers are generally produced using mechanized practices that involve injection of methyl bromide to a depth of 20 – 25 cm. Weeds, especially nutsedge, are the most serious concern precipitating MB use in both transplant beds and the field, although nightshade and hard coated seeds are also problems Nutsedge species grow even under adverse conditions, resist traditional and modern methods of weed control, and are endemic to large tracts of pepper producing area in the Southeastern United States and coastal California. Herbicides are applied to the row middles between raised production beds to manage grass and broadleaf weeds - but there are no currently registered herbicides that control nutsedges near pepper plants. In addition to weeds, soil-borne fungal pathogens and plant-parasitic nematodes are endemic to the region and nearly all production areas have severe infestations, thereby necessitating annual treatment with a broad-spectrum soil fumigant.

There has been extensive research on alternatives for solanaceous crops, and methyl bromide minimizing practices have been incorporated into pepper production systems where possible. However, the effectiveness of chemical and non-chemical alternatives designed to fully replace methyl bromide must still be characterized as preliminary. These alternatives have not been shown to be stand-alone replacements for methyl bromide, and no combination has been shown to provide effective, economical pest control. Methyl bromide is believed to be the only treatment currently available that consistently provides reliable control of nutsedge species and the disease complex affecting pepper production. (Locascio et al., 1997 Nematodes, especially root knot nematodes (*Meloidogyne* spp.), and fungal diseases (such as *Phytophthora* blight) are also of concern. Fungal pests are expected to become serious problems for pepper production if MB were not available for pre-plant fumigation.

As far as EPA can ascertain, virtually none of the studies on key MB alternatives has focused on peppers in coastal California's growing conditions. One exception to this situation can be summarized first, although this study was ongoing at the time it was submitted to EPA. This study is a field trial, conducted in small plots in 2003 in Michigan by M.K. Hausbeck and B.D. Cortright of Michigan State University. The study focused on a number of vegetable crops, including bell peppers. As of July 31, 2003, results indicated that 1,3 D + 35 % chloropicrin treatments (shank-injected at 56.7 liters/ha) showed approximately 6 % plant loss (due to *P. capsici*) – less than the 7 % loss seen in the untreated control plots. Metam-sodium (drip-applied at 58.7 kg/ha) showed a 13 % loss. Methyl iodide with either 50 % or 33 % chloropicrin (shank-injected, at either 46.1 or 36.8 kg/ha, respectively) showed only 2 % plant loss. However, methyl iodide is not registered for this crop in the U.S. at present. It should also be noted that (1) since the trial had not yet ended, statistical analysis on these figures was not conducted, (2) plant loss figures are for all vegetable crops combined, and (3) these plots were being carefully monitored and managed with post-plant prophylactic foliar fungicides (e.g., chlorothalonil and myclobutanil) – an optimal management scheme that will require time to enable growers to adopt.

In studies with other vegetable crops, 1,3 D + chloropicrin has generally shown better control of fungi than metam-sodium formulations (though still not as good as control with MB). For example, in a study using a bell pepper/squash rotation in small plots - conducted in the much warmer conditions of Georgia and without *P. capsici* as a component of the pest complex - Webster et al. (2001) found significantly lower fungal populations with 1,3 D + 35 % chloropicrin (drip irrigated or chisel injected, 146 kg/ha of 1,3 D), as compared to the untreated control. However, MB (440 kg/ha, shank-injected) lowered fungal populations even more. Methyl iodide had no significant suppressive effect, as compared to the untreated control. In another study, conducted on tomatoes in Florida, Gilreath et al. (1994) found that metam-sodium treatments did not match MB in terms of plant vigor at the end of the season; *Fusarium* was one of several pests present.

Without methyl bromide, pepper producers in cool weather climates of Ventura and Santa Clara Counties would most likely use a mixture of 1,3-D and chloropicrin (Telone C-35) to manage the nematode and fungal pathogen populations prior to transplanting pepper. There is evidence from numerous small plot and large-scale trials to indicate that these MB alternatives, in combination, will control nematodes to the extent that MB does nematodes.(e.g. Eger 2000). However, EPA believes that there is no comparable set of research results to indicate that fungal pests, particularly *P. capsici*, will be controlled to a similar extent.

To wit, no large-plot studies have yet been performed to show commercial feasibility against fungal pests in coastal California peppers. Important regulatory constraints on 1,3 D and chloropicrin must also be kept in mind: township caps on the amounts used (which may affect the use rate and hence efficacy), mandatory 100 m buffers near inhabited structures – both of which will cause negative economic impacts that are likely to make the use of these MB alternatives infeasible for the near future. These planting restrictions may thus be important factors inhibiting widespread grower adoption of this MB alternative.

Currently unregistered alternatives, such as furfural and sodium azide, have shown good efficacy against the key pests involved. However, even if registration is pursued soon (and the EPA has no indications of any commercial venture planning to do so) these options will need more research on how to adapt them to commercial pepper production in California.

There are also no non-chemical alternatives that are currently viable for MB replacement for commercial pepper growers. In sum, while the potential exists for a combination of chemical and non-chemical alternatives to replace MB use in California pepper, this goal appears be at least a few years away.

USG does not agree that alternatives are available in California except where regulatory constraints (township caps dictating maximum use of 1.3-D) are binding. California peppers are similar to Michigan, in that the critical pest controlled by MB currently is *P. capsici*. The other important pest targeted by MB use in this region is the root knot nematode. California is requesting MB for less than 10 % of its pepper area, mainly along the coast. As in Michigan, climatological conditions in these coastal areas - primarily long periods of rainy, cloudy weather – exacerbate problems involving possible methyl bromide alternatives, particularly formulations of 1,3 D, which cannot be used when soils are very wet. Growers are also reporting lack of efficacy against both of these pests at the maximum label rates for this alternative. In addition, California has township caps that limit the amount of 1,3-D that can be used in a given area, as well as 100 meter buffer zones near inhabited structures. Urban encroachment is increasing dramatically in California coastal counties, making the buffer zone requirement more constraining. These factors are present in the 10% of California pepper area that need MB

Of the currently available MB alternatives, metam-sodium offers inconsistent control of nutsedges and nematodes, while 1,3-D + chloropicrin provides adequate control of nematodes (Locascio et al. 1997, Eger 2000, Noling et al. 2000). However, metam-sodium has yield losses of up to 44 % compared to MB where weed infestations are moderate to severe (Locascio et al. 1997). Metam-sodium also creates a planting delay as long as 21 days to avoid risk of phytotoxic injury to crops compared to a 14-day delay for MB.

Further, it is the opinion of some U.S. crop experts that metam sodium, in particular, is very inconsistent in its beneficial effects as a nematode control agent (Dr. S. Culpeper, University of Georgia, personal communication).

For California pests 1,3 D + chloropicrin is the only key alternative with efficacy comparable to MB. Regulatory restrictions due to human exposure concerns, combined with technical limitations, reduce its use. Key among these factors are a delay in planting as long as 30 days, due both to label restrictions and low soil temperatures, and mandatory 30 to 100 meter buffers for treated fields near inhabited structures.

MBTOC has suggested that shank-injected 1,3-D/Pic can be used in all areas that are not currently impacted by the township caps. In making this suggestion they are not accounting for both the technical and regulatory factors described above and the actual working of the township caps in California. The township cap is a maximum that can be applied *assuming that the method of application is deep shank injection.* For all other forms of injection an 'application factor' is applied. The purpose of this application factor is to reduce the amount of 1,3-D that can be applied to a given area, reducing exposure to the population to a level comparable to that experienced when deep shank injection is used.

Deep shank injection cannot be used to control pests in California pepper production. Unlike Florida, where the soils are sandy to a considerable depth, in California the soils are prepared for planting to a depth of 12- 18 inches[17]. The deep shank method injects 1,3-D below this level where the soil is not prepared and breaks into clumps. The soil must be re-tilled before planting

[17] This corresponds to 30-45 cm.

which risks introducing pathogens back into the planting zone. When shallow-shank injection is used, the higher application factors mean that a much smaller area can be injected.

Dr. Legard[18] of the California Strawberry Commission has estimated the impact on maximum acreage treated if 1,3-D is (shallow) shank-injected into the soil rather than drip-applied a s a liquid. Using Telone C35® at 39-50 gallons per treated acre, 138.8 to 178.0 acres per township could be treated. When Inline® is used at 25 gallons per acre[19] 473.7 acres per township can be treated. In other words, the use of drip-applied 1,3-D results in 2.5 to 3 times as many treated acres. Shank injection of 1,3-D will greatly reduce the acreage treated[20].

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[18] Daniel Legard, PhD, personal communication. January 9, 2005.

[19] The common use rate on strawberries in California

[20] The main concern associated with broadcast fumigation with telone C35 is related to the telone township cap. There are different emission ratios used for the different application methods that adjusts the amount of telone applied to the township cap. The lbs used are "adjusted" by the following factors (1x for deep shank, 1.1x for drip applied, 1.8x for shallow shank). Hopefully, most growers would use deep shank where possible for broadcast telone applications. However, broadcast applications still involve treating approximately 40% more acreage than drip (2 row bed and slightly lower for 3 and 4 row beds, which are becoming more popular in the North). The net result of both changes is to reduce the maximum treatable area to between 30-40% of the area that can be treated using drip applied 1,3-D.

[21] From a theoretical perspective there are additional losses that should be included: differences in costs between methyl bromide and the alternatives and changes in yield quality. Cost differences between methyl bromide and the alternatives can occur because the prices of the materials differ, amounts used differ, equipment needs differ, additional materials are needed, such as an additional herbicide, an additional application step, either of the alternative or of some ancillary material is required, or there are additional land preparation or other costs. In practice, cost differences between methyl bromide and alternatives are generally small and can usually be ignored.

Quality difference in the yield, such as smaller, scarred, less sweet, or other differences in fruit quality would also be factors in assessing economic loss. In practice quality differences have not been reported in the available literature and so losses from his source cannot be incorporated into the analysis.

c. rate reduction to 200kg/ha under treated strips

MBTOC has also reduced the amount recommended for peppers stating: "A further adjustment was applied to reduce the dosage to the guideline level of 200kg/ha under the strips." When this issue was discussed with MBTOC members during the 16th MOP, U.S. experts agreed to clarify whether the reported rates were in fact the rates used under the strips (as the U.S. believed) or whether they were the average for an acre as MBTOC believed[22]. The U. S. has verified that the application rates provided in the quantitative assessment (the Methyl Bromide Usage Numerical Index, or BUNI) are in fact the rates under the strips. The number of acres reported is the "treated acres". A strip application that results in two thirds of an acre being fumigated while one-third is untreated is reported as two thirds of an acre, not as an acre.

Technical and Economic Assessment of MBTOC/TEAP Report.

We have not been provided by MBTOC with information on their technical assessment of the performance of alternatives, ortheir economic assessment on the impact of converting to alternatives. To support the MBTOC's recommended change in the U.S. request citations of the research references and economic assessments that led to the MBTOC conclusions are needed so we can understand the justification. The technical references should describe the species tested, pest numbers, concentrations, times, and commodity volumes. Economic references should describe the costs of converting from methyl bromide to alternatives, the impact of higher yield losses, longer plant back intervals, the economic feasibility if key market windows are missed, and the economic impact of a 20% transition to alternatives including estimates of management costs for more intensive programs and how the impact of less reliable alternatives is calculated. The sources of estimates of the extent of pest pressure should describe the rationale for using other estimates, a complete description of the questions, species being surveyed and quantitative levels used.

U.S. 2006 nomination

The USG is reiterating its request for an additional 691.683 metric tons of methyl bromide for use in field grown peppers for a total amount in this sector of 1,498.530 which includes a research amount of 2.844 metric tons.

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[22] If the rates were an average per acre, as MBTOC believed, given that in strip treatments approximately one-third of the acre is left untreated, the rates applied would, in some cases, exceed the MBTOC recommended dosage of 200kg/ha.

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