UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
PREVENTION,
PESTICIDES AND TOXIC
SUBSTANCES

MEMORANDUM

SUBJECT: Overview of the Use and Usage of Soil Fumigants

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Attached is BEAD's overview of the use and usage of the currently registered soil fumigants methyl bromide, chloropicrin, 1, 3-dichloropropene, metam sodium, metam potassium, and dazomet.

USE AND USAGE OF SOIL FUMIGANTS:

METHYL BROMIDE
CHLOROPICRIN
1, 3-DICHLOROPROPENE
METAM SODIUM
METAM POTASSIUM
DAZOMET

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SUMMARY

This overview describes the use and usage of soil fumigants in agriculture in the United States and provides context for the human health risk assessments.

Fumigants are used on a wide range of annual and perennial crops, stored commodities, structures and food processing facilities to control insects, nematodes, plant pathogens, and weeds. Million of pounds of fumigants are used to produce these crops every year. Because of their high application rates, the most widely used soil fumigants (methyl bromide, 1,3-dichloropropene, metam sodium, and chloropicrin) rank in the top 20 pesticides, based on pounds applied per year. In 2001, metam sodium was the third most commonly used pesticide (by weight) in the U.S. (57 to 62 million pounds) and methyl bromide was the seventh most commonly used pesticide (20 to 25 million pounds). Telone or 1, 3-dichloropropene was the eighth most commonly used pesticide (20 to 25 million pounds), and chloropicrin was the eighteenth most commonly used pesticide (5 to 9 million pounds) (US EPA, 2004).

Fumigants are needed in situations where the pest pressure is so high that would otherwise be technically or economically infeasible to grow a crop without the use of these chemicals. The largest uses of soil fumigants are in potatoes, tomatoes, tobacco, carrots, and strawberries for the control of plant pathogens, nematodes, and weeds.

Fumigants are formulated and applied in several ways. Granule formulations such as dazomet are applied to the soil surface then watered into the soil or mechanically incorporated. Liquid fumigants can be applied by directly injecting them into the soil and in some cases by injection into the irrigation system. Soil retention of the fumigant, and control of emissions, is improved by the use of tarps or water seals.

In addition to the soil uses, fumigants have two other important uses. First, fumigation prevents the introduction or spread of plant pests or noxious weeds into or within the United States. Under regulation, certain plants fruits, vegetables and other articles must be treated before they may be moved into, or transported within, the United States. Next, commodities, structures, and food processing facilities are fumigated principally to control insects using the penetrating characteristics of gaseous methyl bromide. These fumigations ensure that consumers can buy pest free products.

This overview is general in nature and does not address many of the complexities associated with soil fumigant use in each of the many crops that depend on this group of chemicals. The Office of Pesticide Programs has received valuable input from stakeholders that have provided information on how soil fumigants are used for specific crops and in specific geographical regions. As the Agency receives and analyzes this information, we refine our assumptions related to use parameters. These data will be included when this chapter is updated for the next phase of public comment. Comment on this preliminary overview is invited from all stakeholders. Please see the section entitled “Questions for Public Comment” for the types of information that would be useful in refining this document and the risk assessments of the soil fumigants and developing benefit assessments for these chemicals in the future.

PURPOSE / OBJECTIVES

This document provides a general description of the use and usage of soil fumigants in agriculture in the United States. Further, this overview is intended to place the human health risk assessments in the context of the use that routinely occur in crop production. Comment on this preliminary overview is invited from all stakeholders.

The first section of this document describes why, how and in what crops soil fumigants are used. This section is followed by short descriptions of the use and usage of methyl bromide, chloropicrin, 1,3-dichloropropene, dazomet, metam sodium, and metam potassium. The final section entitled "Questions for Public Comment" identifies the types of information that would be useful in refining the risk assessments of the soil fumigants and in developing future benefit assessments for these chemicals.

INTRODUCTION

Why Fumigants are Used

Fumigants are small, volatile molecules that become gases at a relatively low temperature, around 40 degrees Fahrenheit, or they are chemicals that react to produce such a gas. Most are highly penetrating and move rapidly through large masses of material, where they kill target pests. In the case of soil fumigants, the fumigant is usually injected or incorporated into the soil where it permeates the soil and kills soil-borne pests. After the fumigant dissipates from the soil, which takes from a few days to a couple of weeks, planting can take place.

Fumigants are used to control a wide range of pest species including: insects, nematodes, bacteria, fungi, and weeds (Table 1). Because of the broad range of species controlled, fumigants have found uses on a wide variety of crops as a preplant soil treatment to control soilborne pests and pathogens. Tables 2 and 3 provide a list of over 40 major preplant soil uses on a wide range of crops from potatoes and fresh market tomatoes through green peas and orchard replant sites. A more comprehensive of registered use sites is presented in Appendix A and B. As well as soil uses, methyl bromide can be used on commodities, structures, and food processing facilities to control insects. In 2002, based on data from the Methyl Bromide Critical Use Exemption program, methyl bromide had estimated usage of over 200,000 pounds on commodities such as cocoa, dried fruit, pistachios, and walnuts. In that same year methyl bromide had estimated usage of over 1.7 million pounds on structures and food processing facilities such as bakeries, flour and rice mills, and pet food facilities (US EPA, 2005).

Table 1. Major Types of Pests Controlled by the Soil Fumigants: Methyl Bromide, Chloropicrin, 1,3-Dichloropicrin, Dazomet, Metam Sodium and Metam Potassium.

Fumigant	Major Types of Pests Controlled		
	Nematodes	Plant Pathogens	Weeds
Methyl Bromide	●	●	●
Chloropicrin		●	
1,3-Dichloropropene	●		
Dazomet	●	●	●
Metam sodium	●	●	●
Metam potassium	●	●	●

Note: Level of control of a pest type is variable between chemicals.

Soil fumigation can provide benefits to both consumers and growers. For consumers it means more fresh fruits and vegetables can be cheaply produced year-round because severe pest problems can be efficiently controlled. For example, root crops (e.g., carrots, potato) grown in fumigated soil produce fewer blemished products, which translates into an increase in marketable yields. Fumigation can also provide benefits to growers in the form of increased management flexibility. This includes shorter rotational intervals (e.g., 2-3 year crop rotations on carrots instead of 4-5 year rotations without fumigation), increased flexibility to meet quarantine restrictions (e.g., in some regions strawberry transplants cannot be shipped out of the county unless the soil they were grown in was fumigated), and increased flexibility about cropping decisions (e.g., growing tomatoes where the plant pathogen *Phytophthora capsici* is endemic and no resistant cultivars exist). Soil fumigants can be used alone or in combination to increase the level and the spectrum of pest control. Chloropicrin is used both as a stand-alone soil fumigant and as a chemical warning agent in many formulations. Examples of the different application scenarios include: a single fumigant application such as metam sodium on potatoes, or 1,3-Dichloropropene on carrots, a combination such as methyl bromide plus chloropicrin or 1,3-Dichloropropene plus chloropicrin on strawberries, or sequentially applied as in tomatoes where 1,3-Dichloropropene plus chloropicrin is followed by metam sodium.

Other, non-soil uses include fumigations of commodities, structures, and food processing facilities that also provide benefits to consumers and producers. Insect infestations can be quickly and effectively controlled, insuring a pest-free food supply. For producers it provides increased management, financial, and pest management flexibility by providing a rapid and effective method to reduce insect populations in a wide range of commodities, processed foods, food processing equipment, and structures.

Table 2. Crops with Significant Usage of Soil Fumigants.

Criteria*	Crop	Chloropicrin		Metam Sodium		Methyl Bromide		1,3-Dichloropropene		Total Pounds
		Pounds	PCT	Pounds	PCT	Pounds	PCT	Pounds	PCT	
> 5 PCT	Potatoes	200,000	<1	31,700,000	20	200,000	<1	9,900,000	5	42,000,000
	Tomatoes	1,700,000	10	7,000,000	15	10,600,000	20	300,000	<1	19,600,000
	Tobacco	3,600,000	15	100,000	<1	500,000	<1	7,800,000	10	12,000,000
	Carrots	70,000	<1	9,000,000	40	70,000	<1	1,500,000	10	10,640,000
	Strawberries	1,400,000	20	200,000	<1	7,600,000	50	400,000	5	9,600,000
	Peppers	700,000	10	700,000	5	3,700,000	20	200,000	5	5,300,000
	Watermelons	800,000	<1	700,000	2	2,300,000	5	400,000	<1	4,200,000
	Onions	200,000	<1	1,700,000	5	200,000	<1	900,000	5	3,000,000
	Cucumbers	100,000	5	300,000	<1	1,300,000	5	900,000	10	2,600,000
	Peanuts	5,000	<1	1,100,000	5			1,300,000	<1	2,405,000
	Cantaloupes	100,000	5	800,000	5	800,000	5	300,000	5	2,000,000
	Sweet Potato**	100,000	6	300,000	1	800,000	5	800,000	20	2,000,000
	Squash	80,000	<1	100,000	<1	400,000	5	200,000	5	780,000
	Cabbage			60,000	<1			200,000	5	260,000
	Eggplant			6,000	<1	200,000	45			206,000
	Celery			200,000	10					200,000
	Artichokes			50,000	5					50,000
	Brussels Sprout***			60,000	30			60,000	45	120,000
> 1 million pounds	Almonds	100,000	<1	7,000	<1	2,500,000	<1	200,000	<1	2,807,000
	Walnuts	20,000	<1	5,000	<1	1,700,000	<1	100,000	<1	1,825,000
	Cotton	200,000	<1					1,100,000	<1	1,300,000
Total Pounds	Sugar Beets	60,000	<1	400,000	<1			700,000	<1	1,160,000
	Grapes	8,000	<1	7,000	<1	600,000	<1	500,000	<1	1,115,000

***Notes:** Crops are grouped using criteria of greater than 5 percent of the crop treated (PCT) of at least one fumigant, greater than one millions pounds active ingredient used annually of at least one fumigant, or more than a million pounds active ingredient used of one or more of the soil fumigants. This table does not include values (based on EPA data) for metam potassium, as follows: Cucumber – 120,000; Onions – 130,000; Peppers – 450,000; Potatoes – 1,300,000; Tomatoes – 350,000; Watermelon – 450,000 pounds.

Source: Table data was taken from BEAD Screening Level Usage Analyses (SLUA) unless otherwise indicated.

** Data are from the National Center for Food and Agricultural Policy, 1997 National Pesticide Use Database.

*** Data are from the California Department of Pesticide Regulation, 2001 and 2002 Pesticide Use Reporting Database

Table 3. Crops with Smaller Usage of Soil Fumigants.

Criteria*	Crop	Chloropicrin		Metam Sodium		Methyl Bromide		1,3-Dichloropropene		Total Pounds
		Pounds	PCT	Pounds	PCT	Pounds	PCT	Pounds	PCT	
>/= 500,000 pounds	Lettuce	40,000		500,000	<1	200,000	<1	70,000	<1	810,000
	Cherries	8,000	<1	40,000	<1	600,000	<1	100,000	<1	748,000
	Broccoli			700,000	<1			40,000	<1	740,000
	Peaches	20,000	<1	3,000	<1	500,000	<1	100,000	<1	623,000
	Pears			4,000	<1	500,000	<1			504,000
>/= 200,000 pounds	Floriculture	255,000		22,900		449,600		31,500		759,000
	Beans, Green	40,000	<1	100,000	<1	200,000	<1	200,000	<1	540,000
	Apples	30,000	<1	100,000	<1	300,000	<1	100,000	<1	530,000
	Spinach			200,000	<1	300,000	<1			500,000
	Oranges	60,000	<1	5,000	<1	300,000	<1	40,000	<1	405,000
	Prunes & Plums	40,000	<1			200,000	<1	40,000	<1	280,000
	Garlic			200,000	<1			30,000	<1	230,000
	Pecans	30,000	<1					200,000	<1	230,000
Some use	Cauliflower			60,000	<1			80,000	<1	140,000
	Sweet Corn			30,000	<1			80,000	<1	110,000
	Rice	20,000	<1					40,000	<1	60,000
	Apricots					10,000	<1			10,000
	Pumpkins			10,000	<1					10,000
	Lemons	1,000	<1	2,000	<1	<500	<1	3,000	<1	6,000
	Peas, Green			3,000	<1					3,000
	Nectarines							<500	<1	<500

***Source:** Table data was taken from BEAD Screening Level Usage Analyses (SLUA), with the exception of that for floriculture which was taken from USDA/NASS (2004). Crops are grouped using criteria of greater than 500,000 pounds active ingredient used annually of at least one fumigant, greater than 200,000 pounds active ingredient used of at least one fumigant, or some use reported in EPA's use databases for these chemicals. This table does not include values (based on EPA data) for metam potassium use on lettuce – 1,300,000 pounds active ingredient.

Fumigant Use Sites

As a group, soil fumigants are registered on most crops commercially produced in the United States and are heavily used on many fruit and vegetable crops. Appendix A provides a matrix of use site and individual soil fumigant. Although small in total acreage, one of the most important uses of the soil fumigants is in producing vigorous, disease-free nursery stock and transplants (Appendix B). As well as soil uses, methyl bromide has important uses on commodities (Appendix C).

Alternatives and Non-Fumigant Control Measures

The soil fumigants are to some degree alternatives for each other. In some instances it may be possible to use several non-fumigant pesticides (i.e., a fungicide, nematicide and herbicide combination) to achieve the same level of pest control, although it would result in increased costs to produce the crop.

There are other methods of pest control available for soil and post harvest and structural uses. The Methyl Bromide Technical Options Committee (MBTOC) has provided a list of alternative control measures on their website (MBTOC 2002). While not suitable for all situations many of these methods are currently used by a number of growers to reduce or replace the need for soil fumigants. Some of the common methods are crop rotations non-host cover crops, fallow rotations, integrated pest management, nematode resistant rootstocks for orchards, solarization, and steam sterilization. For post harvest commodities, structures and food processing plants there also several commonly used non-fumigant methods to help control pests (e.g. cleaning and sanitation, cold and heat treatments, irradiation, integrated pest management, vacuum treatments, and pest resistant packaging). All of these alternative methods involve trade offs such as a narrow spectrum of pests controlled, increased cost or down time, do not meet some phytosanitary requirements, or environmental constraints (e.g., solarization may not be effective in northern states).

There is considerable ongoing research on the identification and evaluation of alternatives to the soil fumigants, especially for methyl bromide. Much of this research is presented at the EPA/USDA jointly sponsored Methyl Bromide Alternatives Outreach Conference. More information about the MBAO is presented at www.mbao.org.

How Soil Fumigants are Used

Soil fumigants are applied using several methods. Dazomet is applied as a granular formulation that is soil incorporated. The other fumigants are liquids with high vapor pressure, so they are usually stored and applied as liquids (under pressure) and begin to vaporize shortly after injection in the soil.

Some soil fumigants can be applied by chemigation. Metam sodium, 1,3-Dichloropropene, and metam potassium can be metered into irrigation systems and applied via drip tape or sprinkler.

Methyl bromide can be applied using a "hot gas" method. This method involves first laying a series of drip tubing across the area to be fumigated, laying plastic tarp (usually by hand) over the drip tubing and securing the edges by covering them with soil. Methyl bromide is then forced through a heat exchanger, into the tubing, and from there into the tarped area to be fumigated. This method is limited to areas where mechanical applications are not possible because of limited space or access (such as in some greenhouses).

The portion of the fields that is fumigated varies (Table 4). For the production of some crops, the entire field is treated. This is termed "flat fume", "broadcast", or "broadacre." Fumigants are applied using granular spreaders (dazomet), or are shanked- or knifed-in to the soil, followed by soil incorporation or surface compaction of the soil using a roller. Whole field applications of 1,3-Dichloropropene often use specialized equipment such as a Yetter rig.

For the production of other crops, fumigation occurs when planting beds are formed. A bed press forms a raised bed and the fumigant is injected into the bed as it is formed. The entire bed, or only the portion of the bed, is fumigated. This is termed "strip" treatments. The production of some ornamentals and strawberries use a combination of techniques. First, the entire field is fumigated and tarped. The tarps are then removed, raised beds are formed, and these beds are then tarped.

For all methods of application, the condition of the soil (e.g., soil texture, moisture, temperature) is critical to achieving the desired results from the fumigation.

Often after the fumigation is completed, the fumigated area is tarped or water sealed in order to reduce emissions from the field (Table 4). There are a range of tarps used to reduce the emissions from soil applications of fumigants. Preplant soil applications of methyl bromide typically use low density polyethylene (LDPE) or high density polyethylene (HDPE) tarps to reduce emissions. In 2002 in California, it was indicated that 92.5% of all pre-plant applications of methyl bromide were under tarps, based on information from the Methyl Bromide Critical Use Exemption program. The remaining 7.5% of pre-plant applications were deep injections (over 20 inches, or 50 cm in depth) used for orchard planting and re-planting. In Florida all of the crops that have applied for Methyl Bromide Critical Use Exemptions are grown using plastic mulch culture on LDPE or HDPE tarps. New types of tarps that may have lower emission rates, resistance to tearing, ability to conform to the bed shape are being designed and tested. These high barrier films use multiple layers (e.g., virtually impermeable film or VIF) or metalized coatings to reduce the amount of fumigant that can move through the film. These tarps are also used in conjunction with applications of 1,3-Dichloropropene, chloropicrin, and metam sodium and potassium. In addition to potentially reducing fumigant emissions, these films may also be desirable because they can help keep fruit from touching the soil with a reduction of rotted fruit, control soil temperatures by reflecting or absorbing solar energy as required, and reduce water loss from the soil.

Another method of reducing emissions of metam sodium, metam potassium, and dazomet is the use of water seals (Table 4). This method involves applying additional water after fumigation. Depending on the amounts and frequency of applying additional irrigation water these seals are termed standard or intermittent.

Table 4. Some Soil Fumigation Techniques*.

Formulation	Application Method	Application Equipment	Soil Incorporation Method	Field Treatment	Flat Fume vs. Raised Bed	Tarping / Sealing Method	
						Water Seal	Tarp
Granular	Broadcast	Spreader	None (surface application), roller, rotary harrow, bed press	Entire field, strip (entire bed)	Flat fume, raised bed	None, standard, intermittent	Untarped LDPE HDPE High barrier
Liquid / Gas	Heat exchanger, injection	Injection of hot gas from in-place pipes or drip tubing	None	Entire field	Flat fume	N/A	LDPE HDPE High barrier

Formulation	Application Method	Application Equipment	Soil Incorporation Method	Field Treatment	Flat Fume vs. Raised Bed	Tarping / Sealing Method	
						Water Seal	Tarp
	Shallow shank	Yetter rig, spray blade, shank	Roller, rotary harrow, bed press	Entire field, strip (may be entire bed or only part of the raised bed)	Flat fume, raised bed	None, standard, intermittent	Untarped LDPE HDPE High barrier
	Deep shank	Shank	Roller, rotary harrow, bed press	Entire field, strip (entire bed)	Flat fume, raised bed	N/A	Untarped LDPE HDPE High barrier
	Chemigation	Drip line, sprinkler	None (drip tape(s) under tarp or surface application)	Entire field, strip (entire bed)	Flat fume, raised bed	None, standard, intermittent	Untarped LDPE HDPE High barrier

*Combinations of formulation, application methods and equipment, soil incorporation methods, field treatments, and tarping / sealing methods vary by fumigant, crop, and geographic region. Note that not all potential combinations are used (e.g., water seals are not used with tarps).

Outreach to Stakeholders

The Office of Pesticide Programs (OPP) has been working with the Office of Pest Management and Policy (OPMP), U. S. Department of Agriculture (USDA) to develop information concerning the use of soil fumigants in United States agriculture. Over the last several months, OPMP has contacted many growers, extension agents, trade organizations, and academic researchers to gather information about the use of soil fumigants.

The Office of Pesticide Programs has received valuable input from a number of stakeholders that have provided information on how soil fumigants are used for specific crops and in specific geographical regions. As the Agency receives and analyzes this information, we refine our assumptions related to use parameters. These data will be included when this chapter is updated, and benefit assessments are developed, for the next phase of public comment. Comment on this preliminary overview is invited from all stakeholders. Please see the section entitled "Questions for Public Comment" for the types of information that would be useful in refining the risk assessments of the soil fumigants and developing benefit assessments for these chemicals in the future.

Risk Assessment Parameters vs. Actual Use of Soil Fumigants

The human health risk assessments for soil fumigants selected standard input parameters so that the modeling results could be directly compared across multiple chemicals, resulting in informed reregistration decisions. The values selected represent some, but not all, of the ways that fumigants are commonly used in production agriculture in the

United States. Standard values for the following parameters were used in the risk assessments:

- Acreage treated in a single day (1, 5, 10, 20, 40 acres)
- Application rate (100, 75, 50, 25 percent of the maximum label rate)
- Metrological data (California coastal and inland, Florida coastal and inland, Pacific Northwest, and Michigan)
- Application method and soil treatment (e.g., flat fume, tarped; raised bed, tarped; flat fume, standard water seal)

The Office of Pesticide Programs anticipates that additional analyses will be conducted to more accurately reflect the use of soil fumigants on specific crops and regional use patterns.

METHYL BROMIDE

Trade Names

Bromocoop, Brom-O-Gas, Terr-O-Gas, Tri-con (chloropicrin plus methyl bromide)

Use and Usage

Methyl bromide is used as a soil treatment to control plant pathogens, nematodes, and weeds. Crops that use over a million pounds annually of methyl bromide in their production (Table 2) include tomatoes (10.6 million pounds), strawberries (7.6 million pounds), peppers (3.7 million pounds), almonds (2.5 million pounds), watermelon (2.3 million pounds), walnuts (1.7 million pounds), and cucumbers (1.3 million pounds). All of these uses are generally made in combination with chloropicrin. Fields for strawberry fruit production typically use methyl bromide with application rates from 200 to 250 pounds of active ingredient per acre in Pennsylvania, North Carolina, and Washington (for control of plant pathogens and nematodes). Application rates up to 300 to 350 pounds of active ingredient per acre are used in California (for control of plant pathogens and nematodes) and Florida (for control of weeds, plant pathogens, and nematodes). Fields for fresh market tomato production use application rates ranging from 200 to 250 pounds of active ingredient per acre from California (for plant pathogens) to Florida (for control of weeds, plant pathogens, and nematodes). Replanting of peach and walnut orchards (for control of orchard replant syndrome) have use rate ranges from 400 to 600 pounds active ingredient per acre.

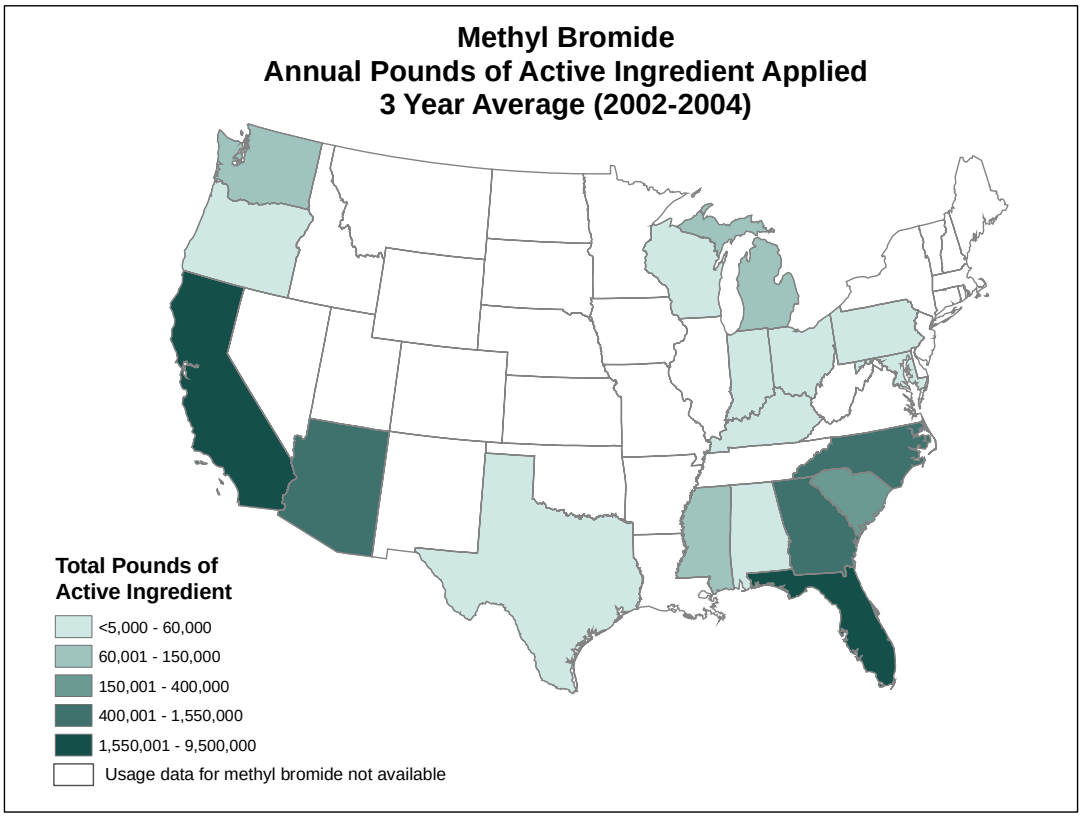

Figure 1. Methyl Bromide. Annual Pounds of Active Ingredient Applied by State for All Surveyed Crops Based on Three Years of EPA Data (2002-2004).

The Montreal Protocol and the Methyl Bromide Critical Use Exemption

The Montreal Protocol on Substances that Deplete the Ozone Layer was established in 1987 and includes both industrialized and non-industrialized countries (presently it has 188 signatories) that have committed to meeting reduction targets, for ozone-depleting substances. Under the Montreal Protocol and the Clean Air Act, the production and import of methyl bromide was reduced by 70 percent from the 1991 baseline in 2003 and was phased out in the United States on 1 January 2005, other than for exempted purposes. Decision IX/6, taken by the Parties to the Protocol, allows for continued production and import of methyl bromide beyond the January 2005 phaseout date, in the form of quarantine and preshipment, critical and emergency uses. According to the protocol "a use of methyl bromide should qualify as "critical" only if the nominating Party determines that: (i) The specific use is critical because the lack of availability of methyl bromide for that use would result in a significant market disruption; and (ii) There are no technically and economically feasible alternatives available to the user that are acceptable from the standpoint of environment and health and are suitable to the crops and circumstances of the nomination " Because of this treaty many growers and food processors have transitioned to other fumigants, crops or different production practices.

Quarantine and Preshipment

The Montreal Protocol on also describes and regulates the quarantine and preshipment (QPS) uses of methyl bromide. The Montreal Protocol considered these to be minor uses of methyl bromide and to be critical to control the spread of pests and maintain a sanitary food supply. These QPS uses are designated to control pests on commodities or products entering or leaving the U.S. or a State (or political subdivision) to meet sanitation standards for international, Federal, State, or local requirements. Some examples of quarantine and preshipment fumigations are: grapes entering the U.S. from Chile, cherries and apples entering Japan from the U.S., soil fumigated for growing propagative plant material, and fumigations to meet food sanitation requirements of the U.S. or importing country as long as these applications are made within 21 days of export.

The Animal Plant and Health Inspection Service has recently published a final rule that updates the treatment schedules and other requirements for fumigation to prevent the introduction or spread of plant pests or noxious weeds into or within the United States (USDA / APHIS, 2005). Under regulation, certain plants fruits, vegetables and other articles must be treated before they may be moved into, or transported within, the United States.

Non-Soil Uses of Methyl Bromide

Methyl bromide is one of the most widely used fumigants to control insect pests in commodities, structures and food processing facilities (Tables 2 and 3; Figure 1). A wide range of commodities such as dried beans, fruit, dates, pistachios, and walnuts are fumigated in California. Based on use data from the Methyl Bromide Critical Use Exemption program, the amounts used in 2003 range from a few thousand pounds to over 100,000 pounds for each of these commodities. Application rates for commodities range from 1.3 to 3.0 pounds active ingredient per 1,000 cubic feet. In structures and food processing facilities such as bakeries, flour and rice mills, and pet food plants the amounts used ranged from approximately 50,000 to over 750,000 pounds with application rates ranging from less than 1.0 to 2.0 pounds active ingredient per 1,000 cubic feet.

CHLOROPICRIN

Trade Names

Chloro-O-Pic; InLine, Telone C-17 (chloropicrin plus 1,3-dichloropropene); Bromocoop, Brom-O-Gas, Terr-O-Gas, Tri-con (chloropicrin plus methyl bromide)

Use and Usage

Chloropicrin is a commonly used soil fumigants because it can be mixed with other fumigants at a low rate to act as a chemical warning agent or used at higher rates to provide plant pathogen control in many crops (Tables 2 and 3, Figure 2). Crops that use over a million pounds annually of chloropicrin in their production (Table 2) include

tobacco (3.6 million pounds), tomatoes (1.7 million pounds), and strawberries (1.4 million pounds). All of these uses are generally in combination with methyl bromide or 1, 3-Dichloropropene. Application rates in tobacco seedbed and fields range from 25 to 75 pounds of active ingredient per acre in fields from Florida to Virginia. Use on tomato fields ranges from 100 to 150 pounds of active ingredient per acre in Florida and Michigan to a high of over 300 pounds of active ingredient per acre in California. Strawberry fields commonly use chloropicrin with 20% of the crop treated with application rates ranging from 100 to 150 pounds of active ingredient per acre in Florida and North Carolina to 250 to 300 pounds of active ingredient per acre in Ohio and Pennsylvania. Replanting and nursery production of grapes (table and wine) occurs primarily in California with rates of 25 to 75 pounds of active ingredient per acre.

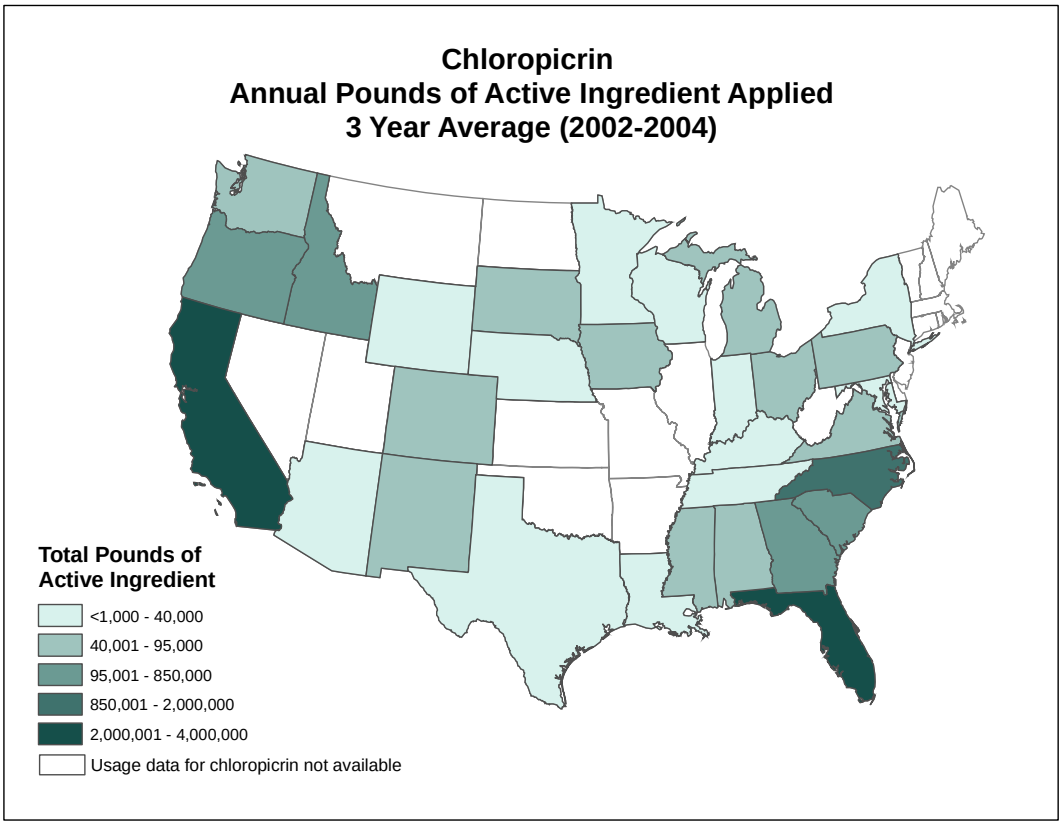

Figure 2. Chloropicrin. Annual Pounds of Active Ingredient Applied By State For All Surveyed Crops Based on Three Years of EPA Data (2002-2004).

1,3-DICHLOROPROPENE

Trade Names

1,3-D, DD-92, InLine, Telone II, Telone, Telone C-17

Use and Usage

1,3-Dichloropropene is used to control nematodes in a wide variety of crops and a wide range of states (Tables 2 and 3; Figure 3). Crops that use over a million pounds annually of 1, 3-dichloropropene in their production (Table 2) include potatoes (9.9 million pounds), tobacco (7.8 million pounds), carrots (1.5 million pounds), peanuts (1.3 million pounds), and cotton (1.1 million pounds). 1,3-Dichloropropene can be mixed with chloropicrin to provide enhanced plant pathogen and weed control. Application rates in potato fields ranges from a low of 50 to 75 pounds of active ingredient per acre in Florida and North Carolina to a high of 200 to 250 pounds of active ingredient per acre in Colorado and Idaho. Use on tobacco seedbeds and plant beds ranges from 100 to 175 pounds of active ingredient per acre from Florida north to Virginia. Strawberry accounts for only a small amount of the total usage but application rates in California, Florida, and North Carolina range from 175 to 400 pounds of active ingredient per acre. While widely used in cotton, the application rates are very low because only a narrow strip around the seed row is treated resulting in application rates ranging from only 25 to 50 pounds of active ingredient per acre from Arizona east to North and South Carolina.

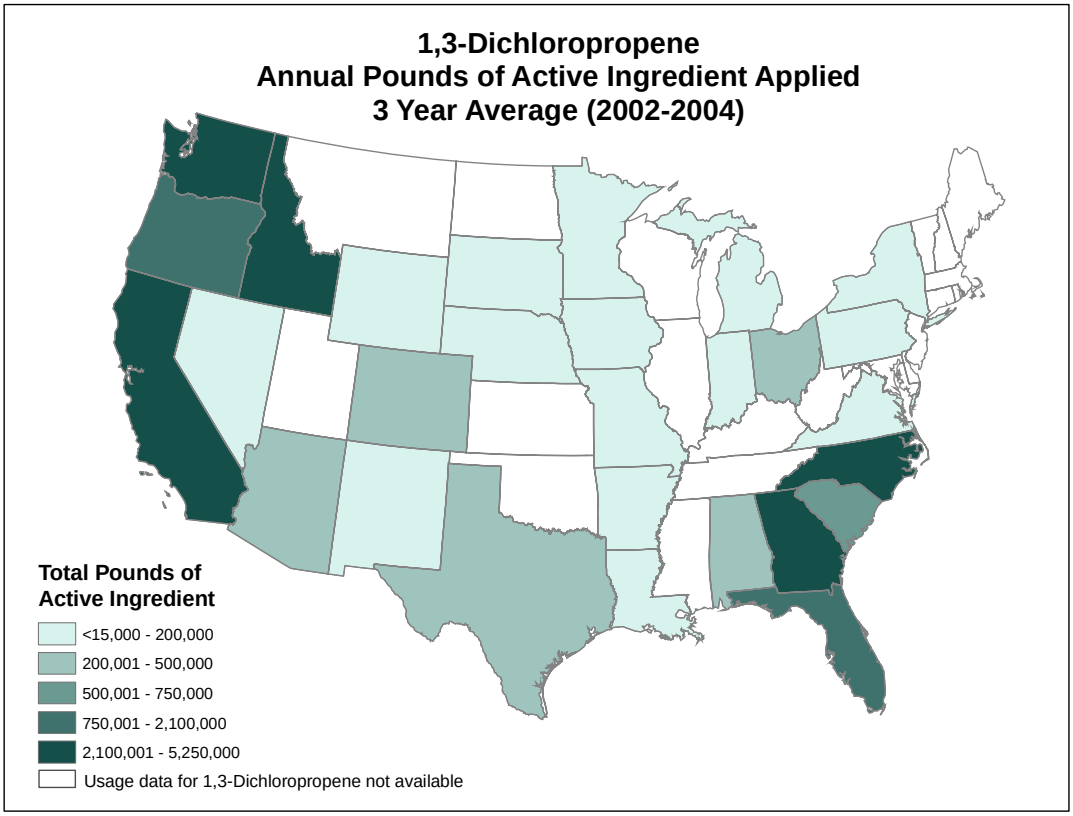

Figure 3. 1,3-Dichloropropene. Annual Pounds of Active Ingredient Applied By State For All Surveyed Crops Based On Three Years Of EPA Data (2002-2004).

DAZOMET

Trade Names

Basamid, Dacron

Use and Usage

Dazomet is registered for use on non-bearing orchard crops, ornamentals, and turf to control plant pathogens, nematodes, and weeds. Unlike other soil fumigants, dazomet is applied as a dry granule and incorporated into the soil or applied to the soil surface and watered into the soil to activate it.

Compared to the other soil fumigants, dazomet has a limited number of registered use sites. The Office of Pesticide Programs currently has insufficient survey data for dazomet to display its usage geographically.

METAM SODIUM AND POTASSIUM

Trade Names

Metam Sodium: Metam 426, Polefume, Turfcure, Vapam, Vapam HL, Busan 1236, Nemasol, Metam CLR, Sectagon 42, Sistan, Meter, Soldier

Metam-Potassium: Curtin, Metam KLR, K-Pam HL, Raisan K-50, Sectagon K-54

Use and Usage

In terms of total pounds used annually, metam sodium and metam potassium are the most widely used soil fumigants in the United States. They are used to control plant pathogens, nematodes, and weeds (Tables 1 and 2; Figures 4 and 5). Crops that use over a million pounds annually of metam sodium in their production (Table 2) include potatoes (31.7 million pounds), carrots (9 million pounds), tomatoes (7 million pounds), onions (1.7 million pounds), and peanuts (1.1 million pounds). Lettuce and potatoes use approximately 1.3 million pounds annually of metam potassium in their production (Tables 2 and 3). Potato fields typically use metam potassium and sodium, for control of plant pathogens and nematodes, with 20% of the crop treated. Application rates range from 100 to 150 pounds of active ingredient per acre in Colorado, Florida and South Dakota up to 200 to 250 pounds of active ingredient per acre in Idaho, Virginia, and Washington. Fresh market carrot fields have 40% of the crop treated for control of nematodes and plant pathogens with application rates ranging from 150 to 250 pounds of active ingredient per acre in Arizona, California, Michigan, and Washington. Tomato fields are typically treated for weed, nematode, and plant pathogen control with 15% of the U.S. tomato acreage treated. The tomato application rates range from 75 to 250 pounds of active ingredient per acre in California and Florida. Onion fields are typically

treated for nematodes, weeds, and sometimes bulb mites with rates generally ranging from 200 to 300 pounds of active ingredient per acre from California, Oregon, and Washington. Peanut fields are typically treated for control of plant pathogens and nematodes with rates ranging from 25 to 50 pounds of active ingredient per acre from North Carolina to Virginia. Metam potassium and sodium are also commonly used to control plant pathogens and nematodes when orchards are replanted.

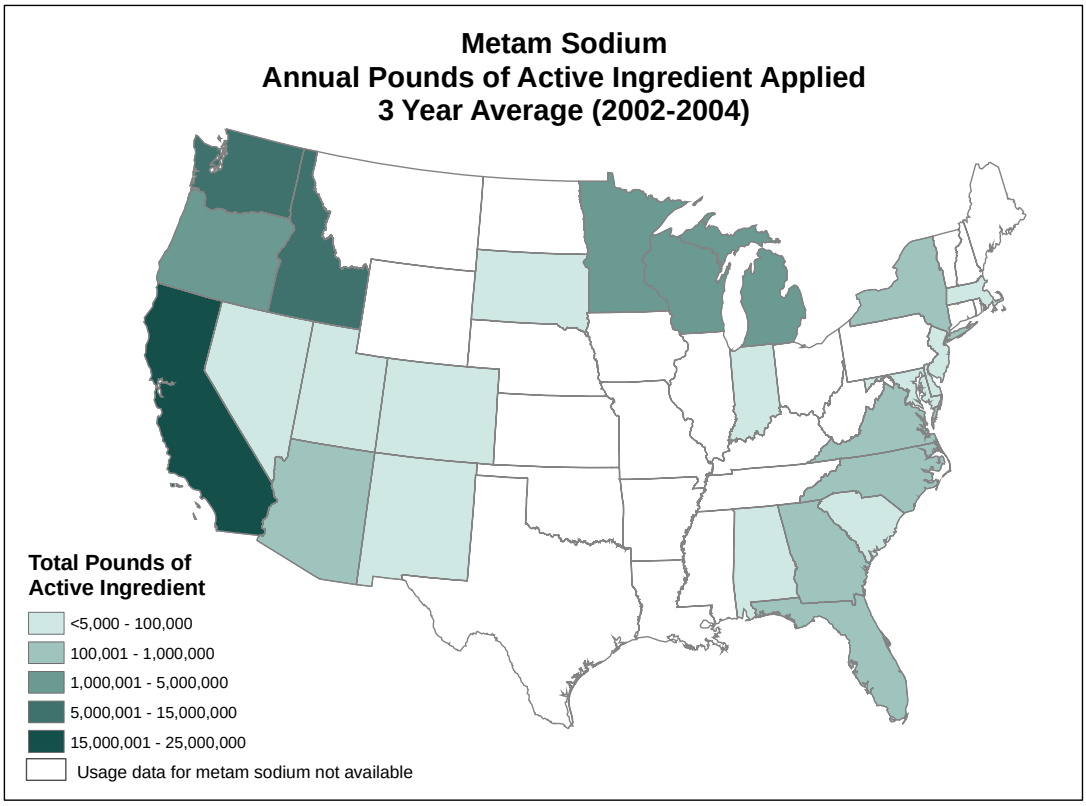

Figure 4. Metam Sodium. Annual Pounds of Active Ingredient Applied By State For All Surveyed Crops Based On Three Years Of EPA Data (2002-2004).

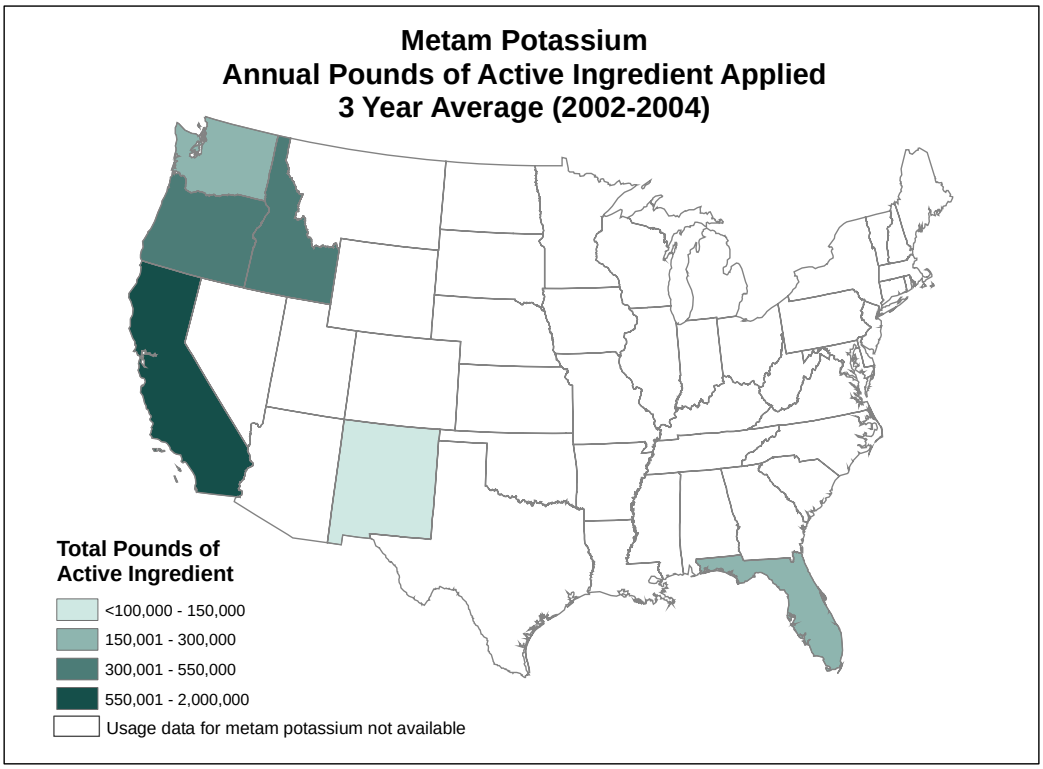

Figure 5. Metam Potassium. Annual Pounds of Active Ingredient Applied By State For All Surveyed Crops Based On Three Years Of EPA Data (2002-2004).

Non-Soil Uses

Metam potassium and sodium are registered as root control agents in sewer lines as a foam formulation, sterilization agents for treated wood (telephone poles only) and a number of antimicrobial and industrial uses for processing equipment for sugar cane and sugar beet plants and sewage, sludge, and animal waste. Usage numbers are not available for these widely divergent uses.

QUESTIONS FOR PUBLIC COMMENT

The following list indicates the types of information that would be useful in refining the risk assessment and developing benefit assessments for the soil fumigants. The Office of Pesticide Programs has worked through USDA's Office of Pest Management and Policy (OPMP) to communicate information needed to stakeholders. This information will be used to refine the risk assessments of the soil fumigants and to develop benefit assessments.

For each crop that is produced using a fumigant, information is needed in the following areas – crop production practices, fumigant use, and economics – for each crop / fumigant combination.

Crop Production Practices

- How many acres are usually grown per enterprise?
- Is the fumigated crop usually rotated with other crops? If so, what crop or crops typically follow the fumigated crop?
- Are there restrictions on the use of this fumigant or an alternative fumigant (e.g., regulatory constraints, permits, etc.)?
- Do soil characteristics influence your choice of fumigant? If so, how?
- What is the next best available alternative (e.g., another fumigant or strategy such as fallow, etc)?
- Could the use of fumigants be alternated (e.g., metam sodium followed by 1,3-dichloropropene)? Specify how.

Fumigant Use

- What equipment is used to apply the soil fumigants?
- What are the maximum numbers of acres that can be fumigated per day?
- What percent of the acres that are grown are fumigated?
- What is the usual application rate of the fumigant(s) (in pounds of active ingredient per acre)?
- What is the lowest application rate of the fumigant(s) that could be used to control soil pests in this crop (in pounds of active ingredient per acre)?
- What is the maximum application rate of the fumigant(s) that would be used in high pest pressure situations (in pounds of active ingredient per acre).
- What time during the year does fumigation usually take place?
- Describe how often you fumigate (e.g., every time a crop is grown, 1 time / year, 1 time / 2 years).
- What pests are targeted by soil fumigation (by category or specific pests)?
- How are the soil fumigants applied (e.g., chemigation, soil injection, etc.)?
- What methods or actions are taken to reduce emissions (e.g., polyethylene tarps or soil cap)?
- Could high density polyethylene (HDPE) films or high barrier films (VIF) be used on this crop?

- What is the time period between fumigation and the next production activity (e.g., time between fumigation and planting)?

Economics

- What changes in yield or quality would likely result by moving from the currently used fumigant to the next best available alternative (i.e., change in commodity price or grade)?
- Would using to the next best alternative impact key market windows? If so, how?
- What would be the cost per acre of the next best available alternative?
- What would be the cost per acre of other fumigation inputs (e.g., tarps and equipment)?
- Is there a crop budget available for this area and crop?

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APPENDICES

Appendix A. Major Registered Use Sites for the Soil Fumigants: Chloropicrin, Dazomet, Metam-potassium, Metam-sodium, Methyl Bromide, and 1,3-Dichloropropene.

Soil Use Sites	Chloropicrin	Dazomet	Metam-potassium	Metam-sodium	Methyl Bromide	1,3-Dichloropropene
Asparagus	x		x		x	x
Bananas	x					x
Barley	x		x	x		x
Beans, Dry	x			x		x
Beans, Dry (Blackeye peas)	x					x
Beets	x					x
Berries - Not specified	x					x
Brassica - Broccoli	x			x	x	x
Brassica - Brussels sprouts	x			x	x	x
Brassica - Cabbage	x			x		x
Brassica - Cauliflower	x				x	x
Brassica - Chinese cabbage				x		
Brassica - Collards	x					x
Brassica - Kale	x					x
Brassica - Kohlrabi	x					x
Brassica - Mustard greens	x			x		x
Brassica - Not specified	x					x
Buckwheat	x					x
Caneberry - Blackberry	x	x		x		x
Caneberry - Blueberry	x	x		x		x
Caneberry - Boysenberry	x					x
Caneberry - Brambles	x					x
Caneberry - Dewberry	x					x
Caneberry - Huckleberry	x					x
Caneberry - Loganberry	x					x
Caneberry - Raspberry	x	x				x
Caneberry - Youngberry	x					x
Carrots	x		x	x		x
Celery	x			x		x
Citrus - Grapefruit	x					x
Citrus - Kumquat	x					x
Citrus - Lemons	x					x
Citrus - Limes	x					x
Citrus - Nonbearing	x				x	
Citrus - Not specified	x			x	x	x

Soil Use Sites	Chloropicrin	Dazomet	Metam-potassium	Metam-sodium	Methyl Bromide	1,3-Dichloropropene
Citrus - Oranges	x					x
Citrus - Tangelos	x					x
Citrus - Tangerines	x					x
Corn - Field	x			x		x
Corn - Pop	x					x
Corn - Sweet				x		
Cotton	x			x		x
Cowpeas	x					x
Cranberries	x	x		x		x
Cucumbers	x			x		x
Currants	x	x				x
Eggplant	x				x	x
Elderberry		x				
Endive	x					x
Fallow					x	
Feed / Forage - Alfalfa	x		x	x		x
Feed / Forage - Birdsfoot Trefoil	x					x
Feed / Forage - Clover	x		x	x		x
Feed / Forage - Grasses	x					x
Feed / Forage - Legumes	x					x
Feed / Forage - Lespedeza	x					x
Feed / Forage - Oatgrass				x		
Feed / Forage - Pasture	x					x
Feed / Forage - Perennial Ryegrass				x		
Feed / Forage - Sudangrass			x	x		
Feed / Forage - Wheatgrass				x		
Feed / Forage -Sudangrass				x		
Fiber Crops - Not specified			x	x		
Flax	x					x
Forest Trees - Not specified	x			x	x	x
Fruit Trees - Apples	x	x	x	x	x	x
Fruit Trees - Apricots	x	x			x	x
Fruit Trees - Cherries	x	x		x	x	x
Fruit Trees - Dates	x					x
Fruit Trees - Figs	x					x
Fruit Trees - Mangos					x	
Fruit Trees - Nectarines	x	x	x			x
Fruit Trees - Not specified	x				x	x
Fruit Trees - Peaches	x	x	x	x	x	x

Soil Use Sites	Chloropicrin	Dazomet	Metam-potassium	Metam-sodium	Methyl Bromide	1,3-Dichloropropene
Fruit Trees - Pears	x	x		x		x
Fruit Trees - Plums/Prunes	x	x		x	x	x
Fruit Trees - Pomegranates	x					x
Fruit Trees - Quinces	x					x
Fruit Trees - Stone Fruits	x					x
Garlic	x			x		x
Gooseberry	x	x				x
Grains					x	
Grapes	x	x	x	x	x	x
Grasses				x		
Hops	x	x	x			x
Horseradish	x					x
Kenaf	x					x
Leeks	x					x
Lettuce	x			x	x	x
Melons - Cantaloupes	x			x	x	x
Melons - Casaba	x		x	x	x	x
Melons - Crenshaw	x		x	x	x	
Melons - Honeydew	x				x	
Melons - Mango	x				x	
Melons - Musk	x				x	
Melons - Not specified	x					x
Melons - Persian	x				x	
Melons - Watermelons	x					x
Millet	x					x
Mint	x		x	x		x
Nonfood Crops					x	
Nut Trees - Almonds	x			x	x	x
Nut Trees - Cashews	x					x
Nut Trees - Chestnuts	x					x
Nut Trees - Filberts	x	x				x
Nut Trees - Hazelnuts	x					x
Nut Trees - Hickory	x					x
Nut Trees - Not specified	x				x	x
Nut Trees - Pecans	x			x	x	x
Nut Trees - Pistachios	x				x	
Nut Trees - Walnuts	x	x		x	x	x
Oats	x		x	x		x
Okra	x					x

Soil Use Sites	Chloropicrin	Dazomet	Metam-potassium	Metam-sodium	Methyl Bromide	1,3-Dichloropropene
Olives	x					x
Onions	x		x	x	x	x
Orchards			x	x		
Ornamental Trees	x			x	x	x
Ornamental Trees - Elm				x		
Ornamental Trees - Juniper		x				
Ornamental Trees - Oak				x		
Ornamental Trees - Taxus (Yew)		x				
Ornamentals	x		x	x	x	x
Ornamentals - Bulbs, Corms, Rhizomes					x	
Ornamentals - Chrysanthemum		x				
Ornamentals - Flowering Fruits	x					
Ornamentals - Flowering Plants	x			x	x	x
Ornamentals - Gladiolus		x				
Ornamentals - Grasses				x		
Ornamentals - Herbaceous Plants	x				x	x
Ornamentals - Pansies		x				
Ornamentals - Woody	x			x	x	x
Ornamentals - Woody (Azalea)		x				
Ornamentals - Woody (Camellia)		x				
Ornamentals - Woody (Rhododendron)		x				
Parsnips	x					x
Pasture - Oats				x		
Pasture - Rye				x		
Peanuts	x		x	x		x
Peas	x			x		x
Peppers	x			x	x	x
Peppers - Pimentos	x					x
Persimmons	x					x
Pineapple	x				x	x
Potatoes	x		x	x	x	x
Pumpkin	x					x
Radishes	x			x		x
Rice				x		
Rutabagas	x					x
Rye	x		x	x		x
Safflower	x					x

Soil Use Sites	Chloropicrin	Dazomet	Metam-potassium	Metam-sodium	Methyl Bromide	1,3-Dichloropropene
Salsify	x					x
Sorghum	x			x		x
Soybeans	x			x		x
Spinach	x			x		x
Squash	x			x		x
Strawberries	x	x		x	x	x
Sugar beets	x		x	x		x
Sugarcane	x					x
Sweet Potatoes	x					x
Swiss Chard	x					x
Tobacco	x			x	x	x
Tomatoes	x			x	x	x
Turf - Bermudagrass				x		
Turf - Bluegrass				x		
Turf - Fescue				x		
Turf - Ornamental	x	x		x	x	
Turf - Ryegrass				x		
Turf - St. Augustinegrass				x		
Turnips	x			x		x
Vegetables - Not specified	x		x	x	x	x
Vine Fruits	x					x
Wheat	x		x	x		x
Yams	x					

Appendix B. Major Registered Nursery / Transplant Bed Use Sites for Chloropicrin, Dazomet, Metam-potassium, Metam-sodium, Methyl Bromide, and 1,3-Dichloropropene.

Nursery / Transplant Bed (Soil)	Chloropicrin	Dazomet	Metam potassium	Metam sodium	Methyl Bromide	1,3-Dichloropropene
Asparagus	x					
Brassica – Broccoli	x					
Brassica – Cauliflower	x					
Celery	x					
Citrus - Not specified	x				x	
Cucumbers	x					
Eggplant	x					
Forest Trees - Not specified	x	x		x	x	x
Fruit Trees - Not specified	x				x	x
Lettuce	x					
Melons – Musk	x					
Melons - Not specified	x					
Nonfood Crops	x				x	
Nursery Crops	x				x	x
Nursery Stock					x	
Nut Trees - Not specified	x					x
Onions	x					
Ornamental Trees	x			x	x	x
Ornamentals	x	x		x	x	x
Ornamentals - Bulbs, Corms, Rhizomes		x				
Ornamentals - Flowering Plants	x				x	x
Ornamentals - Herbaceous Plants	x	x			x	
Ornamentals - Woody	x			x	x	x
Peanuts				x		
Pineapple	x					
Strawberries	x				x	
Sweet Potatoes	x					
Tobacco	x	x	x	x	x	
Tomatoes	x			x	x	
Turf - Ornamental	x	x		x	x	
Vegetables - Not specified	x			x	x	
Vine Fruits	x					x
Yams	x					

Appendix C. Major Registered Methyl Bromide Commodity Use Sites

Animal Feed	Cotton	Ornamentals - Bulbs, Corms, Rhizomes
Apples	Cucumbers	Ornamentals - Herbaceous Plants
Apples - Dried	Cured Meat	Parsnips
Apricots	Dates	Peaches
Apricots - Dried	Dates - Dried	Peaches - Dried
Artichoke	Eggs - Dried	Peanuts
Asparagus	Eggplant	Pears
Bamboo	Feed / Forage - Alfalfa	Peas
Barley	Figs - Dried	Peppers
Beans, Dry	Garlic	Pineapple
Beans, Dry (Blackeye peas)	Grains	Plums/Prunes
Beans, Dry (Kidney)	Grapes	Potatoes
Beans, Dry (Lima)	Herbs	Processed Food/Feed
Beans, Dry (Pinto)	Horseradish	Pumpkin
Beets	Melons - Cantaloupes	Quinces
Brassica - Cabbage	Melons - Citron	Radishes
Caneberry - Blueberry	Melons - Honeydew	Raisins
Carrots	Melons - Musk	Rice
Cheese	Melons - Watermelons	Rutabagas
Cherries	Nectarines	Rye
Cherries - Dried	Nuts - Almonds	Salsify
Citrus - Citron	Nuts - Brazil nuts	Seeds
Citrus - Grapefruit	Nuts - Bushnuts	Sorghum
Citrus - Kumquat	Nuts - Butternuts	Spanish Moss
Citrus - Lemons	Nuts - Cashews	Spices
Citrus - Limes	Nuts - Chestnuts	Squash
Citrus - Oranges	Nuts - Filberts	Strawberries
Citrus - Tangelos	Nuts - Hickory	Structures and Food Processing Facilities
Citrus - Tangerines	Nuts - Macadamia	Sugar beets
Cocoa Beans	Nuts - Pecans	Sweet Potatoes
Coffee Beans	Nuts - Pistachios	Tobacco
Copra	Nuts - Walnuts	Tomatoes
Corn - Field	Oats	Turnips
Corn - Field (Grits)	Okra	Vegetables - Not specified
Corn - Pop	Onions	Wheat
Corn - Sweet	Ornamentals	Yams