NOMINATING PARTY: The United States of America

FILE NAME: USA CUN11 SOIL ORCHARD REPLANT Open Field

BRIEF DESCRIPTIVE TITLE OF NOMINATION:
Methyl Bromide Critical Use Nomination for Preplant Soil Use for Orchard Replant in Open Fields (Submitted in 2009 for 2011 Use Season)

CROP NAME (OPEN FIELD OR PROTECTED): Orchard Replant Open Field

QUANTITY OF METHYL BROMIDE REQUESTED:

TABLE 1: QUANTITY OF METHYL BROMIDE REQUESTED IN EACH YEAR OF NOMINATION

Year	NOMINATION AMOUNT
2011	203,591 kilograms

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Following the requirements of Decision IX/6 paragraph (a)(1) The United States of America has determined that the specific use detailed in this Critical Use Nomination is critical because the lack of availability of methyl bromide for this use would result in a significant market disruption. . ■ Yes ☐ No

____________________ ____________________ ____________

Signature Name Date

Title: ____

(Details on this page are requested under Decision Ex. I/4(7), for posting on the Ozone Secretariat website under Decision Ex. I/4(8).)

This form is to be used by holders of single-year exemptions to reapply for a subsequent year's exemption (for example, a Party holding a single-year exemption for 2005 and/or 2006 seeking further exemptions for 2007). It does not replace the format for requesting a critical-use exemption for the first time.

In assessing nominations submitted in this format, TEAP and MBTOC will also refer to the original nomination on which the Party's first-year exemption was approved, as well as any supplementary information provided by the Party in relation to that original nomination. As this earlier information is retained by MBTOC, a Party need not re-submit that earlier information.

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

1. PAPER DOCUMENTS: **Title of paper documents and appendices**	**No. of pages**	**Date sent to Ozone Secretariat**
USA CUN11 SOIL ORCHARD REPLANT Open Field		
2. ELECTRONIC COPIES OF ALL PAPER DOCUMENTS: ***Title of each electronic file (for naming convention see notes above)**	**No. of kilobytes**	**Date sent to Ozone Secretariat**
USA CUN11 SOIL ORCHARD REPLANT Open Field		

* Identical to paper documents

METHYL BROMIDE CRITICAL USE RENOMINATION FOR PREPLANT SOIL USE (OPEN FIELD OR PROTECTED ENVIRONMENT)

ORCHARD REPLANT

1. SUMMARY OF THE NEED FOR METHYL BROMIDE AS A CRITICAL USE

The U.S. nomination for methyl bromide for orchard replant in 2011 is for the portion of replant sites where alternatives are not suitable, either because of legal restrictions or physical characteristics, such as unacceptable soil type or moisture or topography. The orchard area previously nominated for methyl bromide ranged from 37 ha for raisin grapes to 752 ha for stone fruit replant. These critical areas represent a small portion of the entire orchard replant in California.

Research studies are ongoing to identify methods and technologies to reduce reliance on high rates of fumigants, including the use of GPS-based application equipment (e.g., Browne et al., 2008; Upadhyaya et al., 2008). According to Browne et al. (2008) "orchardists have shifted heavily towards use of 1,3-dichloropropene instead of MB for soil fumigation, but this transition does not appear to be stable in a regulatory sense or completely effective in terms of resulting crop performance." Previously, McKenry et al. (2007, 2006) and Caprile and McKenry (2006) have reported on methods that can help to replant many orchard sites without methyl bromide. Methyl bromide continues to be a critical tool for sites that are not amenable to other treatments due to features such as soil type or soil moisture, or regulatory restrictions, or activity against certain pests, such as Armillaria root rot (e.g., UC Pest Management Guidelines, 2008). In addition, new regulations to reduce volatile organic compound emissions may cause a delay of fumigation beyond October into November and December in some locations (e.g. San Joaquin Valley) when soils are colder. This may result in reduced efficacy of the primary alternative 1,3-D.

The Orchard Replant sector comprises stone fruit, almond, and walnut orchards, and grape vineyards grown in California. Fumigation prior to replanting orchards or vineyards is used to optimize initial growth of young plants in orchard sites with minimal pest populations. Because of the perennial nature of orchards, fumigation occurs only once and is the most efficient system to avoid slow tree growth, early tree removal, added costs, and lost revenue. In addition, effective fumigation appears to reduce the effects of a poorly understood disease complex called orchard replant "problem", or "disorder" The problem can be of varying severity depending on orchard location, crop, soil texture, soil moisture, or other factors. Orchards with replant problem have several visible symptoms—the most apparent is poor tree growth during the early years of establishment (rejection component). Orchard replant problem presents a challenge to growers when replanting orchards and vineyards, considering the long-term investment (typically fruit orchards and vineyards can produce for 20-25 years, walnut orchards can produce for 40 years, and almond orchards produce on average 25-30 years) that is necessary for fruit and nut orchard production. For orchard replant situations where other fumigants are not available, methyl bromide is critical.

2. SUMMARIZE WHY KEY ALTERNATIVES ARE NOT FEASIBLE

Alternatives are considered not feasible where 1) they have not been sufficiently tested or protocols have not been sufficiently developed for their use, 2) costs are excessive, 3) application difficulties exist due to such factors as hilly terrain or equipment requirements, 4) areas of environmental sensitivity or characteristics reduce their efficacy, 5) regulatory restrictions prevent their use, 6) pest pressure is to such an extent that alternatives are not effective.

Only those orchard replant sites that have no alternatives are being nominated for critical use of methyl bromide, which represents a small portion of total replant sites (Table 1). There is a critical need for methyl bromide where there are legally mandated township caps for 1,3-D, or because surface moisture requirements cannot be met (e.g., soils can not be adequately dried prior to use of 1,3-D). New regulations to reduce volatile organic compound emissions may reduce the efficacy of 1,3-D by requiring a delay in fumigation to November or December when soils are colder. The best alternatives for orchard replant that have been identified are 1,3-D or 1,3-D with chloropicrin, and/or metam-sodium, especially in coarse-textured soils. Under certain soil and moisture conditions (less than 12% to 1.5 meters) 1,3-D is an effective management tool for replant problems and is currently used to replant the majority of orchard and vineyard sites.

3. IS THE USE OF METHYL BROMIDE COVERED BY A CERTIFICATION STANDARD?

Methyl bromide is not used to meet a certification standard for orchard replant.

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

The current best alternatives for orchard replant are 1,3-D or 1,3-D with chloropicrin, and/or metam-sodium, especially in light soils (e.g., Caprile and McKenry, 2006). These alternatives are used effectively under optimal soil and moisture conditions (high moisture at surface and less than 12% at depths to 1.5 meters) and methyl bromide is not critical. There is a critical need for methyl bromide in orchards in California where alternatives cannot be used, either because of legally mandated township caps for 1,3-D, local permit requirements for chloropicrin, buffer zone limitations, or surface moisture requirements cannot be met. If rain does not occur, growers without sprinkler systems have difficulty applying water for 1,3-D application.

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

The replacement of methyl bromide to treat soils with alternatives is taking place as research and extension work indicates is appropriate. The current nomination for methyl bromide is an amount that allows a reasonable transition to alternatives in the small portion of replant sites that cannot use alternative treatments. Field studies on the perennial crops of this sector require a multi-season timeframe. Until replicated trials can be analyzed methyl bromide is being nominated for a small portion of replant sites (see Browne et al., 2008; Beede et al., 2008; Upadhyaya et al., 2008; Wang et al., 2008).

The best alternatives for orchard replant that have been identified in research plots are 1,3-D or 1,3-D with chloropicrin (e.g., Browne et al., 2008; Beede et al., 2008). Under specific soil and moisture conditions (high moisture at surface and less than 12% at depths to 1.5 meters) 1,3-D can be an effective management tool for replant problems. However, there is a critical need for methyl bromide in some orchards in California, either because of legally mandated township caps for 1,3-D or chloropicrin, or because surface moisture requirements cannot be met due to heavy soils (e.g., soils can not be adequately dried prior to use of 1,3-D). In addition, a failure of an alternative to manage some pests, such as Armillaria root rot (UC Pest Management Guidelines, 2008), may require the critical use of methyl bromide.

Regulations to meet air quality standards for ground level ozone may change fumigation practices. Pesticides that have been identified as volatile organic compounds (VOC) react with nitrous oxides (NOx) to form ozone. In California, the most at-risk period for fumigation has been identified as May 1 through October 31.

Several areas in California, including the San Joaquin Valley and some areas of Ventura County, will be subject to new regulations. The San Joaquin Valley contains about two-thirds of the almond and stone fruit land, about one-half of the walnut land, and nearly all of raisin grape land. All sources of NOx and VOCs are being evaluated by the California Department of Pesticide Regulation (CDPR), which has the authority to regulate the use of soil fumigants. CDPR has issued a rule to reduce the emissions, including restrictions on timing and methods of fumigation. For example, for orchard replant, the only method of application allowed for methyl bromide or chloropicrin is HDPE-tarped, deep-shank, broadcast fumigation. Strip applications are not allowed in the May-October period. In the past, most orchard replant fumigations occurred during this period. Use of 1,3 D, however, may not be impacted as much as other soil treatments.

6. SUMMARY OF RECENT RESEARCH

Research in California continues to identify ways to optimize orchard replant to improve tree survival and orchard health. Recent research results for this sector were outlined in reports to the 2008 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions (Browne et al., 2008; Upadhyaya et al., 2008; Wang et al., 2008; Beede et al., 2008) as well as the 2007 Research Conference (Browne et al., 2007; Kluepfel and Beede, 2007; McKenry et al., 2007; Coates et al., 2007; Wang et al., 2007).

In general, due to new regulations in California to reduce volatile organic compound emissions, the timing of fumigation in some areas (e.g., San Joaquin Valley) may shift from October to November or December. This could result in application of 1,3-D in cooler soils and a reduced efficacy of this alternative.

Stone Fruit and Almond: Research as part of the USDA Pacific Area-wide Pest Management Program for Integrated Alternatives to Methyl Bromide has been ongoing for stone fruit and almond (Browne et al., 2008). Objectives of research are 1) To develop and demonstrate optimized integrated pest management (IPM) strategies for control of almond and stone fruit replant problems without MB; 2) To provide comprehensive economic assessments of alternatives replant management strategies; 3) Educational outreach with a field demonstration day, May 2008. Stone fruit and almond replant trials continue since their establishment in 2006.

Thus far, results indicate that chloropicrin, iodomethane/chloropicrin, and 1,3-D/chloropicrin "are effective MB alternatives" for control of *Prunus* replant disease (PRD). Results also indicate that GPS-directed shank or drip spot applications may be "nearly" as effective as strip or broadcast application (see also, Upadhyaya et al., 2008, for a description of experimental site-specific fumigant applications using GPS). Therefore, drip application of 1,3-D and chloropicrin can reduce overall fumigant emissions. Nematodes have not been significant factors in replanted sites, although sites selected for trials in 2009 appear to be infested with ring nematode. Browne et al. (2008) stated that "future years' growth and yield data are needed and will be accumulated for economic assessments of these treatments". Iodomethane is not currently registered in California and 1,3-D and chloropicrin are highly regulated.

Wine Grapes, Raisin and Table Grapes: Research is part of the USDA Pacific Area-wide Pest Management Program for Integrated Alternatives to Methyl Bromide (Wang et al., 2008) and a continuation of an ongoing 3-year project (see Wang et al., 2007). Fumigants included were various experimental rates of 1,3-D/chloropicrin with VIF or not tarped, a cover crop, and methyl bromide (448 kg/ha with HDPE film). Citrus nematodes in buried bags were killed in all fumigant-treated plots, but survived in non-fumigated plots. Only methyl bromide controlled *Fusarium* in the surface 15 cm of soil. No significant differences were found in *Fusarium* populations between any of the other treatments. All fumigated plots successfully control *Pythium*—non-fumigated plots did not control *Pythium*. VIF film significantly reduced emissions in the shank and subsurface drip treatments.

Walnuts: There appears to be an increasing shift to alternatives where they are not restricted by regulatory actions. According to the request from the California Walnut Commission, "*walnut growers appear to be shifting to tree site or strip applications, a short-sighted change driven by economic pressure*." A reduction in the use of all fumigants is likely due to regulations to reduce volatile organic compound emissions. Restrictions on the use of fumigants may reduce the ability to use tree-site or strip fumigation (see Section 7 below).

Results of research on walnut was recently reported (Beede et al., 2008) and is an ongoing attempt to: 1) identify cost-effective commercial fumigant alternatives to methyl bromide, 2) test new application technologies, and 3) initiate outreach to growers for walnut production, and 4) test clonal *vs*. seedling plant material.

Research indicates that the continued use of the preferred rootstock Paradox is not advisable. Research continues to search for resistance to ring and lesion nematode pests. Various regimes (different rates and application methods) with 1,3-D, chloropicrin, and methyl bromide were evaluated. Conclusions thus far indicate that "a combination of 1,3-D and chloropicrin" are the best alternatives for the walnut industry. In addition, researchers concluded that fumigation alters the soil microbe community whereby pathogens appear to recolonize to higher population levels in previously fumigated soils as compared to non-fumigated soils.

7. ECONOMIC INFEASIBILITY OF ALTERNATIVES

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

The economic analysis of the orchard replant application compares data on yields, crop prices, revenues and costs using methyl bromide and using alternative pest control regimens in order to estimate the costs from the loss of methyl bromide availability. The alternatives identified as technically feasible - in cases of low pest infestation[1] – are different combinations of chloropicrin, metam sodium and 1,3-Dichloropropene (1,3-D).

The critical use nomination (CUN) for this sector does not include areas where soil conditions are ideal and township caps do not restrict the use of 1,3-D. This CUN only applies to areas where township caps or certain soil types do not permit the use or effective use of 1,3-D. Where 1,3-D is not permitted there are no effective nematicide alternatives to methyl bromide. Trees and vines that survive are not likely to be as healthy and could suffer yield losses. If a nematode infestation causes the death of trees and vines, then replacement trees would also suffer the same infestation unless there use of an effective nematicide, or possibly several years of fallow.

Without methyl bromide growers replanting orchards or vineyards can face losses from several sources. These sources include:

- Delayed planting
- Fallow
- Additional use of herbicides
- Tree loss

[1] It should be noted that the USG does not request methyl bromide for use in areas of low to moderate pest pressure. Only cases where key pests are present at moderate to high levels require methyl bromide for pest pressure.

- Replant costs to replace tree losses
- Loss of trees replanted
- Yield loss of fruit or nuts
- Delayed achievement of full yield potential
- Earlier loss of productivity of whole orchard

A number of soil pathogens and nematodes, many still poorly understood, occur over the lifespan of an orchard. It is important that the grower be able to reduce the amount of inoculum in the soil to ensure that the young trees and vines have the opportunity to get off to a vigorous start to ensure survival. 1,3 D, chloropicrin, and metam-sodium have shown promise on some soil types, but long-term research on tree survival and on yield impacts is incomplete. If the alternatives do not work as effectively as methyl bromide, then it is possible that other losses could occur, such as additional replanting, higher yield losses, and shorter lifespan of the whole orchard or vineyard reducing the ability to amortize the initial investment costs.

The benefits of fumigation with methyl bromide for orchard or vineyard replant can be measured by future yields (orchard crops require several years to begin bearing) when production may be adversely affected by poor tree growth and high pest populations. In addition, fumigant treatments result in healthier young plants. Other fumigants besides methyl bromide are used for fumigation, but in some cases, such as where there are heavy soils or township caps on 1,3-Dichloropropene, these alternatives may not be available.

The effects of orchard replant problem and nematode damage to young seedlings are experienced within the first three years of orchard and vine establishment, and are commonly observed within the first year. Costs associated with individual tree replacement include delayed production as newly replanted trees lag behind previously planted ones. In more severe cases, when replant disorder or high nematode populations are not properly managed at the time of orchard establishment, the entire orchard or vineyard might be lost. Because of the long life of these perennial crops, optimal soil preparation, along with appropriate rootstocks, is a priority for successful production.

Typically, the alternatives to methyl bromide would be evaluated using a partial budget analysis to estimate the impacts of changes in production practices. That is, the consequences on a typical hectare of the crop grown are evaluated, rather than attempt to assess the impacts in the context of a whole enterprise, which could include multiple crops under cultivation. This approach allows the Agency to compare estimated losses to net operating revenue, which is defined as the difference between gross revenue and variable operating costs, on a per-hectare basis. The analysis ignores fixed costs, which are highly dependent on land ownership and the size and diversity of the grower's operation, and therefore difficult to define on a per-hectare basis. As such, this analysis may understate the impacts as a percentage of the grower's income.

An analysis of a single year, however, does not capture the full benefit of fumigation. Establishing an orchard involves considerable costs, including the maintenance of the orchard during the non-bearing years. The returns to this investment occur in the future. Therefore, another approach to evaluating the benefits fumigation is to calculate the net present value of the orchard under different streams of costs and returns. Net present value (NPV) is a way of comparing different investments by summing the discounted costs and returns over time to calculate the value of the investment. The formula for NPV is:

$$NPV = \sum_{t=0}^{T} \text{Revenue}_t - \text{Cost}_t \Big/ (1+r)^t$$

where t is the time period (year), T is the last year the orchard is in production and r is the discount rate. This analysis uses a rate of 7% to represent a private discount rate or an individual's trade-off of money between time periods[2]. Since revenues and costs are not adjusted for future inflation, all measures are in real terms.

Since the choice of discount rate is somewhat arbitrary, BEAD also presents the internal rate of return (IRR), which is the discount rate that makes NPV = 0. One interpretation of this value is that it represents the maximum rate of return on an investment that an individual must be willing to accept before the investment would be considered. That is, if the IRR is 5%, only individuals willing to accept a rate of return less than 5% would find the investment worthwhile.

California Walnuts and Almonds

The current practice for walnut replant is to fumigate with methyl bromide and chloropicrin. An alternative is to use 1,3-D with chloropicrin, but 1,3-D does not penetrate heavier soils as well as methyl bromide and may not provide as effective control of nematodes and soil pathogens. Some growers may not be able to obtain permission to use 1,3-D under California township caps, but in this case that possibility is not considered. Comparing methyl bromide and 1,3-D, both with chloropicrin, for establishing an orchard will be the basis for evaluating the benefits of methyl bromide.

Replacing methyl bromide with 1,3-D, is estimated to result in a 4% decrease in yields during production (Carpenter *et al.*, 2000). Yield losses are due to soil pathogens that infect the trees at an early age, stunting their growth. Table 7 presents the expected differences in production and revenue for California walnut, where operating costs are taken from Buchner *et al.* (2002). Elements of harvest costs are assumed to be directly proportional to yield and we adjust costs accordingly.

[2] The United States Office of Management and Budget suggests using a 3% and 7% rate when evaluating the cost and benefits of government regulation, where 7% is an estimate of the before-tax rate of return to private capital (OMB, 2003).

Table 2. Gross revenue, operating costs, and net operating revenues, California walnuts orchard at full production.

	methyl bromide + chloropicrin	1,3-D + chloropicrin (% change) [1]
Yield (kg/hectare)	1,505	1,445 (-4.0%)
Price ($/kg)	1.43	1.43
Gross Revenue ($/hectare)	5,315	5,101 (-4.0%)
Operating Costs ($/hectare)	1,403	1,403
Harvest Costs ($/hectare)	895	867 (-2.8%)
Net Operating Revenue ($/hectare)	3,018	2,660 (-11.9%)

Source: USDA NASS (2002-2006), Buchner *et al.* (2002), BEAD calculations. Figures may not sum due to rounding.

1 Percent change in comparison to methyl bromide with chloropicrin.

The analysis in Table E.1 indicates that even relatively minor changes in yield can have large effects on net operating revenue. A 4% change in yield results in a 12% change in net operating revenue. The analysis suggests that methyl bromide is worth about $150/hectare each year in terms of improved yield during the lifespan of the walnut orchard. If growers did not have access to methyl bromide or 1,3-D (because of township caps, for example), the consequences would be far more dire.

The analysis in Table E.1 does not consider the investment producers must make in establishing an orchard and maintaining it through several non-bearing years. Table E.2 presents the information on the net operating revenues, NPV and IRR for a walnut orchard under the four treatment options. Field preparation costs are similar for any type of fumigation, but fumigation costs differ according to the mix of chemicals and the cost of application. Chemical costs are average per-hectare cost of products, which incorporates typical application rates. Tree planting costs are identical regardless of fumigant. BEAD assumes that some trees must be replanted the following year. We assume that 4%, or two trees, are replanted following fumigation with methyl bromide and chloropicrin (Buchner *et al.*, 2002) but 6% are replanted with 1,3-D and chloropicrin. The higher replant rates represent the lower survival rate if nematodes are controlled but orchard replant disorder or pathogens are not. Trees begin to produce in the fourth year, initially at 10% of production, climbing to full production in the eighth year (Buchner *et al.*, 2002). Returns during full production are shown in Table E.1.

Table 3. Net operating revenue, net present value (NPV), and internal rate of return (IRR) of a walnut orchard.

Year	Stage	Methyl bromide + chloropicrin	1,3-D + chloropicrin
1	Field Preparation	-585	-585
	Fumigation [1]	-3,127	-1,855
	Establishment	-3,789	-3,789
2	Non-bearing [2]	-978	-1,018
3	Non-bearing	-897	-897
4	Initial production [3]	-637	-657
5	Partial production [5]	-417	-457
6	Partial production [6]	-106	-165
7	Partial production [6]	1,331	1,213
8	Full production [7]	3,018	2,660
9-25	Full production [7]	3,018	2,660
NPV (7% discount rate)		9,495	9,495
IRR		13.8%	13.9%

Source: Buchner *et al.* (2002), and BEAD calculations. Net operating revenues are not discounted; negative numbers represent costs greater than income. Net present value is calculated assuming 7% discount rate.

1 Fumigation costs include chemical costs and application costs.
2 In addition to operating costs, non-bearing costs include replanting trees.
3 Initial production is 10% of full production.
4 Production in the fifth year is 20% of full for combination treatments.
5 Production in the sixth year is 30% of full for combination treatments.
6 Production in the seventh year is 60% of full production for combination treatments.

Assuming a 7% discount rate, establishing a walnut orchard, fumigating with methyl bromide and chloropicrin, yields future returns valued at almost $9,500/hectare today. This is about $530 more per hectare than an hectare treated with 1,3-D and chloropicrin, although the lower initial cost of fumigating with 1,3-D and chloropicrin means that the internal rate of return on the two investments are approximately equal. The IRR for an orchards treated with methyl bromide or 1,3-D are similar, and close to 14%.

These results would also apply almonds grown on heavier soils. Where almonds are replanted after an existing almond orchard, poor vegetative growth has been observed and tree mortality has been estimated as high as 50% (Browne et al., 2006). This would be the case where no fumigant is used on replant sites. With a one year fallow, but no fumigant treatment, a 25-40% yield loss might be experienced (depending on rootstock) with a 24-35% reduction compared to methyl bromide treatment (Carpenter et al., 2000).

BEAD estimates that nearly 43% of almond hectares planted and 86% of walnut plantings are currently treated with methyl bromide. The benefits of methyl bromide would eventually accrue to almost 97,000 bearing hectares of almonds and 74,000 hectares of walnut. At full production, additional yield is valued at about $370/hectare, therefore methyl bromide adds about $63.3

million annually to the value of California nut production. Currently, metam sodium provides little benefit to producers on heavy soils. However, if chloropicrin and methyl bromide were not available, control of soil pathogens would depend on metam sodium. Without these fumigations, some orchards would probably not be established at all; thus these figures may understate the full value of the methyl bromide.

California Stone Fruit

Planting orchards with stone fruit trees requires a large investment of resources as well as numerous choices to establish a long-bearing and productive orchard. Many of the pests associated with these crops and fumigation requirements are similar from crop to crop and location to location. However, management of these pests differs depending on particular crop, soil type, climatic region, availability and cost of orchard land, availability of resistant rootstock to specific key pests, and local regulatory restrictions of some fumigants. In general, when fumigation is deemed necessary, few choices are available to the orchard manager.

We assess the benefits of fumigation with methyl bromide by comparing production under alternative approaches for controlling orchard replant disease. In this case, we focus on prune production in California that is broadly representative of stone fruit production with high fumigant use. This represents a heavy soil environment where methyl bromide and chloropicrin are used. We compare this use to fumigation with 1,3-D and chloropicrin, 1,3-D and metam sodium, and 1,3-D alone to evaluate the benefits of methyl bromide and chloropicrin. This result would also apply to cherry, peach and nectarine, and plum grown on heavier soils. We assume in this analysis that 1,3-D is available for use as a fumigant, which will not necessarily be the case, due to township caps in California. If neither methyl bromide or 1,3-D are available, the consequences are expected to be more dire.

Replacing methyl bromide with 1,3-D, while maintaining the use of chloropicrin, is estimated to result in a 4% decrease in prune yields during production (Carpenter *et al.*, 2000). Yield losses are due to soil pathogens that infect the trees at an early age, stunting their growth. Table E.3 presents the expected differences in production and revenue for California prune, where operating costs are taken from Buchner *et al.* (2001). Harvest costs are assumed to be directly proportional to yield. Differences in net operating revenue for even small changes in yield can be substantial. This analysis suggests that the benefits of methyl bromide alone are approximately $125/hectare.

Table 4. Gross revenue, operating costs, and net operating revenues, California prune orchard at full production.

	Methyl bromide + chloropicrin	1,3-D + chloropicrin (% change) [1]
Yield (dried ton/hectare)	4.4	4.2 (-4.0%)
Price ($/ton)	1,125	1,125
Gross Revenue ($/hectare)	5,002	4,802 (-4.0%)
Operating Costs ($/hectare)	2,080	2,080
Harvest Costs ($/hectare)	1,894	1,818 (-4.0%)
Net Operating Revenue ($/hectare)	1,028	904 (-12.1%)

Source: USDA NASS (2002-2006), Bruchner *et al.* (2001), BEAD calculations. Figures may not sum due to rounding.

[1] Percent change in comparison to methyl bromide with chloropicrin.

The analysis in Table E.3 does not consider the investment producers must make in establishing an orchard and maintaining it through several non-bearing years. Table E.4 presents the information on net operating revenue, NPV, and IRR for a prune orchard under the four treatment options. Field preparation costs are similar for any type of fumigation, but fumigation costs differ according to the mix of chemicals and the cost of application. Chemical costs are average per-hectare cost of products, which incorporates typical application rates. Trees are planted the following spring and costs are identical regardless of fumigant. BEAD assumes that some trees must be replanted the following year. We assume that 2% are replanted following fumigation with methyl bromide an chloropicrin (Bruchner *et al.*, 2001); 3% are replanted with 1,3-D and chloropicrin; The higher replant rate represents the lower survival rate if nematodes are controlled but soil pathogens are not and amount to two or four trees. Trees begin to produce in the fourth year, initially at 20% of production, climbing to full production in the seventh year (Bruchner *et al.*, 2001). Returns during full production are shown in Table E.3.

Table 5. Net operating revenue, net present value (NPV), and internal rate of return (IRR) of a prune orchard.

Year	Stage	Methyl bromide + chloropicrin	1,3-D + chloropicrin
0	Field Preparation	-618	-618
	Fumigation [1]	-2,519	-2,025
1	Establishment	-3,137	-3,137
2	Non-bearing [2]	-995	-1,018
3	Non-bearing	-1,294	-1,294
4	Initial production [3]	-1,336	-1,361
5	Partial production [5]	-1,023	-1,072
6	Partial production	2	-82
7	Full production	1,028	904
8-40	Full production	1,028	904
NPV (7% discount rate)		-874	-1,529
IRR		6.3%	5.7%

Source: Buchner *et al.* (2001), and BEAD calculations. Net operating revenues are not discounted; negative numbers represent costs greater than income. Net present value is calculated assuming 7% discount rate.

1 Fumigation costs include chemical costs and application costs.

2 In addition to operating costs, non-bearing costs include replanting trees.

3 Initial production is 20% of full production. On-set of production is delayed one year if 1,3-D is used alone.

4 Production in the fifth year is 40% of full for combination treatments.

5 Production in the sixth year is 67% of full for combination treatments.

Assuming a 7% rate of interest, prune production does not appear to be a good investment using any of the fumigation options. It may be that the information we have on production costs are somewhat high. Relatively speaking, however, methyl bromide provides substantial benefits over 1,3-D. Failure to adequately control soil pathogens substantially reduces the return to investing in a prune orchard. This result would also apply to cherry, peach and nectarine, and plum grown on heavier soils.

California Grape

It appears that the current practice for vineyard replant is to fumigate with 1,3-D and chloropicrin. Methyl bromide, with chloropicrin, is used on a few vineyards. Methyl bromide penetrates heavier soils, *i.e.*, higher clay content or lower porosity soils, better than 1,3-D, but vineyards tend to be planted on coarser soils. However, some growers may not be able to obtain permission to use 1,3-D under California township caps, which would severely limit their options. Table E.5 presents the expected differences in production and revenue for California table grape where 1,3-D cannot be used. According to McKenry (1999), yield losses of up to 20% could occur on some highly problematic sites if no fumigation is conducted. Using metam sodium alone would result in higher yields than without any fumigation, but would probably not be as effective as 1,3-D alone since metam sodium is the least efficient at dispersing through soil.

For situation where 1,3-D is a workable alternative, such as those areas without heavy soils or restrictions from township caps, we assume that yields of a producing vineyard are the same with 1,3-D and methyl bromide. In heavy soils, or without 1,3-D as an alternative, we assume that growers replanting orchards will instead use metam sodium, or no fumigation. Table E.5 presents the expected differences in production and revenue for California table grapes with these fumigation treatments. Baseline yield for table grape and price for the fresh market are averages of 2001-2005, reported by USDA NASS (2002-2006). Operating costs are taken from Vasquez *et al.* (2004). Harvest costs are assumed to be directly proportional to yield and BEAD adjusts costs accordingly.

As shown in Table E.5, methyl bromide shows no benefit over 1,3-D once a vineyard is in production. In places where 1,3-D cannot be used, the loss of methyl bromide would be extremely costly. Fumigating with methyl bromide and chloropicrin is worth $270 per hectare relative to metam sodium, and almost $400 per hectare more than no fumigation.

Methyl bromide with chloropicrin is used on a few vineyards. Methyl bromide penetrates heavier soils, *i.e.*, higher clay content or lower porosity soils, better than 1,3-D, but vineyards tend to be planted on coarser soils. However, some growers may not be able to obtain permission to use 1,3-D under California township caps, which would severely limit their options. Table E.5 presents the expected differences in production and revenue for California table grape where 1,3-D cannot be used. According to McKenry (1999), yield losses of up to 20% could occur on some highly problematic sites if no fumigation is conducted. Using metam sodium alone would result in higher yields than without any fumigation, but would not be as effective as 1,3-D or methyl bromide.

Table 6. Gross revenue, operating costs, and net operating revenues, California table grape vineyard at full production.

	Methyl bromide + chloropicrin	1,3-D + chloropicrin	Metam Sodium (% change) [1]	No fumigation (% change) [1]
Yield (ton/hectare)	22	22	20 (-10%)	19 (-15%)
Price ($/ton)	720	720	720	720
Gross Revenue ($/hectare)	15,828	15,828	14,244 (-10%)	13,454 (-15.0%)
Operating Costs ($/hectare)	5,362	5,362	5,362	5,362
Harvest Costs ($/hectare)	9,137	9,137	8,223 (-10%)	7,776 (-15.0%)
Net Operating Revenue ($/hectare)	1,329	1,329	659 (-50.3%)	326 (-75.5%)

Source: USDA NASS (2002-2006), Vasquez *et al.* (2004), BEAD calculations. Figures may not sum due to rounding.

[1] Percent change in comparison to methyl bromide with chloropicrin.

In situations where 1,3-D is not available or feasible, growers obtain substantial benefits from fumigation with methyl bromide and chloropicrin. The increased value of production throughout the life of the orchard is worth about $670/hectare annually compared to metam sodium and about $990/hectare annually compared to no fumigation.

The analysis in Tables E.5 does not consider the investment producers must make in establishing an orchard and maintaining it through several non-bearing years. Table E.6 presents the information on net revenue through time, the NPV and the IRR for a table grape vineyard, assuming that 1,3-D is available. Field preparation costs are similar for any type of fumigation, but fumigation costs differ according to the mix of chemicals and the cost of application. Chemical costs are average per-hectare cost of products, which incorporates typical application rates. Vine planting costs are identical regardless of fumigant. In the second year, a trellis is installed, which represents the majority of costs. BEAD assumes that some vines must be replanted the second year. We assume that 2% or nine vines are replanted following fumigation with 1,3-D and chloropicrin (Vasquez *et al.*, 2002); 6% are replanted with metam sodium; and 8% are replanted if there is no fumigation. The higher replant rates represent the lower survival rate of vines if nematodes are controlled but soil pathogens are not. Vines begin to produce in the third year, initially at 80% of production, but are not of sufficient quality for the fresh market. Grapes are harvested mechanically and sold for wine (Vasquez et al., 2004).

Table 7. Net operating revenue, net present value (NPV), and internal rate of return (IRR) of a California table grape vineyard.

Year	Stage	Methyl Bromide + chloropicrin	1,3-D + chloropicrin
1	Field Preparation	-741	-741
	Fumigation [1]	-3,127	-1,198
	Establishment	-4,036	-4,036
2	Non-bearing [2]	-9,164	-9,164
3	Initial production [3]	62	62
4	Full production	1,329	1,329
5-25	Full production [4]	1,329	1,329
NPV (7% discount rate)		-3,359	-1,554
IRR		4.5%	5.7%

Source: Vasquez *et al.* (2004), and BEAD calculations. Net operating revenues are not discounted; negative numbers represent costs greater than income. Net present value is calculated assuming 7% discount rate.

1 Fumigation costs include chemical costs, according to EPA proprietary data, and application costs. 1,3-D and chloropicrin are applied as a single product, but 1,3-D and metam sodium must be applied separately.

2 In addition to operating costs, non-bearing costs include replanting vines. The major expense is construction of a trellis system.

3 Initial production is 80% of full production (Vasquez, *et al.*, 2004). Initial production is mechanically harvested and sold for wine.

4 Production ceases one year earlier with 1,3-D alone.

Table grapes do not appear to make a particularly attractive investment. Using a 7% discount rate, the NPV is negative. The IRR for a vineyard established with a fumigation of 1,3-D and chloropicrin is about 5.7%. The difference in NPV's between fumigant treatments, however, is substantial. Estimates of NPV and IRR for metam sodium alone and no fumigation are not provided, because losses are so great that they are negative for all discount rates, which is equivalent to a negative IRR.

About 200 hectares of grapes are fumigated with methyl bromide and chloropicrin in California each year on average. This represents about 3.3% of the planted hectares. The benefits of fumigation therefore accrue to about 10,800 bearing hectares. Assuming that this represents growers who cannot use 1,3-D because of township caps, and that the benefits of methyl bromide and chloropicrin are about $670/hectare to wine grapes as well as table grapes, methyl bromide and chloropicrin contribute about $7.2 million annually to the California economy. This does not include the possibility that fumigating with methyl bromide and/or chloropicrin make an investment in grape production viable for some growers.

TABLE 8. NOMINATION AMOUNT: 2011 Methyl Bromide Usage Newer Numerical Index (BUNNI) – Transition Use Reduction Description Spreadsheet**.**

SECTOR		ORCHARD REPLANT					
		CA G&TFL - Stone Fruit	CA G&TFL - Raisin Grape	CA Walnut Commission	Almond Hullers & Processors	CA Wine Grapes Replant	Sector Total / Average
Quantity Requested for 2010:	Amount (kgs)	153,333	9,255	22,255	18,887	22,290	226,020
Quantity Recommended by MBTOC/TEAP for 2010 :	Amount (kgs)	150,400	7,400	21,800	18,600	17,600	215,800
Quantity Approved by Parties for 2010:	Amount (kgs)	150,400	7,400	21,800	18,600	17,600	215,800
	Area (ha)	752	37	109	93	88	1,079
	Rate	200	200	200	200	200	200
Transition from 2010 Baseline Adjusted Value	Percentage (%)	-12%	-8%	0%	-7%	-8%	-10%
Quantity Required for 2011 Nomination:	Amount (kgs)	**134,695**	**8,544**	**22,200**	**17,575**	**20,577**	**203,591**
	Area (ha)	**673**	**43**	**111**	**88**	**103**	**1018**
	Rate	**200**	**199**	**200**	**200**	**200**	**200**

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