

**2003 NOMINATION FOR A CRITICAL USE EXEMPTION  
FOR PEPPERS  
FROM THE UNITED STATES OF AMERICA**

**1. Introduction**

In consultation with the co-chair of the Methyl Bromide Technical Options Committee (MBTOC), the United States (U.S.) has organized this version of its Critical Use Exemption Nomination in a manner that would enable a holistic review of relevant information by each individual sector team reviewing the nomination for a specific crop or use. As a consequence, this nomination for pepper, like the nomination for all other crops included in the U.S. request, includes general background information that the United States believes is critical to enabling review of our nomination in a manner that meets the requirements of the Parties' critical use decisions. With that understanding, the fully integrated U.S. nomination for pepper follows.

**2. Background**

In 1997, the Parties to the Montreal Protocol adjusted Article 2H of the Protocol, and agreed to accelerate the reduction in the controlled production and consumption of methyl bromide. This adjustment included a provision calling for a phaseout of methyl bromide by the year 2005 "save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be critical uses." At the same time, the Parties adopted decision IX/6, the critical use exemption decision, which laid out the terms under which critical use exemptions under Article 2H would be granted.

**3. Criteria for Critical Uses Under the Montreal Protocol**

In crafting Decision IX/6 outlining the criteria for a critical use exemption, the Parties recognized the significant differences between methyl bromide uses and uses of other ozone-depleting chemicals previously given scrutiny under the Protocol's distinct and separate Essential Use exemption process. The United States believes that it is vitally important for the MBTOC to take into account the significant differences between the critical use exemption and the essential use exemption in the review of all methyl bromide critical use nominations.

During the debate leading up to the adoption of the critical use exemption Decision IX/6, an underlying theme voiced by many countries was that the Parties wanted to phase out methyl bromide, and not agriculture. This theme was given life in various provisions of the critical use exemption, and in the differences in approach taken between the critical use exemption and the essential use exemption. Those differences are outlined below.

*The Protocol's negotiated criteria for the critical use exemption for methyl bromide are much different from the criteria negotiated for "essential uses" for other chemicals.*

Under the Essential Use provisions, in order to even be considered for an exemption, it was necessary for each proposed use to be "critical for health, safety or the functioning of society." This high threshold differs significantly from the criteria established for the methyl bromide Critical Use exemption. Indeed, for methyl bromide, the Parties left it solely to the nominating governments to find that the absence of methyl bromide would create *a significant market disruption*.

For the U.S. nomination for peppers, following detailed technical and economic review, the U.S. has determined that some use of methyl bromide in pepper production is critical to ensuring that there is no significant market disruption. The detailed analysis of technical and economic viability of the alternatives listed by MBTOC for use in growing peppers is discussed later in this nomination, and is the basis for the U.S. estimate of the amount of methyl bromide needed within this sector.

*In the case of methyl bromide, the Parties recognized many agricultural fumigants were inherently toxic, and therefore there was a strong desire not to replace one environmentally problematic chemical with another even more damaging.*

The critical use exemption language explicitly requires that an alternative should not only be technically and economically feasible, it must also be acceptable from the standpoint of health and environment. This is particularly important given the fact that most chemical alternatives to methyl bromide are toxic and pose some risk to human health or the environment; in some cases, a chemical alternative may pose risks even greater than methyl bromide.

*In the case of methyl bromide, the Parties recognized that evaluating, commercializing and securing national approval of alternatives and substitutes is a lengthy process.*

In fact, even after an alternative is tested and found to work against some pests in a controlled setting, adequate testing in large-scale commercial operations in the many regions of the U.S. where a particular crop is grown can take many cropping seasons before the viability of the alternative can be adequately demonstrated. In addition, the process of securing national and sub-national approval of the use of alternatives requires extensive analysis of environmental consequences and risk to human health. The average time for the national review of scientific information in support of a new pesticide, starting from the date of submission to registration, is approximately 38 months. In most cases, the company submitting the information has spent approximately 7-10 years developing the toxicity data and other environmental data necessary to support the registration request.

*The Parties to the Protocol recognized that unlike other chemicals controlled under the Montreal Protocol, the use of methyl bromide and available alternatives could be site specific and must take into account the particular needs of the user.*

The Essential Use exemption largely assumed that an alternative used in one place could, if approved by the government, be used everywhere. Parties clearly understood that this was not the case with methyl bromide because of the large number of variables involved, such as crop type, soil types, pest pressure and local climate. That is why the methyl bromide Critical Use exemption calls for an examination of the feasibility of the alternative *from the standpoint of the user, and in the context of the specific circumstances of the nomination*, including use and geographic location. In order to effectively implement this last, very important provision, we believe it is critical for MBTOC reviewers to understand the unique nature of U.S. agriculture, as well as U.S. efforts to minimize the use of methyl bromide, to research alternatives, and to register alternatives for methyl bromide.

#### **4. U.S. Consideration/Preparation of the Critical Use Exemption for Pepper**

Work on the U.S. critical use exemption process began in early 2001. At that time, the U.S. Environmental Protection Agency (U.S. EPA) initiated open meetings with stakeholders both to inform them of the Protocol requirements, and to understand the issues being faced in researching alternatives to methyl bromide. During those meetings, which were attended by State and association officials representing literally thousands of methyl bromide users, the provisions of the critical use exemption Decision IX/6 were reviewed in detail, and questions were taken. The feedback from these initial meetings led to efforts by the U.S. to have the Protocol Parties establish international norms for the details to be in submissions and to facilitate standardization for a fair and adequate review. These efforts culminated in decision XIII/11 which calls for specific information to be presented in the nomination.

Upon return from the Sri Lanka meeting of the Parties, the U.S. took a three track approach to the critical use process. First, we worked to develop a national application form that would ensure that we had the information necessary to answer all of the questions posed in decision XIII/11. At the same time, we initiated sector specific meetings. This included meetings with representatives of pepper growers across the U.S. to discuss their specific issues, and to enable them to understand the newly detailed requirements of the critical use application. These sector meetings allowed us to fine tune the application so we could submit the required information to the MBTOC in a meaningful fashion.

Finally, and concurrent with our preparation phase, we developed a plan to ensure a robust and timely review of any and all critical use applications we might receive. This involved the assembly of more than 45 PhDs and other qualified reviewers with expertise in both biological and economic issues. These experts were divided into interdisciplinary teams to enable primary and secondary reviewers for each application/crop. As a consequence, each nomination received by the U.S. was reviewed by two separate teams. In addition, the review of these interdisciplinary teams was put to a broader review of experts on all other sector teams to enable a third look at the information, and to ensure consistency in review between teams. The result was a thorough evaluation of the merits of each request. A substantial portion of requests did not meet the criteria of decision IX/6, and a strong case for those that did meet the criteria has been included.

Following our technical review, discussions were held with senior risk management personnel of the U.S. government to go over the recommendations and put together a draft package for submission to the parties. As a consequence of all of this work, it is safe to say that each of the sector specific nominations being submitted is the work of well over 150 experts both in and outside of the U.S. government.

## **5. Overview of Agricultural Production**

### **5a. U.S. Agriculture**

The United States is fortunate to have a large land expanse, productive soils and a variety of favorable agricultural climates. These factors contribute to and enable the U.S. to be a uniquely large and productive agricultural producer. Indeed, the size and scope of farming in the U.S. is different than in most countries. Specifically, in 2001, U.S. farm land totaled 381 million hectares, a land area larger than the size of many entire countries. Of this, approximately 140 million hectares were devoted to cropland, with the rest devoted to pasture, forest, and other special uses. There were 2.16 million farms, with average farm size across all farms of 176 hectares (approximately 10 times larger than average farm size in the European Union). The availability of land and the fact that so many U.S. regions are conducive to outdoor cultivation of fruits and vegetables, has had an important influence on the way agriculture has developed. Specifically, these factors have meant that greenhouse production has generally proven to be very costly (in relative terms) and has as a consequence, been limited.

Other factors also affected the general development of farming in the U.S. While land for farming is widely available, labor is generally more expensive and less plentiful. As a result, the U.S. has developed a system of highly mechanized farming practices that are highly reliant on pesticides such as methyl bromide and other non-labor inputs. The extent of mechanization and reliance on non-labor inputs can be best demonstrated by noting the very low levels of labor inputs on U.S. farms: in 2001, only 2.05 million workers operated the 2.16 million U.S. farms, with help from less than 1 million hired workers.

Finally, the above factors have contributed to a harvest of commodities that has enabled the U.S. to meet not only its needs, but also the needs of many other countries. The U.S. produced 88.3 million metric tonnes of fruits and vegetables in 2001, up 10 percent from 1990. At the same time, the land planted in fruits and vegetables has remained stable, and individual farm size has increased as the number of farms has fallen. The related yield increases per land area are almost exclusively related to non-labor inputs, like the adoption of new varieties, and the application of new production practices, including plastic mulches, row covers, high-density planting, more effective pesticide sprays, and drip irrigation, as well as increased water irrigation practices. Optimization of yields through these and other scientific and mechanized practices make U.S. agricultural output very sensitive to changes in inputs. Therefore, as evidenced by the U.S. nomination for critical uses of methyl bromide, the phaseout of methyl bromide can have a very significant impact on both the technical and economic viability of production of certain crops in certain areas.

### **5b. Pepper Production**

U.S. pepper production exemplifies many of the characteristics of U.S. agriculture noted above. Peppers are a long-season commodity grown in most of the major vegetable growing areas of the U.S., with production concentrated in California and Florida. As a consequence, this nomination covers methyl bromide use in a variety of areas with differing soil and climactic characteristics. Peppers in both regions are mostly grown using multiple row transplants placed in polyethylene plastic-mulch raised beds. Transplants are typically planted from August through March—planted in January and February in the spring, and in September during the fall—although in some areas they are present in the field through the year. Plants are in the field for 2.5 to 5 months, depending on the season of the year. Pepper crops are sometimes double-cropped with a cucurbit crop after harvest (e.g., cucumber, squash, watermelon). Specialty peppers (e.g., chili peppers, pimientos, jalapeño peppers) are usually grown on a small percentage of the land as a second crop in fields that produced tomatoes as the primary crop.

Peppers are grown primarily in two states on opposite sides of the U.S., Florida and California, with significant additional pepper production in several other Eastern states including North Carolina, Georgia, and New Jersey. California and Florida account for approximately 38 percent and 27 percent of the U.S. commercial pepper area, respectively, and together account for approximately 78 percent of the value of U.S. commercial pepper production. The availability of land and the fact that these U.S. regions are conducive to outdoor cultivation of fruits and vegetables has had an important influence on the way agriculture has developed. Specifically, these factors have meant that greenhouse production is generally not competitive in cost, and has as a consequence, been limited.

In all production areas, peppers are generally produced using mechanized, scientific practices that involve deep injection of methyl bromide. In California, methyl bromide is used in certain areas to control a fungal disease, *Phytophthora capsici*, for which effective alternatives are not available. On the East Coast, methyl bromide is used primarily to control a pervasive weed, nutsedge, for which there are no effective alternatives. Estimates of the impact of the loss of methyl bromide in vegetable production suggest that without methyl bromide, a significant proportion of pepper production will no longer be economically feasible. Results from ongoing research evaluating alternatives to methyl bromide lead to the conclusion that methyl bromide cannot be replaced with a single chemical or cultural tactic.

## **6. Results of Review - Determined Need for Methyl Bromide in the Production of Peppers**

### **6a. Target Pests Controlled with Methyl Bromide**

In growing pepper, weeds - especially nutsedge - are the most serious concern precipitating methyl bromide use in both transplant beds and in the field. The critical use exemption nomination is primarily based on the lack of reliable alternatives to control nutsedge species. Nutsedge species grow even under adverse growing conditions and resist traditional and modern methods of weed control and are endemic to large tracts of pepper producing area in the Southeast region of the U.S. 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 and fungal diseases (such as *Phytophthora* blight) are also of concern and are commonly more of a problem than nutsedge on the West Coast of the

U.S. These pests are expected to become serious problems for pepper production if methyl bromide were not available for pre-plant fumigation.

**Yellow & purple nutsedge: (*Cyperus* spp.)** Yellow nutsedge (*Cyperus esculentus* L.) and purple nutsedge *Cyperus rotundus* L.) are perennial species of the Cyperaceae family that are widely recognized for their detrimental economic impact on agriculture. Purple nutsedge is considered the world's worst weed due to its widespread distribution and the difficulties in controlling it (Holm et al., 1977). Purple nutsedge is considered a weed in at least 92 countries and is reported infesting at least 52 different crops. Yellow nutsedge is listed among the top fifteen worst weeds and is found throughout the continental U.S. Purple nutsedge is primarily found in the Southern Coastal U.S. and along the Pacific coast in California and Oregon. A survey conducted in Georgia ranked the nutsedges as the most troublesome weeds in vegetable crops (there are more 30 vegetable crops grown in Georgia) and among the top five most troublesome weeds in corn, cotton, peanut, and soybean (Webster et al., 2001 b).

Nutsedge is propagated by tubers formed along underground rhizomes and corms. The parent tuber could be a tuber or a corm from the previous generation. During tillage of the soil, the underground stems are broken and new plants are established from either single or chains of tubers or corms. A single plant is capable of producing 1,200 new tubers within 25 weeks (Gilreath et al., 1999). Each tuber is capable of sprouting several times (Thullen et al., 1975). Tuber populations between 1,000 and 8,700 per/m<sup>2</sup> have been reported for purple nutsedge (Gamini et al., 1987). Nutsedge is very difficult to eradicate once it is established because of dormancy factors in the tubers and their ability to survive an array of adverse conditions for long periods of time. Nutsedge species are strong competitors with most vegetable crops for water and nutrients and can dramatically reduce crop yields, even at low plant densities, if not controlled effectively.

Purple and yellow nutsedge are serious problems in polyethylene film mulch vegetable production systems. Most weeds are controlled by these films, but nutsedges are able to penetrate the plastic films and actively compete with the vegetable crops, causing yield losses reported between 41 and 89 percent (Patterson, 1998).

There are very few herbicides that provide effective nutsedge control and none are registered for use on pepper. The herbicides that are available for these crops are generally older chemicals that are marginally effective against the spectrum of weeds that are problematic for solanaceous crops. Among the areas covered by this nomination for continued methyl bromide in peppers, 30 to 40 percent of East Coast pepper production areas are moderately to heavily infested with nutsedge.

**Root-knot nematode (*Meloidogyne* spp.)** Root damage caused by these nematodes leads to reduced rooting systems, which in turn lead to reduced water and nutrient uptake. The gall formation induced by the nematodes at their root feeding sites results in symptoms like stunting, wilting, and chlorosis, and renders the plant more susceptible to secondary infections. Preplant control of nematodes is important because once root damage is done and symptoms are evident, it is very difficult to avoid significant yield losses. Nematodes are found in all pepper producing regions in the U.S.

**Fungal diseases.** Phytophthora blight, caused by *Phytophthora capsici*, causes seed rot and seedling blight in many solanaceous crops including eggplants, pepper, and tomato. Phytophthora blight is one of the most destructive diseases and there are few control measures. Resistance to metalaxyl has been documented for *Phytophthora* species. Southern stem blight, caused by *Sclerotium rolfsii*, is also a very common and destructive disease affecting pepper and other solanaceous crops. In California's pepper producing areas, Phytophthora blight is the major problem controlled with methyl bromide, and this disease is endemic in about 10 percent of California's pepper production area.

## **6b. Overview of Technical and Economic Assessment of Alternatives**

Pepper growers rely on fumigation with methyl bromide/chloropicrin within the full-bed, plastic mulch production system to control soil borne diseases and pests. On the East Coast, where most methyl bromide is needed for pepper production, this system is designed to allow effective sedge control in pepper production. In California, this system is effective in controlling fungal diseases where other control are ineffective. In both areas, methyl bromide is also effective in controlling nematodes, other weeds (in addition to nutsedge), and other fungal pathogens (in addition to *Phytophthora*). 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.

We begin our technical and economic assessment by presenting in-kind (chemical) alternatives, and then describe the attributes of the not-in-kind alternatives.

## **6c. Technical Feasibility of In-Kind (Chemical) Alternatives**

**Table 1. In-Kind Methyl Bromide Alternatives Identified by MBTOC for Pepper:**

<b>Methyl Bromide Alternative</b>	<b>Technically Feasible</b>	<b>Economically Feasible</b>
1,3-Dichloropropene (Telone)	No	No
1,3-Dichloropropene + Chloropicrin	No	No
Chloropicrin	No	No
Metam Sodium	No	No
Metam sodium combined with crop rotation	No	No

**1, 3-Dichloropropene.** Telone is not a technically feasible stand-alone alternative to methyl bromide for the control of nutsedge and the disease complex that affects pepper production. Telone provides good control of nematode populations, but poor control of diseases and weeds. In addition, 1,3-

dichloropropene is restricted in key pepper growing areas of the U.S. which have soils underlain by karst topography and sandy (porous) sub-soils, geological features that could lead to ground-water contamination. Approximately 40 percent of Florida's pepper production land is in areas facing these soil constraints. As a consequence, 1,3-dichloropropene is prohibited in key growing areas like Dade County, Florida where about 1,300 hectares of peppers are grown each year. In California, use of 1,3-dichloropropene is restricted by township caps and buffer zones. In areas 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. The set back restrictions are expected to limit 1,3-dichloropropene use in about 1 percent of Florida's pepper production area.

There are also highly restrictive personal protective equipment (PPE) requirements for 1,3-dichloropropene application, which limit the ability of farmers to use the chemical in tropical and subtropical climates. For example, PPE restrictions may require applicators to wear fully sealed suits, with respirators. Such suits are do not have refrigeration components, and under conditions of high heat and humidity, rapidly become unbearable for a typical applicator.

Additionally, a 3-week time interval before planting is recommended to avoid phytotoxic levels after 1,3-dichloropropene application. This interval can 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.

Broadcast applications and use of emulsified formulations applied through micro-irrigation systems have been investigated in an effort to minimize the impacts of PPE and worker exposures. While related trials continue in an effort to optimize results, results from prior trials using these application techniques indicate increased variability in the efficacy of the chemical. Trials comparing broadcast 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-dichloropropene applied via broadcast. Applications via micro-irrigation systems have yielded mixed results, probably due to poor lateral distribution of the chemical in the soil. Yield losses for peppers from broadcast methods are expected to be 6 to 7 percent greater than losses from more precision methods (compared to methyl bromide), based on reported results from tomato.

**1, 3-Dichloropropene + Chloropicrin.** The 1,3-dichloropropene and chloropicrin combination is not technically feasible in cases with high/moderate nutsedge pressure because it needs to be coupled with an herbicide to provide season long control. It does however provide control of nematodes and diseases. All constraints described above for 1,3-dichloropropene also apply to this pesticide combination, including soil limitations, township caps, and worker exposure safeguards (PPE).

A bell pepper-squash rotation field study early in the growing season with chisel injected applications of 1,3-dichloropropene + chloropicrin (Webster et al., 2001a) had yield losses that ranged from 0 to 40 percent compared to methyl bromide. However, by the end of the season, only methyl bromide treatments



effectively controlled nutsedge. Interviews with growers indicated pepper yield losses of between 10 to 20 percent; and increases of nutsedge and nightshade populations of approximately 30 percent with Telone C-35 treatments compared to methyl bromide (grower estimates were not verified with field data).

The 1,3-dichloropropene + chloropicrin combination has shown activity suppressing weeds, but control of nutsedge has not been as consistent or as effective as methyl bromide in pepper production.

Trials comparing broadcast 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-dichloropropene applied via broadcast. Applications via micro-irrigation systems have yielded mixed results, probably due to poor lateral distribution of the chemical in the soil. Yield losses for peppers from broadcast methods are expected to be 6 to 7 percent greater than losses from more precision methods (compared to methyl bromide), based on reported results from tomato. Based on the results experienced in the tomato trials, we've assumed similar results for peppers. Yield increases of up to 2 percent were reported compared to methyl bromide when there was a second application of chloropicrin at the time of bed shaping following a Telone C-35 broadcast application.

**Chloropicrin.** Chloropicrin alone is not technically feasible because it is not sufficiently efficacious against nematodes and weeds. Chloropicrin provides effective control of soilborne pathogens/diseases but is less effective against nematodes and weeds. Most of the research data are for 1, 3-D + chloropicrin, and as previously noted, control of nutsedge and nematodes has not been reliable or effective.

Airborne concentrations of chloropicrin must be monitored. Airborne chloropicrin levels of 0.1 ppm require the use of air-purifying respirators and levels exceeding 4 ppm require the use of air-supplying respirators. Furthermore, emission of chloropicrin from agricultural fields into urban areas has been a concern due to lachrymating effects. Increased use of chloropicrin will trigger the need to address these issues.

**Metam Sodium.** Metam sodium is not a technically feasible alternative because research data show metam sodium alone provides limited and erratic performance at suppressing all major solanaceous pathogens and pests. Metam sodium degrades in the soil to form methylisothiocyanate, which has activity against nematodes, fungi, insects, and weeds. Metam sodium has a lower vapor pressure than methyl bromide, and therefore cannot penetrate and diffuse throughout the soil as effectively as methyl bromide. In addition, the effectiveness of metam sodium is very dependent on the organic matter and moisture content of the soil. Studies to evaluate best delivery systems for metam sodium are being conducted. Some studies have shown that soil injections and drenches are more effective than drip irrigation. Research trials show that incorporation of metam sodium with a tractor-mounted tillage implement provides good results but most growers do not have this equipment.

A 3-week time interval before planting is recommended to avoid phytotoxic levels; causing delays/adjustments in production schedules that could lead to missing specific market windows, thus reducing profit or actually causing a loss for a grower.

Data indicate that metam sodium is not an effective alternative to methyl bromide for nutsedge control. Webster et al. (2002 a), showed that commercial rates of metam sodium did not control nutsedge in bell pepper fields, relative to the non-treated control by the end of the season. Locascio et al. (1997) showed a 54 to 80 percent yield loss (compared to methyl bromide + chloropicrin treatments) in tomato fields with heavy and very heavy densities of nutsedge. Similar effects are expected for peppers. In other trials, metam sodium applied through drip irrigation under plastic mulch controlled nutsedge 80 to 90 percent in a 23 cm band along the drip line (Dowler, 1999). However, research has shown that nutsedge tubers from adjacent areas can quickly re-infest previously treated areas in a single growing season (Webster, 2002 b), and the effectiveness of this method raises enough questions that further research is needed, and it cannot currently be considered an effective and reliable alternative.

**Metam Sodium + Crop Rotation.** The metam sodium and crop rotation combination is not a technically feasible alternative because research data show metam sodium alone provides limited and erratic performance at suppressing all major solanaceous pathogens and pests and crop rotation does not address this deficiency. Issues regarding effects of allelochemicals from cover crops are also a concern. Unpublished data (Norsworthy, 2000) shows that incorporation of wild radish (metam sodium crop rotation) caused stand loss and phytotoxicity to cotton. More research is needed to evaluate the possibility of similar effects for vegetable crops.

#### **6d. Economic Feasibility of In-Kind (Chemical Alternatives)**

None of the alternatives listed by MBTOC and reviewed above were found to be technically viable for pepper. Despite this, reviewers analyzed the economic losses associated with the use of two alternative pest-control regimes: 1,3-dichloropropene + chloropicrin, and metam-sodium. These are the two alternatives considered most likely to be used in the absence of methyl bromide.

The economic assessment of feasibility for *pre-plant uses of methyl bromide*, such as for peppers, included an evaluation of economic losses from three basic sources: (1) yield losses, referring to reductions in the quantity produced, (2) quality losses, which generally affect the price received for the goods, and (3) increased production costs, which may be due to the higher-cost of using an alternative, additional pest control requirements, and/or resulting shifts in other production or harvesting practices.

The economic reviewers then analyzed crop budgets for pre-plant sectors to determine the likely economic impact if methyl bromide were unavailable. Various measures were used to quantify the impacts, including the following:

(1) losses as a percent of gross revenues. This measure has the advantage that gross revenues are usually easy to measure, at least over some unit, *e.g.*, an hectare of land or a storage operation. However, high value commodities or crops may provide high revenues but may also entail high costs. Losses of even a small percentage of gross revenues could have important impacts on the profitability of the activity.

(2) absolute losses per hectare. For crops, this measure is closely tied to income. It is relatively easy to measure, but may be difficult to interpret in isolation.

(3) losses per kilogram of methyl bromide requested. This measure indicates the value of methyl bromide to crop production but is also useful for structural and post-harvest uses.

(4) losses as a percent of net cash revenues. We define net cash revenues as gross revenues minus operating costs. This is a very good indicator as to the direct losses of income that may be suffered by the owners or operators of an enterprise. However, operating costs can often be difficult to measure and verify.

(5) changes in profit margins. We define profit margin to be profits as a percentage of gross revenues, where profits are gross revenues minus all fixed and operating costs. This measure would provide the best indication of the total impact of the loss of methyl bromide to an enterprise. Again, operating costs may be difficult to measure and fixed costs even more difficult.

These measures represent different ways to assess the economic feasibility of methyl bromide alternatives for methyl bromide users, who are pepper producers in this case. Because producers (suppliers) represent an integral part of any definition of a market, we interpret the threshold of significant market disruption to be met if there is a significant impact on commodity suppliers using methyl bromide. The economic measures provide the basis for making that determination.

The results of the economic evaluation of the 1,3-dichloropropene/chloropicrin alternative are shown below in Table 2, beginning with the estimates of yield loss, which is also a measure of gross revenue loss. Percent yield losses are 5 percent in California, lower than in the East because losses from *Phytophthora* are not expected to be as great as losses from nutsedge. Yield loss in California is only expected for the 10 percent of the California growing area where methyl bromide is needed to control *Phytophthora*, and in our analysis the level of disease pressure is assumed to be what is typically found in California. Yield losses in Florida and the Southeast are expected to be 20 percent, primarily due to difficulties controlling nutsedge, as described earlier. This yield loss is expected on the 30 to 40 percent of pepper producing area in this region infested with moderate and high levels of nutsedge pressure. It should be noted that the yield loss estimates has substantial uncertainty, because most of the referenced studies reported wide ranges of yield effects. The reviewing experts conducted the economic analysis with yield losses estimates that they believed represented a likely or central estimate.

Shifting to metam-sodium is expected to slightly decrease production costs. In California, production costs are expected to fall about US\$170 or 1 percent (calculated from crop budgets). Specific estimates of cost increases were not available for Florida, or the Southeast so we assumed the decrease was the same as in California.

Economic losses (per hectare) are calculated by adding the expected loss in yield/revenue to the increase in production costs. Revenue losses are higher for Florida and California because they have relatively high

yields compared to the Southeast, which generally has lower yields (Georgia has the highest yields in this region). In other words, a 20 percent yield loss in Florida corresponds to a higher absolute loss than a 20 percent yield loss in North Carolina. In addition to region-specific yields, the analysis takes into account the price of peppers in each region.

Economic loss per kilogram of methyl bromide is a measure of the marginal contribution of methyl bromide. It is calculated by dividing usage rates (per hectare) into the estimate of economic losses per hectare. Comparing these losses provides a rough measure of the loss in economic efficiency associated with adoption of methyl bromide alternatives. Under this measure, pepper production in Florida suffers high efficiency losses compared to the Southeast and California, but it is important to note that in all cases, losses are greater than zero, suggesting the loss of methyl bromide would lead to efficiency losses in all pepper producing areas.

Expressed as proportion of gross and net revenue, economic losses can also describe the impact on the economic viability of a given production system. Using these measures, one can see that adoption of 1,3-dichloropropene/chloropicrin as the methyl bromide alternative would lead to substantial economic impacts. Given the competitive nature of vegetable production in the U.S., these economic impacts would represent a substantial market disruption to U.S. pepper producers.

**Table 2. Economic Impact of Using 1,3-Dichloropropene + Chloropicrin in Place of Methyl Bromide on Bell Peppers in the U.S.**

	<b>Florida</b>	<b>Southeast</b> (including Georgia)	<b>California</b>
Direct yield loss	20% loss (great uncertainty about this number)	20% loss (great uncertainty about this number)	5% loss (higher if township caps and setbacks limit use of alternatives)
Change in production costs	\$170/ha reduction in operating costs (assuming similar to CA)	\$170/ha reduction in operating costs (assuming similar to CA)	\$170/ha reduction in operating costs 1% of operating costs
Economic loss per hectare	\$6180	\$2064	\$830
Economic loss per kg of methyl bromide	\$20.02	\$6.69	\$4.15
Economic loss as percent of gross revenues	19%	18%	4%
Economic loss as percent of net cash revenues	unknown	unknown	80% loss

Note: Florida and Southeast economic data were very limited. These calculations based on California information and information in 2001 Ag. Stats.

The results of the economic evaluation of the metam-sodium alternative are shown below in Table 3, beginning with the estimates of yield loss, which is also a measure of gross revenue loss. Percent yield losses are 8 percent in California, lower than in the East because losses from *Phytophthora* are not expected to be as great as losses from nutsedge. Yield loss in California is only expected for the 10 percent of California growing area where methyl bromide is needed to control *Phytophthora*, and in our

analysis the level of disease pressure is assumed to be what is typically found in California. Yield losses in Florida and the Southeast are expected to be 30 percent, primarily due to difficulties controlling nutsedge, as described earlier. This yield loss is expected on the 30 to 40 percent of pepper producing area in this region infested with moderate and high levels of nutsedge pressure. It should be noted that the yield loss estimates have substantial uncertainty, because most of the referenced studies reported wide ranges of yield effects. The reviewing experts conducted the economic analysis with yield losses estimates that they believed represented a likely or central estimate.

In addition to declines in expected gross revenue, shifting to the metam-sodium combination increases production costs. These costs increase because of higher pesticide costs, as well as higher costs of applying pesticides. In California, production costs changes of about US\$1065 per hectare or 6 percent are expected (calculated from crop budgets). Specific estimates of cost increases were not available for Florida and the Southeast so we assumed the increase would be the same as in California.

Economic losses (per hectare) are calculated by adding the expected loss in yield/revenue to the increase in production costs. Revenue losses are higher for Florida and California because they have relatively high yields compared to the Southeast, which generally has lower yields (Georgia has the highest yields in this region). In other words, a 30 percent yield loss in Florida corresponds to a higher absolute loss than a 30 percent yield loss in North Carolina. In addition to region-specific yields, the analysis takes into account the price of peppers in each region.

Economic losses per kilogram of methyl bromide are a measure of the marginal contribution of methyl bromide. It is calculated by dividing usage rates (per hectare) into the estimate of economic losses per hectare. Comparing these losses provides a rough measure of the loss in economic efficiency associated with adoption of methyl bromide alternatives. Under this measure, pepper production in Florida suffers high efficiency losses compared to the Southeast and California, but it is important to note that in all cases, losses are greater than zero, suggesting efficiency losses in all pepper producing areas.

Expressed as proportion of gross and net revenue, economic losses can also describe the impact on the economic viability of a given production system. Using these measures, one can see that adoption of metam-sodium as the methyl bromide alternative would lead to substantial economic impacts.

**Table 3. Economic Impact of Using Metam-Sodium in Place of Methyl Bromide on Bell Peppers in the U.S.**

	<b>Florida</b>	<b>Southeast</b> (including Georgia)	<b>California</b>
Direct yield loss	30% loss (great uncertainty about this number)	20% loss (great uncertainty about this number)	8% loss (higher if township caps and setbacks limit use of alternatives)
Change in production costs	\$1065/ha (assuming similar to CA)	\$1065/ha (assuming similar to CA)	\$1065/ha 6% of operating costs
Economic loss per hectare	\$10591	\$4417	\$2,666
Economic loss per kg of methyl bromide	\$31.30	\$14.31	\$14.02
Economic loss as percent of gross revenues	33%	40%	13%
Economic loss as percent of net cash revenues	unknown	unknown	250% loss

Note: Florida and Southeast economic data were very limited. These calculations based on California information and information in 2001 Ag. Stats.

#### **6e. Technical Feasibility of Not-In-Kind (Non-Chemical) Alternatives**

This section summarizes the analysis of the remainder of the methyl bromide alternatives identified by MBTOC for pepper, primarily non-chemical alternatives. Table 4 contains a summary of the technical assessment, which is that none of these alternatives were found to be technically feasible. A description of each alternative follows. Because no alternative was found to be technically feasible, no economic assessment was performed.

**Table 4. Not-in-Kind Methyl Bromide Alternatives Identified by MBTOC for Pepper**

Methyl Bromide Alternative	Technically Feasible	Economically Feasible
Biofumigation	No	No
Solarization	No	No
Solarization, Fungicides	No	No
Steam	No	No
Biological control	No	No
Cover crops and mulching	No	No
Crop rotation/Fallow	No	No
General IPM	No	No
Grafting/Resistant rootstock/Plant breeding	No	No
Organic amendments/Compost	No	No
Resistant Cultivars	No	No
Substrates/Plug plants	No	No

**Biofumigation** is not a technically feasible alternative because it has not been shown to control the pest complex. Research conducted in Florida showed some control of plant pathogens but no control of nematodes or weeds in the soil. In cases where biofumigation have been shown to control weeds, the data are mostly for small-seeded weed species that have small carbohydrate energy sources compared to nutsedge. The data on biofumigation are too limited to consider it as a practical alternative to methyl bromide.

**Solarization** is not technically feasible because alone it does not control the wide range of soil-borne diseases and pests affecting pepper. Solarization involves covering the soil with clear plastic under direct sunlight for several weeks. Solarization is a weather sensitive process that requires ideal soil moisture and sunlight conditions, and is most successful in regions with continuous high temperature periods during summer.

Data indicate that soil solarization can be an effective replacement for methyl bromide in the management of some pests and diseases, but not the primary pests in peppers that are currently controlled through fumigation. Temperatures of 65 degrees C for 30 minutes will control many soil-borne fungi, nematodes and weeds, with the exception of *Cyperus* species. 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. 1998; Egley, 1983). Field studies indicate that raising and maintaining soil temperatures throughout the soil profile to levels shown to control nutsedge is extremely difficult. Nutsedge have shown ability to emerge from deep in the soil profile and to reinvade from areas outside the solarization zone, so solarization alone will not be an effective and dependable control method for nutsedge, which is the primary pest underlying the nomination for continued methyl bromide in pepper.

**Solarization and fungicides.** Fungicides are not effective for control of weeds and nematodes. Therefore, their use in combination with solarization is no more efficacious than solarization alone.

**Steam.** Steam for soil sterilization is impractical in large-scale, open field production areas characteristic of pepper production. Steam can be used as an alternative to methyl bromide soil fumigation in small-scale or closed production areas but has yet to be proven economical and practical for large-scale, open field production systems (UNEP,1998). As described earlier, U.S. pepper production is not of a scale small enough to make steam a cost-effective alternative.

**Biological Control.** Biological control is not a technically feasible alternative to methyl bromide in pepper production because no biological control agent has been identified to effectively control nutsedge or *Phytophthora*. Therefore, biological control is not a stand-alone 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.

Several pathogens have been evaluated for control of nutsedge, but to date, there are no bioherbicides registered for management of nutsedge species. *Dactylaria higginsii* and *Puccinia canaliculata* have shown potential to control nutsedge tuber formation, however, the prolific ability of nutsedge to reproduce and recolonize will limit the use of these biological control agents as alternatives to methyl bromide.

Biological control is not a stand-alone replacement for methyl bromide in pepper crops. Research is needed to develop appropriate mechanisms to integrate the use of biological control into vegetable production systems, including proper selection of pesticides that will not be detrimental to populations of potential biological control agents.

**Cover crops and Mulching.** Cover crops and mulching are not technically feasible alternatives because data do not support their use as stand-alone alternatives to methyl bromide. The use of cover crops is a common practice to improve soil structure and suppress an array of soilborne pathogens. Cover crops and mulches have been integrated to solanaceous crop production management.

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 et al., 1996; Galloway et al., 1996). Cowpea and sunn hemp have been shown to suppress nutsedge, but the effect is short lived, due to the weed's capacity for rapid tuber production. Allelochemicals released by some cover crops or organic mulches can injure crops (Johnson et al.,1993; Norsworthy, 2002).

Trials conducted in southern Florida with the leguminous crops sunn hemp, velvet bean, cowpea, and sorghum Sudan grass showed crop yields comparable to methyl bromide + chloropicrin treatments. However, nematode and disease densities were described as very low in the soils involved in these studies. Iron clay cowpea has been shown to reduce populations of northern root knot nematode, and to increase population of the sting nematode. Increased sting nematode populations have been reported as well with



millet as a cover crop. Proper selection of cover crops can be very important in suppressing or promoting pest populations.

**Crop Rotation/Fallow.** Crop rotation/fallow are not technically feasible alternatives because they do not control nutsedge. Crop rotation and fallow are effective tools for management of weeds, diseases and nematodes, especially as part of an IPM program. However, these practices may be difficult for growers of pepper and other high-value crops; especially in areas where land is a limited and expensive resource. Agronomic crops are more effective competitors than vegetable crops and planting dates are difficult to adjust for vegetable crops due to marketing factors. There are registered herbicides that are effective for nutsedge control in agronomic crops. These herbicides are not available for most vegetable crops, and many of them have 12 to 26-month carryover restrictions to vegetable crops.

Crop rotation and fallow will not suppress nutsedge. Johnson & Mullinix (1997) showed that uninterrupted plantings of peanut, corn, or cotton, with moderate levels of weed management suppressed yellow nutsedge in Georgia. Their data also showed an increase in nutsedge densities in fallow plots, likely due to the longevity of nutsedge tubers in soil, mild winters that prevent winter-kill of tubers, and the ability of tubers to regenerate with the long growing season in the southeastern coastal plain. There are also reports of increasing populations of yellow nutsedge in fallowed fields, even when weed control/management is performed. Since there are no herbicides registered for use on pepper that will effectively control nutsedge, management of these weeds during short-term rotations and fallow is not effective.

**General IPM.** IPM, the use of pest monitoring activities coupled with chemical and non-chemical management tools, has been adopted for management of weed, diseases, and nematodes on solanaceous crops. However, problematic weeds like nutsedge and nightshade, and soilborne diseases and nematodes are not effectively controlled by these practices.

**Grafting/Resistant Rootstock/Plant Breeding.** Grafting has not been evaluated for vegetable production due to the high cost and the large number of plants that would be needed. These alternatives are primarily used for nematode and disease management, but there is no evidence that they apply to competition from weeds.

Plant breeding is suited for the management of soilborne diseases as part of an IPM program. This alternative is not applicable to competition from weeds. Breeding for resistance is a long term process and is dependent on the availability of natural sources of resistance.

**Organic Amendments/Compost.** Organic amendment/compost is not a technically feasible stand-alone alternative for methyl bromide for solanaceous crop production. The use of compost as a pest control tool is still new and not clearly understood. Although available data suggest that the use of compost is a viable alternative for suppression of some diseases, especially when used with IPM in small-scale and greenhouse operations, additional research is needed to determine the specific interactions that make compost effective and to determine its usefulness in large-scale field applications.

**Resistant Cultivars.** Resistant cultivars by themselves are not technically feasible alternatives for controlling all the target pests of pepper production. Disease resistant varieties are used in pepper production, especially for bacterial and viral diseases. Research with root-knot nematode resistant varieties has shown that genes for nematode resistance are heat sensitive and not stable at high soil temperatures typical of pepper crop production areas. These plants are open pollinated and homozygous for the resistant gene, which means that the host-plant resistance does not persist across generations.

**Substrates/Plug Plants.** Substrates/plug plants by themselves are not technically feasible alternatives because they do not control competition from nutsedge. Plug plants are extensively used on high value vegetable crops like peppers. Amendments with biological control organisms provide limited resistance/control and yield enhancements in solanaceous crops due to the specific nature of biological control microorganisms and the heterogeneous distribution of pathogens in soils.

## 7. Critical Use Exemption Nomination for Peppers

As noted above, this nomination is for a critical use exemption for methyl bromide for pepper production in the states of Florida, Georgia, California, and a group of Southeastern states. The U.S. interdisciplinary review team found a critical need for methyl bromide for pepper growers in Florida, Georgia, California and Southeastern states the U.S. The alternatives identified by the MBTOC were, as reviewed in detail above, regarded by reviewers as technically and economically infeasible for acceptable management of the major pepper pests, most importantly, yellow and purple nutsedge and several nematode and fungal pathogens.

The following tables provide information on methyl bromide historical usage, including area treated, and the 2005 thru 2007 actual amount requested for pepper.

**Table 5. Methyl Bromide Usage & Request for Peppers in Florida**

	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>kg</b>	1,727,644	1,630,376	1,644,501	1,431,639	1,577,412	1,371,662	1,371,662	1,371,662
<b>hectares</b>	9,429	8,903	8,984	8,741	8,741	8,741	8,741	8,741
<b>rate (kg/ha)</b>	183	183	183	164	180	157	157	157

For purposes of calculating the overall U.S. critical need for methyl bromide, only enough MeBr to treat Florida pepper production infested with nutsedge, that has superficial karst topography or that has regulatory constraints is included in the nomination.

Florida pepper production typically uses a 67/33 formulation of methyl bromide.

**Table 6. Methyl Bromide Usage & Request for Peppers in Georgia**

	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>kg</b>	294,550	313,053	337,163	347,944	338,248	338,248	338,248	338,248
<b>hectares</b>	1,192	1,267	1,767	2,263	2,252	2,252	2,252	2,252
<b>rate (kg/ha)</b>	247	247	191	154	150	150	150	150

For purposes of calculating the overall U.S. critical need for methyl bromide, only enough MeBr to treat Georgia pepper production infested with nutsedge is included in the nomination.

Methyl bromide use in Georgia pepper production has changed over time from the 98/2 formulation commonly used in 1997 to predominately the 67/33 formulation used in 2000 and 2001.

**Table 7. Methyl Bromide Usage & Request for Peppers in the Southeast (excluding Georgia)**

	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>kg</b>	151,137	164,472	118,524	112,445	112,445	112,445	112,445	112,445
<b>hectares</b>	688	749	789	749	749	749	749	749
<b>rate (kg/ha)</b>	220	220	150	150	150	150	150	150

For purposes of calculating the overall U.S. critical need for methyl bromide, only enough MeBr to treat Southeastern pepper production infested with nutsedge, which represent about 10% of pepper production, is included in the nomination.

Methyl bromide use in southeastern pepper production has changed over time from the 98/2 formulation commonly used in 1997 to predominately the 67/33 formulation used currently.

**Table 8. Methyl Bromide Usage & Request for Peppers in California**

	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>kg</b>	133,882	182,834	247,191	170,830	224,528	181,437	181,437	181,437
<b>hectares</b>	726	864	1,226	995	890	1,012	1,012	1,012

<b>rate (kg/ha)</b>	184	212	202	172	252	179	179	179
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The amount requested in the nomination reflects area for California pepper growers that is infested with Phytophthora and Verticilium pathogens and represents about 10% of total California production. For purposes of calculating the overall U.S. critical need for methyl bromide, only enough MeBr to treat California pepper production infested Phytophthora and Verticilium pathogens, representing about 10% of this state's total pepper production, is included in the nomination.

The total U.S. nomination has been determined based first on consideration of the requests we received and an evaluation of the supporting material. This evaluation, which resulted in a reduction in the amount being nominated, included careful examination of issues including the area infested with the key target (economically significant) pests for which methyl bromide is required, the extent of regulatory constraints on the use of registered alternatives (buffer zones, township caps), environmental concerns such as soil based restrictions due to potential groundwater contamination, and historic use rates, among other factors.

**Table 9. Methyl Bromide Critical Use Exemption Nomination for Peppers**

<b>Year</b>	<b>Total Request by Applicant (kilograms)</b>	<b>U.S. Sector Nomination (kilograms)</b>
<b>2005</b>	2,003,793	<b>1,085,265</b>

## **8. Minimizing Use/Emissions of Methyl Bromide in the United States/Stockpiles**

In accordance with the criteria of the critical use exemption, we will now describe ways in which we strive to minimize use and emissions of methyl bromide. While each sector based nomination includes information on this topic, we thought it would be useful to provide some general information that is applicable to most methyl bromide uses in the country

The use of methyl bromide in the United States is minimized in several ways. First, because of its toxicity, methyl bromide is regulated as a restricted use pesticide in the United States. As a consequence, methyl bromide can only be used by certified applicators who are trained at handling these hazardous pesticides. In practice, this means that methyl bromide 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 methyl bromide and keep related emissions to the lowest level possible, methyl bromide is machine injected into soil to specific depths. In addition, as methyl bromide has become more scarce, users in the United States have, where possible, experimented with different mixes of methyl bromide and chloropicrin. Specifically, in the early 1990s, methyl bromide was typically sold and used in methyl bromide mixtures made up of 98% methyl bromide 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 methyl bromide, users have been experimenting with significant increases in the level of chloropicrin and reductions in the level of methyl bromide. While these new mixtures have generally been effective at controlling target pests, it must be stressed that the long term efficacy of these mixtures is unknown. Reduced methyl bromide concentrations in mixtures, more mechanized soil injection techniques, and the extensive use of tarps to cover land treated with methyl bromide has resulted in reduced emissions and an application rate that we believe is among the lowest in the world.

In terms of compliance, in general, the United States has used a combination of tight production and import controls, and the related market impacts to ensure compliance with the Protocol requirements on methyl bromide. Indeed, over the last – years, the price of methyl bromide has increased substantially. As Chart 1 in Appendix D demonstrates, the application of these policies has led to a more rapid U.S. phasedown in methyl bromide consumption than required under the Protocol. This accelerated phasedown on the consumption side may also have enabled methyl bromide production to be stockpiled to some extent to help mitigate the potentially significant impacts associated with the Protocol's 2003 and 2004 70% reduction. We are currently uncertain as to the exact quantity of existing stocks going into the 2003 season that may be stockpiled in the U.S. We currently believe that the limited existing stocks are likely to be depleted during 2003 and 2004. This factor is reflected in our requests for 2005 and beyond.

At the same time we have made efforts to reduce emissions and use of methyl bromide, we have also made strong efforts to find alternatives to methyl bromide. The section that follows discusses those efforts.

## **9. U.S. Efforts to Find, Register and Commercialize Alternatives to Methyl Bromide**

Over the past ten years, the United States has committed significant financial and technical resources to the goal of seeking alternatives to methyl bromide that are technically and economically feasible to provide pest protection for a wide variety of crops, soils, and pests, while also being acceptable in terms of human health and environmental impacts. The U.S. pesticide registration program has established a rigorous process to ensure that pesticides registered for use in the United States do not present an unreasonable risk of health or environmental harm. Within the program, we have given the highest priority to rapidly reviewing methyl bromide alternatives, while maintaining our high domestic standard of environmental protection. A number of alternatives have already been registered for use, and several additional promising alternatives are under review at this time. Our research efforts to find new alternatives to methyl bromide and move them quickly toward registration and commercialization have allowed us to make great progress over the last decade in phasing out many uses of methyl bromide. However, these efforts have not provided effective alternatives for all crops, soil types and pest pressures, and we have accordingly submitted a critical use nomination to address these limited additional needs.

### ***Research Program***

Through 2002, the USDA Agricultural Research Service (ARS) alone has spent US\$135.5 million to implement an aggressive research program to find alternatives to methyl bromide (see Table below). Through the Cooperative Research, Education and Extension Service, USDA has provided an additional \$11.4m since 1993 to state universities for alternatives research and outreach. This federally supported research is a supplement to extensive sector specific private sector efforts, and that all of this research is very well considered. Specifically, the phaseout challenges brought together agricultural and forestry leaders from private industry, academia, state governments, and the federal government to assess the problem, formulate priorities, and implement research directed at providing solutions under the USDA's Methyl Bromide Alternatives program. The ARS within USDA has 22 national programs, one of which is the Methyl Bromide Alternatives program (Select Methyl Bromide Alternatives at this web site: <http://www.nps.ars.usda.gov> ). The resulting research program has taken into account these inputs, as well as the extensive private sector research and trial demonstrations of alternatives to methyl bromide. While research has been undertaken in all sectors, federal government efforts have been based on the input of experts as well as the fact that nearly 80 percent of preplant methyl bromide soil fumigation is used in a limited number of crops. Accordingly, much of the federal government pre-plant efforts have focused on strawberries, tomatoes, ornamentals, peppers and nursery crops, (forest, ornamental, strawberry, pepper, tree, and vine), with special emphasis on tomatoes in Florida and strawberries in California as model crops.

**Table 6. Methyl Bromide Alternatives Research Funding History**

<b>Year</b>	<b>Million (US\$)</b>
1993	\$7.255
1994	\$8.453
1995	\$13.139
1996	\$13.702
1997	\$14.580
1998	\$14.571
1999	\$14.380
2000	\$14.855
2001	\$16.681
2002	\$17.880

The USDA/ARS strategy for evaluating possible alternatives is to first test the approaches in controlled experiments to determine efficacy, then testing those that are effective in field plots. The impact of the variables that affect efficacy is addressed by conducting field trials at multiple locations with different crops

and against various diseases and pests. Alternatives that are effective in field plots are then tested in field scale validations, frequently by growers in their own fields. University scientists are also participants in this research. Research teams that include ARS and university scientists, extension personnel, and grower representatives meet periodically to evaluate research results and plan future trials.

Government funded studies related to U.S. pepper production that are currently on-going include the following:

### **1. Multi-Tactic Approach to Pest Management for Methyl Bromide Dependent Crops in Florida (Sep 2000 - Aug 2003)**

To evaluate the use of reduced risk pesticides applied through drip irrigation for nematode, fungal pathogen control and yield; to evaluate vegetable transplants grown in mixes amended with plant growth-promoting rhizobacteria (PGPR) in a production system that includes the most promising alternatives for methyl bromide. Tomato or pepper seed will be placed in a standard 70% peat, 30% vermiculite medium. Medium amendment(s) consisting of formulations of plant growth promoting rhizobacteria (PGPR) will be applied as formulations of BioYield 213 before seeding. A subsample of 5 to 6 week old seedlings, depending on time of year, will be assessed for height, root and shoot dry weight, leaf area, stem caliper, chlorophyll density, and associated calculated ratios. Both treated and untreated plants will be transplanted to field plots treated with a variety of alternative soil treatments and application methodologies including the reduced risk chemical Plantpro applied through drip irrigation. Natural incidences of soilborne pathogens will be assessed throughout the growing season. Disease incidence ratings will be made and confirmed where necessary by plating on appropriate media. Marketable yield will be assessed for treated and untreated plots. These treatments will be evaluated in four field trials conducted over 24 months. Trials will utilize split plot designs.

### **2. Field Scale Demonstration/validation Studies of Alternatives for Methyl Bromide in Plastic Mulch (Apr 2000 - Jun 2003)**

Evaluate and validate the effectiveness and economic viability of alternatives to Methyl Bromide soil fumigation for nematode disease and weed control in plastic mulch vegetable production systems in Florida. Establish alternative treatments on grower fields at a scale sufficient to allow their evaluation as components of production systems; Establish paired subplots in alternative treatments and adjacent grower standard treatments; Diagnose and monitor nematodes, soil-borne diseases, and practice including grading fruit and recording weights conduct a comparative cost/benefit analysis of the alternative treatments using the whole enterprise budget analysis method.

### **3. Field Demo and Scale-Up of Soilless Culture As An Alternative to Soil/methyl Bromide for Tomato & Pepper (Sep 2001 - Aug 2002)**

The objective of this research will be to field test the practicality and economics of outdoor soilless culture of tomato and pepper, and to determine solutions to scale-up problems. A soilless system will be field tested on a commercial farm operation using tomato and pepper. Inputs and crop production will be monitored and compared to conventional crop production practices.

#### **4. Field Eval Studies of *Dactylaria Higginsii* As a Component in An Integrated Approach to Pest Management (Sep 2001 - Aug 2003)**

The objective of this cooperative research agreement is to evaluate the nutsedge biological control agent, *Dactylaria higginsii*, as a component in an integrated pest management program for vegetables.

Large-scale field experiments will be conducted to include multiple offseason nutsedge management tools including tillage, herbicide applications and the biological control agent *dactylaria higginsii*. A fall tomato crop will then be produced using a conventional system and the biologically based system.

#### **5. Resistance to Diseases and Nematodes in Vegetable Crops (Apr 2001 - Apr 2003)**

Describe the nature, genetics, and mechanisms of host resistance to major pathogens and root-knot nematodes that attack vegetable crops region-wide or nationally. Develop durable, resistant cultivars and formulate environmentally compatible management practices that reliably reduce disease losses and pesticide use. In southern peas and peppers, use PCR to identify molecular markers for resistance to root-knot nematodes; characterize mechanisms, stability, specificity of resistance; as alternatives to methyl bromide and nematicides, determine efficacy of resistance and develop cropping systems rotating nematode resistant cultivars with susceptible to reduce losses. In sweet potato, characterize resistance to root-knot species. In melons, use PCR to identify molecular markers for disease resistance; investigate downy mildew resistance in cucumber; identify sources of durable resistance; verify downy mildew resistance in broccoli lines. Cooperate with public plant breeders and seed companies to facilitate use of identified resistance and markers in development of resistant cultivars of vegetable crops.

#### **6. Evaluation of Fumigant Efficacy with Virtually Impermeable Film (VIF) Plastic (Sep 2002 - Mar 2005)**

Evaluate the effect of methyl bromide replacement soil fumigants applied under standard polyethylene plastic or virtually impermeable film on pathogen control and plant health in production fields.

#### **7. Replacement of Methyl Bromide by Integrating the Use of Alternative Soil Fumigants, Cultural Practices, and Herbicides for Tomato, Pepper (University of Georgia/CSREES Sep 2001 - Sep 2003)**

Evaluate soil fumigant alternatives to methyl bromide for management of weeds, diseases, and nematodes in cooperation with growers in tomato, pepper, and watermelon. Evaluate the most effective application methods for soil fumigant alternatives in tomato, pepper and watermelon. Evaluate the need and efficacy of herbicides applied in combination with methyl bromide alternative soil fumigants in tomato, pepper and watermelon. Additionally, evaluate crop tolerance to these herbicides. To determine a systems approach of managing weeds, diseases, and nematodes that can be effectively and economically adopted by growers in tomato, pepper and watermelon.

#### **8. Sodium Azide and Furfural-Based Biofumigants for soil Pest Control in Crops (Auburn University/CSREES Sep 2001 - Sep 2003)**

Develop, optimize and implement management strategies using sodium azide as an alternative to methyl bromide to control nematodes, weeds and pathogens in bell peppers and ornamental nursery crops.



Research results submitted with the critical use exemption request packages (including published, peer-reviewed studies by (primarily) university researchers, university extension reports, and unpublished studies) include trials conducted to assess the effectiveness of the most likely chemical and non-chemical alternatives to methyl bromide, including some potential alternatives that are not currently included in the MBTOC list.

Based on preliminary results from research conducted in this area and largely in the area of tomatoes and strawberries, researchers believe that a mix of fumigants together with an herbicide treatment is the best possible alternative to methyl bromide. Combinations of Telone/chloropicrin, and metam-sodium/chloropicrin are being tested for disease and weed control. Future research plans will test combinations of these fumigants with chemicals, such as halosulfuron, metolachlor, and sulfentrazone. A program to evaluate host resistance to *Phytophthora* root and crown rot has been implemented. Growers are starting to deploy lines identified as having both genetic resistance and acceptable horticultural qualities.

Research in application technology (e.g., injection methods and application rates) may improve the uniformity of soil movement of chemicals, such as metam-sodium. Non-chemical alternatives have been incorporated and methods such as IPM, mulching, solarization, and biofumigation are being examined as part of an overall strategy to manage pepper production. Trials evaluating compost-based systems as alternatives for chemical-based fumigations are already being conducted. These trials will continue and weed ratings, disease incidence, and crop yield data will be collected.

As demonstrated by the chart above, U.S. efforts to research alternatives for methyl bromide have been substantial, and they have been growing in size as the phaseout has approached. The United States is committed to sustaining its research efforts out into the future until technically and economically viable alternatives are found for each and every controlled use of methyl bromide. We are also committed to continuing to share our research, and enable a global sharing of experience. Toward that end, for the past several years, key U.S. government agencies have collaborated with industry to host an annual conference on alternatives to methyl bromide. This conference, the Methyl Bromide Alternatives Outreach (MBAO), has become the premier forum for researchers and others to discuss scientific findings and progress in this field.

In addition to the research that is ongoing under the U.S. Department of Agriculture, applicants to the U.S. government for inclusion in the nomination for critical uses have cited the following research plans as ones they are funding or otherwise participating in. Many of the studies are the same ones conducted for tomatoes and eggplant. They are:

#### Florida Peppers:

Ongoing research conducted by USDA, University of Florida Institute of Food and Agricultural Sciences and the Florida Fruit and Vegetable association will continue. In the near term, additional attention will be paid to Telone/chloropicrin/herbicide combinations (see appendix for list of planned grower trials). Over 120 peer reviewed articles have been published to date based on trials conducted in cooperation with the above groups.

#### Georgia Peppers:

A study will be conducted in 2003-2004 for watermelon, pepper and tomato crops by University experts. They will test chloropicrin; 1,3-dichloropropene; chloropicrin + 1,3-D; halosulfuron; metam sodium; metam potassium; sulfentrazone and combinations of the above. This study will measure yield.

#### Southeastern Pepper Consortium:

A study will be conducted in North Carolina by regional experts looking at herbicides such as metolachlor, halosulfuron, rimsulfuron, and dimehenamid. These herbicides will be tested in combination with certain fumigants. Yield will be measured.

#### California Peppers:

Applicant will conduct various research studies in California on breeding stocks and alternatives. For example, the applicant will test disease resistant strains, using broccoli as a rotational crop, and ongoing grower attempts to learn how to use Vapam and Telone/Chloropicrin combinations in an efficacious way. Yield will be measured.

#### Michigan Peppers:

University experts will trial a variety of alternatives on test plots owned by commercial growers in Michigan in 2003 and 2004. They will analyze the ability of these alternatives to control Verticillium, Fusarium and Phytophthora. Alternatives they will test include Pytaline C-35; Multigard FFA; Multigard Protect with Vapam HL; CX-100 (applied as drip or preplant); Chloropicrin (100%); Iodomethane (67%/33%); and composted chicken manure.

As demonstrated by the chart above, U.S. efforts to research alternatives for methyl bromide have been substantial, and they have been growing in size as the phaseout has approached. The United States is committed to sustaining its research efforts out into the future until technically and economically viable alternatives are found for each and every controlled use of methyl bromide. We are also committed to continuing to share our research, and enable a global sharing of experience. Toward that end, for the past several years, key U.S. government agencies have collaborated with industry to host an annual conference on alternatives to methyl bromide. This conference, the Methyl Bromide Alternatives Outreach (MBAO), has become the premier forum for researchers and others to discuss scientific findings and progress in this field.

### ***Registration Program***

The United States has one of the most rigorous programs in the world for safeguarding human health and the environment from the risks posed by pesticides. While we are proud of our efforts in this regard, related safeguards do not come without a cost in terms of both money and time. Because the registration process is so rigorous, it can take a new pesticide several years (3-5) to get registered by EPA. It also takes a large number of years to perform, draft results and deliver the large number of health and safety studies that are required for registration.

The U.S. EPA regulates the use of pesticides under two major federal statutes: the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA), both significantly amended by the Food Quality Protection Act of 1996 (FQPA). Under FIFRA, U.S. EPA registers pesticides provided its use does not pose unreasonable adverse effects to humans or the environment. Under FFDCA, the U.S. EPA is responsible for setting tolerances (maximum permissible residue levels) for any pesticide used on food or animal feed. With the passage of FQPA, the U.S. EPA is required to establish a single, health-based standard for pesticides used on food crops and to determine that establishment of a tolerance will result in a “reasonable certainty of no harm” from aggregate exposure to the pesticide.

The process by which U.S. EPA examines the ingredients of a pesticide to determine if they are safe is called the registration process. The U.S. EPA evaluates the pesticide to ensure that it will not have any unreasonable adverse effects on humans, the environment, and non-target species. Applicants seeking pesticide registration are required to submit a wide range of health and ecological effects toxicity data, environmental fate, residue chemistry and worker/bystander exposure data and product chemistry data. A pesticide cannot be legally used in the United States if it has not been registered by U.S. EPA, unless it has an exemption from regulation under FIFRA.

Since 1997, the U.S. EPA has made the registration of alternatives to methyl bromide a priority. Because the U.S. EPA currently has more applications pending in its review process than the resources to evaluate them, U.S. EPA prioritizes the applications in its registration queue. 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. The average processing time for a new active ingredient, from date of submission to issuance of a registration decision, is approximately 38 months. In most cases, the registrant (the pesticide applicant) has spent approximately 7-10 years developing the data necessary to support registration.

As one incentive for the pesticide industry to develop alternatives to methyl bromide, the U.S. EPA has worked to reduce the burdens on data generation, to the extent feasible while still ensuring that the U.S. EPA’s registration decisions meet the Federal statutory safety standards. Where appropriate from a scientific standpoint, the U.S. EPA 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, U.S. EPA 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 USDA/EPA Methyl Bromide Alternatives Work Group since 1993 to help coordinate research, development and the registration of viable alternatives. The work group conducted six workshops in Florida and California (states with the highest use of methyl bromide) with growers and researchers to identify potential alternatives, critical issues, and grower needs covering the major methyl bromide dependent crops and post harvest uses.

This coordination has resulted in key registration issues (such as worker and bystander exposure through volatilization, township caps and groundwater concerns) being directly addressed through USDA's Agricultural Research Service's \$13.5 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 submitted to the USDA's Cooperative State Research, Education, and Extension Service methyl bromide alternatives research program of US\$ 2.5 million per year has further ensured that critical registration issues are being addressed by the research community.

Since 1997, EPA has registered the following chemical/use combinations as part of its commitment to expedite the review of methyl bromide alternatives:

- 1999: Pebulate to control weeds in tomatoes
- 2000: Phosphine to control insects in stored commodities
- 2001: Indian Meal Moth Granulosis Virus to control Indian meal moth in stored grains
- 2001: Terrazole to control pathogens in tobacco float beds
- 2001: Telone applied through drip irrigation - all crops
- 2002: Halosulfuron-methyl to control weeds in melons and tomatoes

EPA is currently reviewing several additional applications for registration as methyl bromide alternatives, with several registration eligibility decisions expected within the next year, including:

- Iodomethane as a pre-plant soil fumigant for various crops
- Fosthiazate as a pre-plant nematocide for tomatoes
- Sulfuryl fluoride as a post-harvest fumigant for stored commodities
- Trifloxysulfuron sodium as a pre-plant herbicide for tomatoes
- Dazomet as a pre-plant soil fumigant for strawberries and tomatoes

Again, while these activities appear promising, it must be noted that issues related to toxicity, ground water contamination, and the release of air pollutants may pose significant problems with respect to some alternatives that may lead to use restrictions since many of the growing regions are in sensitive areas such as those in close proximity to schools and homes. Ongoing research on alternate fumigants is evaluating ways to reduce emission under various application regimes and examining whether commonly used agrochemicals, such as fertilizers and nitrification inhibitors, could be used to rapidly degrade soil fumigants. For example, if registration of iodomethane or another alternative occurs in the near future, commercial availability and costs will be factors that must be taken into consideration.

It must be emphasized, however, that finding potential alternatives, and even registering those alternatives is not the end of the story. Alternatives must be tested by users and found technically and economically feasible before widespread adoption will occur. As noted by TEAP, a specific alternative, once available may take two or three cropping seasons of use before efficacy can be determined in the specific circumstance of the user. In an effort to speed adoption the United States government has also been involved in these steps by promoting technology transfer, experience transfer, and private sector training.

While the U.S. government's role to find alternatives is primarily in the research arena, we know that research is only one step in the process. As a consequence, we have also invested significantly in efforts to register alternatives, as well as efforts to support technology transfer and education activities with the private sector.

## **10. Conclusion and Policy Issues Associated with the Nomination**

On the basis of an exhaustive review of a large, multi-disciplinary team of sector and general agricultural experts, we have determined that the TEAP listed potential alternatives for the specific crops and areas covered in this nomination are not currently technically or economically viable from the standpoint of United States growers covered by this exemption request. We have also determined that the absence of methyl bromide for the nominated uses will result in a significant market disruption to the effected sectors. We have and continue to expend significant efforts to find and commercialize alternatives, and that potential alternatives to the use of methyl bromide for many important uses are under investigation and may be on the horizon. Based on this analysis, we believe those requests included in this nomination meet the criteria set out by the Parties in Decision IX/6.

In accordance with those Decisions, we believe that the U.S. nomination contained in this document provides all of the information that has been requested by the Parties. On the basis of an exhaustive review of a large, multi-disciplinary team of sector and general agricultural experts, we have determined that the MBTOC listed potential alternatives for peppers are not currently technically or economically feasible in the management of the major pests of peppers, specifically on insects, weeds, nematodes, and pathogens from the standpoint of United States pepper growers covered by this exemption nomination.

In addition, we have demonstrated that we have and continue to expend significant efforts to find and commercialize alternatives, and that potential alternatives to the use of methyl bromide in peppers may be on the horizon. That said, it must be stressed that the registration process, which is designed to ensure that new pesticides do not pose an unacceptable risk, is a long and rigorous process, and the U.S. need for methyl bromide for peppers will be maintained for the period being requested for an exemption in this nomination.

In reviewing this nomination, we believe that it is important for the MBTOC, the TEAP and the Parties to understand some of the policy issues associated with our request. A discussion of those follows:

***a. Request for Aggregate Exemption for All Covered Methyl Bromide Uses:*** As mandated by Decision XIII/11, the nomination information that is being submitted with this package includes information requested on historic use and estimated need in individual sectors. That said, we note our agreement with past MBTOC and TEAP statements which stress the dynamic nature of agricultural markets, uncertainty of specific production of any one crop in any specific year, the difficulty of projecting several years in advance what pest pressures might prevail on a certain crop, and, the difficulty of estimating what a particular market

for a specific crop might look like in a future year. We also concur with the MBTOC's fear that countries that have taken significant efforts to reduce methyl bromide use and emissions through dilution with chloropicrin may be experiencing only short term efficacy in addressing pest problems. On the basis of those factors, we urge the MBTOC and the TEAP to follow the precedent established under the essential use exemption process for Metered Dose Inhalers (MDIs) in two key areas.

First, because of uncertainties in both markets and the future need for individual active moieties of drugs, the TEAP has never provided a tonnage limit for each of the large number of active moieties found in national requests for a CFC essential use exemption for MDIs, but has instead recommended an aggregate tonnage exemption for national use. This has been done with an understanding that the related country will ensure that the tonnage approved for an exemption will be used solely for the group of active moieties/MDIs that have been granted the exemption. We believe that the factors of agricultural uncertainty surrounding both pest pressures in future year crops, and efficacy of reduced methyl bromide application provide an even stronger impetus for using a similar approach here. The level of unpredictability in need leads to a second area of similarity with MDIs, the essential need for a review of the level of the request which takes into account the need for a margin of safety.

***b. Recognition of Uncertainty in Allowing Margin for Safety:*** With MDIs, it was essential to address the possible change in patient needs over time, and in agriculture, this is essential to address the potential that the year being requested for could be a particularly bad year in terms of weather and pest pressure. In that regard, the TEAP's Chart 2 in Appendix D demonstrates the manner in which this need for a margin of safety was addressed in the MDI area. Specifically, Chart 2 in Appendix D tracks national CFC requests for MDIs compared with actual use of CFC for MDIs over a number of years.

Chart 2 in Appendix D demonstrates several things. First, despite the best efforts of many countries to predict future conditions, it shows that due to the acknowledged uncertainty of out-year need for MDIs, Parties had the tendency to request, the TEAP recommended, and the Parties approved national requests that turned out to include an appreciable margin of safety. In fact, this margin of safety was higher at the beginning – about 40% above usage – and then went down to 30% range after 4 years. Only after 5 years of experience did the request come down to about 10% above usage. While our experience with the Essential Use process has aided the U.S. in developing its Critical Use nomination, we ask the MBTOC, the TEAP and the Parties to recognize that the complexities of agriculture make it difficult to match our request exactly with expected usage when the nomination is made two to three years in advance of the time of actual use.

Chart 2 in Appendix D also demonstrates that, even though MDI requests included a significant margin of safety, the nominations were approved and the countries receiving the exemption for MDIs did not produce the full amount authorized when there was not a patient need. As a result, there was little or no environmental consequence of approving requests that included a margin of safety, and the practice can be seen as being normalized over time. In light of the similar significant uncertainty surrounding agriculture and the out year production of crops which use methyl bromide, we wish to urge the MBTOC and TEAP to take a similar, understanding approach for methyl bromide and uses found to otherwise meet the critical

use criteria. We believe that this too would have no environmental consequence, and would be consistent with the Parties aim to phaseout methyl bromide while ensuring that agriculture itself is not phased out.

**c. Duration of Nomination:** It is important to note that while the request included for the use above appears to be for a single year, the entire U.S. request is actually for two years – 2005 and 2006. This multi-year request is consistent with the TEAP recognition that the calendar year does not, in most cases, correspond with the cropping year. This request takes into account the facts that registration and acceptance of new, efficacious alternatives can take a long time, and that alternatives must be tested in multiple cropping cycles in different geographic locations to determine efficacy and consistency before they can be considered to be widely available for use. Finally, the request for multiple years is consistent with the expectation of the Parties and the TEAP as evidenced in the Parties and MBTOC request for information on the duration of the requested exemption. As noted in the Executive Summary of the overall U.S. request, we are requesting that the exemption be granted in a lump sum of 9,920,965 kilograms for 2005 and 9,445,360 kilograms for 2006. While it is our hope that the registration and demonstration of new, cost effective alternatives will result in even speedier reductions on later years, the decrease in our request for 2006 is a demonstration of our commitment to work toward further reductions in our consumption of methyl bromide for critical uses. At this time, however, we have not believed it possible to provide a realistic assessment of exactly which uses would be reduced to account for the overall decrease.

## **11. Contact Information**

For further general information or clarifications on material contained in the U.S. nomination for critical uses, please contact:

John E. Thompson, Ph.D.  
Office of Environmental Policy  
US Department of State  
2201 C Street NW Rm 4325  
Washington, DC 20520  
tel: 202-647-9799  
fax: 202-647-5947  
e-mail: [ThompsonJE2@state.gov](mailto:ThompsonJE2@state.gov)

### *Alternate Contact:*

Denise Keehner, Director  
Biological and Economic Analysis Division  
Office of Pesticides Programs  
US Environmental Protection Agency, 7503C  
Washington, DC 20460  
tel: 703-308-8200  
fax: 703-308-8090

e-mail: [methyl.bromide@epa.gov](mailto:methyl.bromide@epa.gov)

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### **13. Appendices**

#### **Appendix A. List of Critical Use Exemption (CUE) Requests for the Pepper Sector in the U.S.**

CUE-02-0017, California Pepper Commission

CUE-02-0041, Southeastern Pepper Consortium (Alabama, Arkansas, North Carolina, South Carolina, Tennessee, and Virginia)

CUE-02-0049, Georgia Fruit and Vegetable Growers Association

CUE-02-0054, Florida Fruit & Vegetable Association

#### **Appendix B. Spreadsheets Supporting Economic Analyses**

This appendix presents the calculations, for each sector, that underlie the economic analysis presented in the main body of the nomination chapter. As noted in the nomination chapter, each sector is comprised of a number of applications from users of methyl bromide in the United States, primarily groups (or consortia) of users. The tables below contain the analysis that was done for each individual application, prior to combining them into a sector analysis. Each application was assigned a unique number (denoted as CUE #), and an analysis was done for each application for technically feasible alternatives. Some applications were further sub-divided into analyses for specific sub-regions or production systems. A baseline analysis was done to establish the outcome of treating with methyl bromide for each of these scenarios. Therefore, the rows of the tables correspond to the production scenarios, with each production scenario accounting for row and the alternative(s) accounting for additional rows.

The columns of the table correspond to the estimated impacts for each scenario. (The columns of the table are spread over several pages because they do not fit onto one page.) The impacts for the methyl bromide baseline are given as zero percent, and the impacts for the alternatives are given relative to this baseline. Loss estimates include analyses of yield and revenue losses, along with estimates of increased production costs. Losses are expressed as total losses, as well as per unit treated and per kilogram of methyl bromide. Impacts on profits are also provided.

After the estimates of economic impacts, the tables contain basic information about the production systems using methyl bromide. These columns include data on output price, output volume, and total revenue. There are also columns that include data on methyl bromide prices and amount used, along with data on the cost of alternatives, and amounts used. Additional columns describe estimates of other production (operating) costs, and fixed/overhead costs.

The columns near the end of the tables combine individual costs into an estimate of total production costs, and compare total costs to revenue in order to estimate profits. Finally, the last several columns contain the components of the loss estimates.

Pepper Metric					Loss Estimates							Profit Impacts	
Sector Summary of Economic Estimates				28-Jan-03		as a % of Gross Revenue							
CUE # 02-00	Applicant/Site	Alternative	Notes	Brief Description of Estimate	Technically Feasible?	Percent Yield Loss	Revenue Loss	Increased Costs	All Losses Thresholds: Strong > 15% Weak < 5%	\$ Loss/Hectare/ Fumigation	\$ Loss per kg ai of MeBr Thresholds: Strong > \$13 Weak < \$7	% Operating Profit Loss Thresholds: Strong > 100% Weak < 50%	Profit Margin Threshold: >0 w/ MBr <0 w/o MBr >10% less
4	MI pepper	methyl bromide		baseline--peppers	Y	0%	0%	0%	0%	\$0	\$0.00	0%	
4	MI pepper	1,3 D + chloropicrin	1	applicant's yield and price loss	N	25%	25%	-26%	-1%	(\$298)	(\$2.55)		

- # Notes
- 1 Assumed alternative cost the same as MeBr. If it costs more, then it is less economically feasible.
- \* kg ai that would be applied/hectare = application rate for the alternatives or requested application rate for MBr
- \* Other pest control costs are those other than methyl bromide or its alternatives.

Pepper Metric				Revenue or Value					MeBr or Alternative Costs				
Sector of Economic Estimates			28-Jan-03	P	Y	R	Q	Qp		Pp	Ca	Ap	Cp
CUE # 02-00	Applicant/Site	Alternative	Brief Description of Estimate	average crop price per 11.4 kg box	yield # of 11.4 kg boxes per hectare	revenue or value per hectare = P×Y	kg ai that would be applied* per hectare	units of product applied per hectare	unit	price per unit of product	appli- cation & other costs	# of appl/ year	Cost per hectare= (Q × Pp + Ca) × Ap
4	MI pepper	methyl bromide	baseline--peppers	\$4.90	5,187	\$25,416	117	117	kg ai	\$4.84	\$519	1	\$1,084
4	MI pepper	1,3 D + chloropicrin	applicant's yield and price loss	\$4.90	3,890	\$19,062						1	\$1,084

Pepper Metric				Other Op Costs per Hectare			Fixed & OH Costs/Hectare			Total	Profits per Hectare		Loss Estimates per Hectare			
Sector of Economic Estimates			28-Jan-03	Cc	Co	Cop	Ce	Cf	Coh	C	Nop	N	Lr	Lp	Lo	L
CUE #	Applicant/Site	Alternative	Brief Description of Estimate	other pest control costs*	other operating costs	total operating costs = Cp+Cc+Co	equipment	fixed costs	over-head costs	Total Costs / Hectare Cop+Ce+Cf+Coh	Operating = R-Cop	Profit = R-C	revenue or value	additional cost of alternatives	add. other costs	all losses = Lr+Lp+Lo
4	MI pepper	methyl bromide	baseline--peppers	\$687	\$33,624	\$35,395		\$862		\$36,257	(\$9,978)	(\$10,840)	\$0	\$0	\$0	\$0
4	MI pepper	1,3 D + chloropicrin	applicant's yield and price loss	\$687	\$26,972	\$28,743		\$862		\$29,605	(\$9,681)	(\$10,543)	\$6,354	\$0	(\$6,652)	(\$298)

## Appendix C: U.S. Technical and Economic Review Team Members

**Christine M. Augustyniak** (Technical Team Leader). Christine has been with the U.S. Environmental Protection Agency since 1985. She has held several senior positions, both technical and managerial, including Special Assistant to the Assistant Administrator for Prevention, Pesticides, and Toxic Substances, Chief of the Analytical Support Branch in EPA's office of Environmental Information and Deputy Director for the Environmental Assistance Division in the Office of Pollution Prevention and Toxics. She earned her Ph. D. (Economics) from The University of Michigan (Ann Arbor). Dr. Augustyniak is a 1975 graduate of Harvard University (Cambridge) *cum laude* (Economics). Prior to joining EPA, Dr. Augustyniak was a member of the economics faculty at the College of the Holy Cross (Worcester).

**William John Chism** (Lead Biologist). Bill has been with the U.S. Environmental Protection Agency since 2000. He evaluates the efficacy of pesticides for weed and insect control. He earned his Ph. D. (Weed Science) from Virginia Polytechnic Institute and State University (Blacksburg), a Master of Science (Plant Physiology) from The University of California (Riverside) and a Master of Science (Agriculture) from California Polytechnic State University (San Luis Obispo). Dr. Chism is a 1978 graduate of The University of California (Davis). For ten years prior to joining the EPA Dr. Chism held research scientist positions at several speciality chemical companies, conducting and evaluating research on pesticides.

### Technical Team

**Jonathan J. Becker** (Biologist) Jonathan has been with the U.S. Environmental Protection Agency since 1997. He has held several technical positions and currently serves as a Senior Scientific Advisor within the Office of Pesticides Programs. In this position he leads the advancement of scientific methods and approaches related to the development of pesticides use information, the assessment of impacts of pesticides regulations, and the evaluation of the benefits from the use of pesticides. He earned his Ph. D. (Zoology) from The University of Florida (Gainesville) and a Masters of Science (Biology/Zoology) from Idaho State University (Pocatello). Dr. Becker is a graduate of Idaho State University. Prior to joining EPA, Dr. Becker worked as a senior environmental scientist with an environmental consulting firm located in Virginia.

**Diane Brown-Rytlewski** (Biologist) Diane is the Nursery and Landscape IPM Integrator at Michigan State University, a position she has held since 2000. She acts as liaison between industry and the university, facilitating research partnerships and cooperative relationships, developing outreach programs and resource materials to further the adoption of IPM. Ms. Rytlewski holds a Master of Science (Plant

Pathology) and a Bachelor of Science (Entomology), both from the University of Wisconsin (Madison). She has over twenty year experience working in the horticulture field, including eight years as supervisor of the IPM program at the Chicago Botanic Garden.

**Greg Browne** (Biologist). Greg has been with the Agricultural Research Service of the U.S. Department of Agriculture since 1995. Located in the Department of Plant Pathology of the University of California (Davis), Greg does research on soilborne diseases of crop systems that currently use methyl bromide for disease control, with particular emphasis on diseases caused by *Phytophthora* species. He is the author of numerous articles on the use of alternatives to methyl bromide for the control of diseases in fruit and nut crops. He earned his Ph. D. (Plant Pathology) from the University of California (Davis) and a Master of Science (Plant Pathology) from the same institution. Dr. Browne is a graduate of The University of California (Davis). Prior to joining USDA was a farm advisor in Kern County.

**Nancy Burrelle** (Biologist). Nancy Burrelle is a Research Ecologist with USDA's Agricultural Research Service, currently working on preplant alternatives to methyl bromide. She earned both her Ph. D. and Master of Science degrees (both in Plant Pathology) from Auburn University (Auburn).

**Linda Calvin** (Economist). Linda Calvin is an agricultural economist with USDA's Economic Research Service, specializing in research on topics affecting fruit and vegetable markets. She earned her Ph. D. (Agricultural Economics) from The University of California (Berkeley).

**Kitty F. Cardwell** (Biologist). Kitty has been the National Program Leader in Plant Pathology for the U.S. Department of Agriculture Cooperative State Research, Extension and Education Service since 2001. In this role she administrates all federally funded research and extension related to plant pathology, of the Land Grant Universities throughout the U.S. She earned her Ph.D. (Phytopathology) from Texas A&M University (College Station). Dr. Cardwell is a 1976 graduate of The University of Texas (Austin) *cum laude* (Botany). For twelve years prior to joining USDA Dr. Cardwell managed multinational projects on crop disease mitigation and food safety with the International Institute of Tropical Agriculture in Cotonou, Bénin and Ibadan, Nigeria.

**William Allen Carey** (Biologist). Bill is a Research Fellow in pest management for southern forest nurseries, supporting the Auburn University Southern Forest Nursery Management Cooperative. He is the author of numerous articles on the use of alternative fumigants to methyl bromide in tree nursery applications. He earned his Ph. D. (Forest Pathology) from Duke University (Durham) and a Master of Science (Plant Pathology) from The University of Florida (Gainesville). Dr. Carey is a nationally recognized expert in the field of nursery pathology.

**Margriet F. Caswell** (Economist). Margriet has been with the USDA Economic Research Service since 1991. She has held both technical and managerial positions, and is now a Senior Research Economist in the Resource, Technology & Productivity Branch, Resource Economics Division. She earned her Ph.D. (Agricultural Economics) from the University of California (Berkeley). Dr. Caswell also received a Master of Science (Resource Economics) and Bachelor of Science (Natural Resource Management) from the University of Rhode Island (Kingston). Prior to joining USDA, Dr. Caswell was a member of both the Environmental Studies and Economics faculties at the University of California at Santa Barbara.

**Tara Chand-Goyal** (Biology). Tara has been with the U.S. Environmental Protection Agency since 1997. He serves in the Office of Pesticide Programs as a plant pathologist and specializes in analyzing the efficacy of pesticides with emphasis on risk reduction. He earned his Ph. D. (Mycology and Plant Pathology) from The Queen's University (Belfast) and a Master of Science (Plant Pathology and Mycology) from Punjab University (Ludhiana). Dr. Chand-Goyal is a graduate of Punjab University. Prior to joining EPA Dr. Chand-Goyal was a member of the faculty of The Oregon State University (Corvallis) and of The University of California (Riverside). His areas of research and publication include: the biology of viral, bacterial and fungal diseases of plants; biological control of plant diseases; and, genetic manipulation of microorganisms.

**Daniel Chellemi** (Biologist). Dan has been a research plant pathologist with the U.S. Department of Agriculture since 1997. His research speciality is the ecology, epidemiology, and management of soilborne plant pathogens. He earned his Ph.D. (Plant Pathology) from The University of California (Davis) and a Master of Science (Plant Pathology) from The University of Hawaii (Manoa). Dr. Chellemi is a 1982 graduate of the University of Florida (Gainesville) with a degree in Plant Science. He is the author of numerous articles in the field of plant pathology. In 2000 Dr. Chellemi was awarded the ARS "Early Career Research Scientist of the Year". Prior to joining USDA, Dr. Chellemi was a member of the plant pathology department of The University of Florida (Gainesville).

**Angel Chiri** (Biologist). Angel has been with the U.S. Environmental Protection Agency since 1997. He serves in the Office of Pesticide Programs as an entomologist and specializes in analyzing the efficacy of pesticides with emphasis on benefits of pesticide use. He earned his Ph. D. (Entomology) from The University of California (Riverside) and a Master of Science (Biology/Entomology) from California State University (Long Beach). Dr. Chiri is a graduate of California State University (Los Angeles). Prior to joining EPA Dr. Chiri was a pest and pesticide management advisor for the U.S. Agency for International Development working mostly in Latin America on IPM issues.

**Colwell Cook** (Biologist). Colwell has been with the U.S. Environmental Protection Agency since 2000. She serves in the Office of Pesticide Programs as an entomologist and specializes in analyzing the efficacy of pesticides with emphasis on benefits of pesticide use.

She earned her Ph. D. (Entomology) from Purdue University (West Lafayette) and has a Master of Science (Entomology) from Louisiana State University (Baton Rouge). Dr. Cook is a 1979 graduate of Clemson University. Prior to joining EPA Dr. Cook held several faculty positions at Wabash College (Crawfordsville) and University of Evansville (Evansville).

**Julie B. Fairfax** (Biologist) Julie has been with the U.S. Environmental Protection Agency since 1989. She currently serves as a senior biologist in the Biological and Economics Analysis Division, and has previously served as a Team Leader in other divisions within the Office of Pesticides Programs. She has held several technical positions specializing in the registration, re-registration, special review and regulation of fungicidal, antimicrobial, and wood preservative pesticides. Ms. Fairfax is a 1989 graduate of James Madison University (Harrisonburg, VA) where she earned her degree in Biology. Prior to joining EPA, Julie worked as a laboratory technician for the Virginia Poultry Industry.

**John Faulkner** (Economist) John has been with the U. S . Environmental Protection Agency since 1989. He serves in the Office of Pesticide Programs analyzing the costs imposed by the regulation of pesticides. He earned his Ph. D. (Economics) from the University of Colorado (Boulder) and holds a Master's of Business Administration from The University of Michigan (Ann Arbor). Dr. Faulkner is a 1965 graduate of the University of Colorado (Boulder). Prior to joining EPA was a member of the economics faculty of the Rochester Institute of Technology (Rochester), The University of Colorado (Boulder) and of the Colorado Mountain College (Aspen).

**Clara Fuentes** (Biologist). Clara has been with the U.S. Environmental Protection agency since 1999, working in the Philadelphia, Pennsylvania (Region III) office. She specializes in reviewing human health risk evaluations to pesticides exposures and supporting the state pesticide programs in Region III. She earned her Ph. D. (Entomology) from The University of Maryland (College Park) and a Master of Science (Zoology) from Iowa State University (Ames). Prior to joining EPA, Dr. Fuentes worked as a research assistant at U.S. Department of Agriculture, Agricultural Research Service (ARS) (Beltsville), Maryland, and as a faculty member of the Natural Sciences Department at InterAmerican University of Puerto Rico. Her research interest is in the area of Integrated Pest Management in agriculture.

**James Gilreath** (Biologist). Jim has been with the University of Florida Gulf Coast Research and Education Center since 1981. In this position his primary responsibilities are to plan, implement and publish the results of investigations in weed science in vegetable and ornamental crops. One main focus of the research is the evaluation and development of weed amangement programs for specific weed pests. He earned his Ph.D. (Horticulture) from The University of Florida (Gainesville) and a Master of Science, also in Horticulture, from Clemson University (Clemson). Dr. Gilreath is a 1974 graduate of Clemson University (Clemson) with a degree in Agronomy and Soils.



**Arthur Grube** (Economist). Arthur has been with the U.S. Environmental Protection Agency since 1987. He is now a Senior Economist in the Biological and Economics Analysis Division, Office of Pesticide Programs. He earned his Ph.D. (Economics) from North Carolina State University (Raleigh) and a Masters of Arts (Economics) also from North Carolina State University. Dr. Grube is a 1970 graduate of Simon Fraser University (Vancouver) where his Bachelor of Arts degree (Economics) was earned with honors. Prior to joining EPA Dr. Grube conducted work on the costs and benefits of pesticide use at the University of Illinois (Urbana). Dr. Grube has been a co-author of a number of journal articles in various areas of pesticide economics

**LeRoy Hansen** (Economist). LeRoy Hansen is currently employed as an Agricultural Economist for the USDA Economic Research Service, Resource Economics Division in the Resources and Environmental Policy Branch. He received his Ph.D. in resource economics from Iowa State University (Ames) in 1986. During his 16 years at USDA, Dr. Hansen has published USDA reports, spoken at profession meetings, and appeared in television and radio interviews.

**Frank Hernandez** (Economist). Frank has been with the U.S. Environmental Protection Agency since 1991. He is a staff economist at the Biological and Economic Analysis Division of the Office of Pesticide Programs. He holds degrees in Economics and Political Science from the City University of New York.

**Arnet W. Jones** (Biologist). Arnet has been with the U.S. Environmental Protection Agency since 1990. He has had several senior technical and management positions and currently serves as Chief of the Herbicide and Insecticide Branch, Biological and Economic Analysis Division, Office of Pesticide Programs. Prior to joining EPA he was Senior Agronomist at Development Assistance Corporation, a Washington, D.C. firm that specialized in international agricultural development. He holds a Master of Science (Agronomy) from the University of Maryland (College Park).

**Hong-Jin Kim** (Economist). Jin has been an economist at the National Center for Environmental Economics at the U.S. Environmental Protection Agency (EPA) since 1998. His primary areas of research interest include environmental cost accounting for private industries. He earned his Ph.D. (Environmental and Resource Economics) from The University of California (Davis) and holds a Master of Science from the same institution. Dr. Kim is a 1987 graduate of Korea University (Seoul) with a Bachelor of Arts (Economics). Prior to joining the U.S. EPA, Dr. Kim was an assistant professor at the University of Alaska (Anchorage) and an economist at the California Energy Commissions. Dr. Kim is the author of numerous articles in the fields of resource and environmental economics.

**James Leesch** (Biologist). Jim has been a research entomologist with the Agricultural Research Service of the U.S. Department of Agriculture since 1971. His main area of interest is post-harvest commodity protection at the San Joaquin Valle. He earned his Ph.D. (Entomology/ Insect Toxicology) from The University of California (Riverside) Dr. Leesch received a B.A. degree in Chemistry from Occidental College in Los Angeles, CA in 1965. He is currently a Research entomologist for the Agricultural Research Service (USDA) researching Agricultural Sciences Center in Parlier, CA. He joined ARS in June of 1971.

**Sean Lennon** (Biologist). Sean is a Biologist interning with the Office of Pesticide Programs of the U.S. Environmental Protection Agency. He will receive his M.S. in Plant and Environmental Science in December 2003 from Clemson University (Clemson). Mr. Lennon is a graduate of Georgia College & State University (Milledgeville) where he earned a Bachelor of Science (Biology). Sean is conducting research in Integrated Pest Management of Southeastern Peaches. He has eight years of experience in the commercial peach industry.

**Nikhil Mallampalli** (Biologist). Nikhil has been with the U.S. Environmental Protection Agency since 2001. He is an entomologist in the Herbicide and Insecticide Branch of the Biological and Economic Analysis Division. His primary duties include the assessment of pesticide efficacy in a variety of crops, and analysis of the impacts of risk mitigation on pest management. Dr. Mallampalli earned his Ph.D. (Entomology) from The University of Maryland (College Park) and holds a Master of Science (Entomology) from the same institution. Prior to joining the EPA, he worked as a postdoctoral research fellow at Michigan State University (East Lansing) on IPM projects designed to reduce reliance on pesticides in small fruit production.

**Tom Melton** (Biologist). Tom has been a member of the Plant Pathology faculty at North Carolina State University since 1987. Starting as an assistant professor and extension specialist, Tom has become the Philip Morris Professor at North Carolina State University. His primary responsibilities are to develop and disseminate disease management strategies for tobacco. Dr. Melton earned his Ph.D. (Plant Pathology) from The University of Illinois (Urbana-Champaign) and holds a Master of Science (Pest Management) degree from North Carolina State University (Raleigh). He is a 1978 graduate of North Carolina State University (Raleigh) Prior to joining the North Carolina State faculty, Dr. Melton was a member of the faculty at The University of Illinois (Urbana-Champaign).

**Richard Michell** (Biologist). Rich has been with the U.S. Environmental Protection Agency since 1972. He is a nematologist/plant pathologist in the Herbicide and Insecticide Branch of the Biological and Economic Analysis Division. His primary duties include the assessment of pesticide efficacy in a variety of crops, with special emphasis on fungicide and nematicide use and the development of risk

reduction options for fungicides and nematicides. Dr. Michell earned his Ph.D. (Plant Pathology/Nematology) from The University of Illinois (Urbana-Champaign) and holds a Master of Science degree (Plant Pathology/Nematology) from The University of Georgia (Athens).

**Lorraine Mitchell** (Economist). Lorraine has been an agricultural economist with the U.S. Department of Agriculture, Economic Research Service since 1998. She works on agricultural trade issues, particularly pertaining to consumer demand in the EU and emerging markets. Dr. Mitchell earned her Ph.D. (Economics) from The University of California (Berkeley). Prior to joining ERS, Dr. Mitchell was a member of the faculty of the School of International Service of The American University (Washington) and a research assistant at the World Bank.

**Thuy Nguyen** (Chemist). Thuy has been with the U.S. Environmental Protection Agency since 1997, as a chemist in the Office of Pesticides Program. She assesses and characterizes ecological risk of pesticides in the environment as a result of agricultural uses. She earned her degrees of Master of Science (Chemistry) from the University of Delaware and Bachelor of Science (Chemistry and Mathematics) from Mary Washington College (Fredericksburg, VA). Prior to joining the EPA, Ms Nguyen held a research and development scientist position at Sun Oil company in Marcus Hook, PA, then managed the daily operation of several EPA certified laboratories for the analyses of pesticides and other organic compounds in air, water, and sediments.

**Jack Norton**(Biologist). Jack has worked for the U.S. Department of Agriculture Interregional research Project #4 (IR-4) as a consultant since 1998. The primary focus of his research is the investigation of potential methyl bromide replacement for registration on minor crops. He is an active member of the USDA/EPA Methyl Bromide Alternatives Working Group. Dr. Norton earned his Ph.D. (Horticulture) from Texas A&M University (College Station) and holds a Master of Science (Horticultural Science) from Oklahoma State University(Stillwater). He is a graduate of Oklahoma State University (Stillwater). Prior to joining the IR-4 program, Dr. Norton worked in the crop protection industry for 27 years where he was responsible for the development and registration of a number of important products.

**Olga Odiott** (Biologist) Olga has been with the U.S. Environmental Protection Agency since 1989. She has held several technical positions and currently serves as a Senior Biologist within the Office of Science Coordination and Policy. In this position she serves as Designated Federal Official and liaison on behalf of the Office of Pesticide Programs and the FIFRA Scientific Advisory Panel, an independent peer review body that provides advice to the Agency on issues concerning the impact of pesticides on health and the environment. She holds a Masters of Science (Plant Pathology) from the University of Puerto Rico (San Juan). Prior to joining EPA, Ms. Odiott worked for the U.S. Department of Agriculture.

**Craig Osteen**(Economist). Craig has been with the U.S. Department of Agriculture for over 20 years. He currently is with the Economic Research Service in the Production Management and Technology Branch, Resource Economics Division. His primary areas of interest relate to issues of pest control, including pesticide regulation, integrated pest management, and the methyl bromide phase out. Dr. Osteen earned his Ph.D. (Natural Resource Economics) from Michigan State University (East Lansing).

**Elisa Rim** (Economist). Elisa is an Agricultural Economist interning with the Office of Pesticide Programs of the U.S. Environmental Protection Agency. She earned her Master of Science (Agricultural Economics) from The Ohio State University (Columbus) and holds a Bachelor of Arts (Political Science) from the same institution. She has conducted research in environmental economics and developed a cost analysis optimization model for stream naturalization projects in northwest Ohio.

**Erin Rosskopf** (Biologist). Erin received her PhD from the Plant Pathology Department, University of Florida, Gainesville in 1997. She is currently a Research Microbiologist with the USDA, ARS and has served in this position for 5 years.

**Carmen L. Sandretto** (Agricultural Economist). Carmen has been with the Economic Research Service of the U.S. Department of Agriculture for over 30 years in a variety of assignments at several field locations, and since 1985 in Washington, DC. He has worked on a range of natural resource economics issues and in recent years on soil conservation and management, pesticide use and water quality, and small farm research studies. Mr. Sandretto holds a Master of Arts degree (Economics) from Harvard University (Cambridge) and a Master of Science (Agricultural Economics) from The University of Wisconsin (Madison). Mr Sandretto is a graduate of Michigan State University (East Lansing). Prior to serving in Washington, D.C. he was a member of the economics faculty at Michigan State University and at the University of New Hampshire (Durham).

**Judith St. John** (Biologist). Judy has been with the USDA's Agricultural Research Service since 1967. She currently serves as Associate Deputy Administrator and as such she is responsible for the Department's intramural research programs in the plant sciences, including those dealing with pre- and post-harvest alternatives to methyl bromide. Dr. St. John earned her Ph.D. (Plant Physiology) from The University of Florida (Gainesville).

**James Throne** (Biologist). Jim is a Research Entomologist with the U.S. Department of Agriculture's Agricultural Research Service and Research Leader of the Biological Research Unit at the Grain Marketing and Production Research Center in Manhattan, Kansas. He conducts research in insect ecology and development of simulation models for improving integrated pest management systems for stored grain and processed cereal products. Other current areas of research include investigating seed resistance to stored-grain insect pests and use

of near-infrared spectroscopy for detection of insect-infested grain. Jim has been with ARS since 1985. Dr. Throne earned his Ph.D. (Entomology) in 1983 from Cornell University (Ithaca) and earned a Master of Science Degree (Entomology) in 1978 from Washington State University (Pullman). Dr. throne is a 1976 graduate (Biology) of Southeastern Massachusetts University (N. Dartmouth).

**Thomas J. Trout** (Agricultural Engineer). Tom has been with the U.S. Department of Agriculture, Agricultural Research Service since 1982. He currently serves as research leader in the Water Management Research Laboratory in Fresno, CA. His present work includes studying factors that affect infiltration rates and water distribution uniformity under irrigation, determining crop water requirements, and developing alternatives to methyl bromide fumigation. Dr. Trout earned his Ph.D. (Agricultural Engineering) from Colorado State University (Fort Collins) and holds a Master of Science degree from the same institution, also in agricultural engineering. Dr. Trout is a 1972 graduate of Case Western Reserve University (Cleveland) with a degree in mechanical engineering. Prior to joining the ARS, Dr. trout was a member of the engineering faculty of Colorado State University (Fort Collins). He is the author of numerous publications on the subject of methyl bromide alternatives.

**J. Bryan Unruh** (Biologist). Bryan is Associate Professor of Environmental Horticulture at The University of Florida (Milton) and an extension specialist in turfgrass. He leads the statewide turfgrass extension design team. Dr. Unruh earned his Ph.D. (Horticulture) from Iowa State University (Ames) and holds a Master of Science degree (Horticulture) from Kansas State University (Manhattan). He is a 1989 graduate of Kansas State University.

**David Widawsky** (Chief, Economic Analysis Branch). David has been with the U.S. Environmental Protection Agency since 1998. He has also served as an economist and a team leader. As branch chief, David is responsible for directing a staff of economists to conduct economic analyses in support of pesticide regulatory decisions. He earned his Ph.D. (Development and Applied Economics) from Stanford University (Palo Alto), and a Master of Science (Agricultural Economics) from Colorado State University (Fort Collins). Dr. Widawsky is a 1987 graduate (Plant and Soil Biology, Agricultural Economics) of the University of California (Berkeley). Prior to joining EPA, Dr. Widawsky conducted research on the economics of integrated pest management in Asian rice production, while serving as an agricultural economist at the International Rice Research Institute (IRRI) in the Philippines.

**TJ Wyatt** (Economist). TJ has been with the U. S . Environmental Protection Agency since 2001. He serves in the Office of Pesticide Programs analyzing the costs and benefits of pesticide regulation. His other main area of research is farmer decision-making, especially pertaining to issues of soil fertility and soil conservation and of pesticide choice. Dr. Wyatt earned his Ph.D. (Agricultural Economics) from The University of California (Davis). Dr. Wyatt holds a Master of Science (International Agricultural Development) from the same

institution. He is a 1985 graduate of The University of Wyoming (Laramie). Prior to joining the EPA, he worked at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and was based at the Sahelian Center in Niamey, Niger.

**Leonard Yourman** (Biologist). Leonard is a plant pathologist with the Biological and Economic Analysis Division of the U. S. Environmental Protection Agency. He currently conducts assessments of pesticide use as they relate to crop diseases. He earned his Ph. D. (Plant Pathology) from Clemson University (Clemson) and holds a Master of Science (Horticulture/ Plant Breeding) from Texas A&M University (College Station). Dr. Yourman is a graduate (English Literature) of The George Washington University (Washington, DC). . Prior to joining EPA, he conducted research on biological control of invasive plants with USDA at the Foreign Disease Weed Science Research Unit (Ft. Detrick, MD). He has also conducted research on biological control of post harvest diseases of apples and pears at the USDA Appalachian Fruit Research Station (Kearneysville, WV). Research at Clemson University concerned the molecular characterization of fungicide resistance in populations of the fungal plant pathogen *Botrytis cinerea*.

**Istanbul Yusuf** (Economist). Istanbul has been with the U. S . Environmental Protection Agency since 1998. She serves in the Office of Pesticide Programs analyzing the costs imposed by the regulation of pesticides. She earned her Master's degree in Economics from American University (Washington). Ms Yusuf is a 1987 graduate of Westfield State College (Westfield) with a Bachelor of Arts in Business Administration. Prior to joining EPA Istanbul worked for an International Trading Company in McLean, Virginia.

## **Appendix D: Charts**

**(See the separate electronic file for CHART 1 and CHART 2)**