PRELIMINARY BENEFITS ANALYSIS

OF

1,3-DICHLOROPROPENE USE

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PRELIMINARY BENEFITS ASSESSMENT OF 1,3-DICHLOROPROPENE

Introduction

The soil fumigant 1,3-dichloropropene (1,3-D) is one of only three broad spectrum fumigants which are registered for use on all food and non-food sites. Metam-sodium and chloropicrin are the other two. Irish potatoes, tobacco, cotton, carrots, crucifers, cucurbits, tomatoes, onions, sugar beets, peanuts, sweetpotatoes, and peppers are crops receiving annual or biannual applications of 1,3-D. Peaches, pears, some citrus, almonds, grapes, pineapple and walnut are some of the perennial fruit and nut trees that growers apply 1,3-D as a pre-plant nematicide. Appendix A lists all sites currently registered for 1,3-D usage.

1,3-D is registered for use in the control of all plant-parasitic nematodes and some plant diseases, insects, and weeds. Nematodes are the principal type of target pests associated with 1,3-D usage on most crops, however, diseases are also important target pests on certain crops.

At the present time, twelve products containing 1,3-D are federally registered, representing four chemical companies.[1] Twelve Section 24(c) registrations exist for seven different states.[2] 1,3-D is available in single and multiple active ingredient liquid products.[3] The single active ingredient products contain about 94 percent 1,3-D; the multiple active ingredient products typically include combinations with chloropicrin. However, one product is a combination with 70 percent methyl bromide. The percentage of chloropicrin in the combination products varies from about 15 to 60 percent, with the remainder of the product formulations primarily composed of 1,3-D.

A limited number of non-chemical and registered alternative control measures are available for use in the control of the principal target pests associated with 1,3-D usage. The principal registered alternatives include the fumigants metam-sodium, methyl bromide, dazomet, and chloropicrin and the non-fumigants aldicarb, ethoprop, fenamiphos, oxamyl, and terbufos. Metam-sodium and chloropicrin are registered for use on all 1,3-D sites, whereas the other alternatives are each registered for use on limited subsets of the 1,3-D sites. The alternative aldicarb is currently under Special Review and the production and importation of the alternative methyl bromide is scheduled to be phased out by the year 2000 by EPA's Air and Radiation Program.

Although a wide array of potential non-chemical alternatives exist (e.g., fallowing, non-host

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[1] DowElanco is considered to be the primary registrant who markets the predominant single and multiple active ingredient products (Telone®II and Telone®C-17, respectively).

[2] South Carolina, North Carolina, Oregon, Washington, Michigan, Arizona, and Texas have Special Local Needs registrations for 1,3-D products.

[3] Vorlex® and Vorlex® 201 were other 1,3-dichloropropene formulations which contained 1,3-dichloropropene and methyl isothiocyanate. However, the manufacturer voluntarily cancelled the Vorlex® registration because of increased costs associated with the reregistration of methyl isothiocyanate in 1992.

crop rotation, resistant varieties, soil solarization, deep plowing of crop remains), in most instances these practices are found to be infeasible or have only limited pest control value. Those which are determined to be of limited value are often classified as supplemental control measures, which are used in conjunction with the registered pesticide alternatives.

The ~~Agency currently~~ estimates that approximately 33 to 44 million pounds a.i. are applied annually to 0.3 to 0.6 million acres in the United States during the 1988 to 1990 growing seasons. Irish potatoes, tobacco, sugar beets, cotton, sweetpotatoes, onions, pineapples, peanuts, fruit and nut trees, grapevines, and tomatoes comprise the sites with about 90% of 1,3-D use. Carrots, crucifers, peppers, strawberries, and tomatoes are other sites that account for another 5% of the total usage.

Prior to 1991, California (CA) was the state with the largest volume of 1,3-dichloropropene usage, with 30 to 35 percent of the domestic market according to the registrant. CA usage of 1,3-D was about 11 to 15 million pounds a.i. annually between 1988 and 1989 according to CA usage data.(REF) In May 1990, CA suspended 1,3-D use permits because of high levels of 1,3-D detected in the air. Until the registrant submits tests indicating a lower concentration of 1,3-D, the use permits will remain suspended. Therefore, this assessment does not include usage estimates or analysis for CA.

In 1988, 1,3-D was placed under Special Review (SR) as a result of potentially high air levels of 1,3-D that may expose workers ~~and area residents.~~ Ten sites were determined to comprise about 90 percent of the 1,3-D use in the United States in the Position Document 1 (PD 1). Irish potatoes, cotton, sugar beets, tobacco, tomatoes, pineapples, carrots, crucifers, nursery crops and pineapples were found to be the major use sites. Other sites were known to use 1,3-D; however, only limited data were available to support analysis on the other sites. Information and data were requested on use and usage on these ten sites as well as others in the PD 1.

The Agency received approximately 270 responses to the FR notice (##) submitting information on 1,3-D use and usage. Representatives in 35 states sent comments on 100 sites. Most of the respondents discussed their use of 1,3-D and its importance; however, very little empirical data were submitted to support these claims. Few sent published or farm data, state statistics or extension reports. The Agency's response to these comments by site is in Appendix B.

The Agency published a Data Call-In (DCI) in **June , 1991** (*##-##*) because of insufficient data to further evaluate 1,3-D usage for major as well as minor use sites. Minor use sites were defined as those that utilize small quantities of 1,3-D relative to the U.S. total. The DCI requested biological and economic information from registrants regarding 1,3-D and its alternatives use and usage and comparative product performance data by site by state. Three registrants sent information in response to the DCI; however, a majority of the DCI data used in this analysis are from DowElanco. Their data submission was the most comprehensive and consistent, with 1,3-D use and usage data for 23 sites from 27 states.

The DCI provided the use and usage information data for further analysis. Two of the ten major sites have changed since the PD 1 because minimal empirical usage data were received for citrus and nursery crops. Onions replaced nursery crops and citrus has now been included as part of a site grouping called fruit and nut trees and grapevines.

Purpose of the Analysis

covering — label uses

The benefit analysis presents information, data and estimates on the possible biological and economic effects of cancelling 1,3-D. An individual benefit analysis was completed for 15 sites. The benefit assessment is part of the technical document for the PD 2/3 for the 1,3-D SR which, in turn, is utilized by the Administrator to make a decision on the continued use of 1,3-D. This analysis fullfills the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requirements that mandate the Administrator consider both the risks and benefits when making registration decisions for pesticides.

Scope and Approach

The scope of the benefit assessment entails detailed biological and economic evaluations for 1,3-D use on 15 sites. The biological evaluation documents the registration status for 1,3-D and alternatives, current pest management practices and recommendations, outlook for new chemical and non-chemical controls, pest damage and infestations associated with the principal target pests, and comparative performance of alternatives. The economic impact analysis documents the economic approach and data, 1,3-D usage, comparative cost analysis for use of 1,3-D and alternatives, economic profile of users and nonusers, pesticide usage projections if 1,3-D is cancelled, and economic impacts on users, markets, consumers, and society. Benefit assessments were completed for the 10 major use sites (Irish potatoes, cotton, fruit and nut trees and grapevines, onions, peanuts, pineapples, sugarbeets, sweet potatoes, tobacco, and tomatoes) and five minor-use sites (carrots, crucifers, cucurbits, peppers and strawberries).

The basic economic research approach used was a partial budgeting method and simple supply-demand analysis using possible cost changes and yield effects. If 1,3-D use is cancelled on a given site, the Agency made projections on the alternatives that growers would use to control the target pests on acreage currently treated with 1,3-D. If the current status of an alternative changes, revisions to this benefit assessment would be needed. Once the value of these effects are estimated, an evaluation of the potential impact on users, commodity markets, consumers, social and/or community and trade is made.

Data was compiled from several sources for this study. These data sources include, but were not limited to, previous EPA reports, the DowElanco DCI data and other industry sources, proprietary market surveys, other Federal and state published statistics and studies, crop specialists, university and extension specialists and state pest recommendations. When estimates were formulated utilizing sources other than published data, the source is identified in the individual site summaries. The DCI data (1988 to 1990) were the primary source used in developing the usage estimates and supplemented with other published resources. USDA usage data for 1991 and other proppprietary sources were used to identify new trends or significant differences for each site.

General Limitations of the Analyses

Limitations for these analyses, in general, were similar for most sites. The DCI data were the primary source utilized to develop the usage estimates for 1,3-D and the alternatives. Some supplemental information was found at the state and federal level to verify the estimate; however, the DCI data were the major resource. Some minor use sites with low annual usage were not evaluated as an individual site because of insufficient data for an analysis and limited resources by the Agency to research the data.

Comparative product performance data for 1,3-D relative to the soil fumigants, the non-fumigant nematicides and the non-chemical controls were limited for most sites which affected the market shift estimates for alternatives. When product performance data were available, an estimate for production losses were calculated. However, if the opinions of state crop specialists were used to determine the yield loss estimates in place of published studies, the potential production losses were not included in the total value of impacts. Additionally, the costs of non-chemical controls were not estimated because of the variety of options in each state.

The availability of currently registered alternatives, methyl bromide and aldicarb, and future alternatives could significantly affect this assessment. Presently, methyl bromide and aldicarb are available; however, methyl bromide is to be phased out by the year 2000. It is difficult to predict the development of new alternatives for some sites. If these two chemicals are no longer available and new alternatives are not developed, the impacts estimated in this analysis will change.

Summary of Findings

An executive summary of this assessment presents an overview of the usage by site, the market shift in alternatives and a range of the potential economic impacts without the use of 1,3-dichloropropene. A more detailed evaluation of the individual site analyses is given in the site summaries.

Site Summaries

A brief synopsis of each site analysis is given below. The individual site summaries include a registration summary and use recommendations, lists the alternatives and comparative product performance data if available, the usage summary by state, and the potential economic impacts with the loss of 1,3-D. The major use sites are presented first, followed by the minor use sites and, lastly, usage estimates and data for all other sites are given.

Irish Potatoes

Use and Recommendations

1,3-D is labeled as a preplant soil treatment for use on potatoes for control of Verticillium wilt and various nematodes. Major target pests are *Verticillium dahliae*, the fungus associated with Verticillium wilt; the potato rot nematode *Ditylenchus destructor*, root-knot nematodes, *Meloidogyne hapla* and *Meloidogyne chitwoodi*; the lesion nematode, *Pratylenchus penetrans*; and the stubby-root nematode (*Paratrichodorus* sp.).

Damage associated with the target pests is dependent on environmental factors such as length of the growing season, moisture, temperature, and soils. Many of these pests tend to be a problem in sandy soils mainly in the western states. Verticillium wilt causes the plant to exhibit symptoms of premature aging and eventually affects potato yields by interfering with the transport of water and nutrients through the plant. Nematodes either attack the potato tubers or feed on the roots causing cracks, lesions or knots to the outer appearance, soft, chalky rotted inside or possibly, making the plant more susceptible to other pests and diseases.

Both Telone®II and Telone®C-17 formulations are commonly used on potatoes.[4] 1,3-D may be applied as a broadcast or row (band) treatment. The registered application rates for nematode control on potatoes vary according to soil texture and type of application. The broadcast rate in mineral soil ranges from 85.4 to 170.8 pounds a.i. per acre for Telone II® and 85 to 141.2 pounds a.i. of 1,3-D per acre for Telone®C-17. Slightly higher broadcast rates are recommended for difficult-to-control root-knot nematodes and for applications on muck soils. Row treatment applications will be proportionally lower than broadcast rates. Row treatment of Telone®C-17 is not recommended for potatoes in irrigated areas of western and northwestern states according to the label.

Alternatives

Metam-sodium is the only labeled alternative for both Verticillium wilt and nematodes. Ethoprop and oxamyl are labeled for the control of nematodes. At the time of this analysis, no new chemical alternatives are known to be in the process of development.

Non-chemical controls are primarily used to supplement chemical controls. Crop rotation

[4] Vorlex® was another 1,3-dichloropropene formulation used on potatoes; however, the manufacturer voluntarily cancelled the registration in 1992.

and planting resistant varieties are primarily for control of Verticillium wilt. Planting sudangrass which is plowed under as a green manure, optimum plant nutrition, and solarization are other management strategies of disease or nematode reduction. Early harvesting merely prevents further damage if certain nematodes are present in the field. These non-chemical controls are generally not considered sufficient for complete control of target potato pests.

Metam-sodium is considered a comparable alternative to 1,3-D in North Dakota, Minnesota, Wisconsin, Michigan, Maine and Colorado according to a few studies and crop specialists (Ref). In the Pacific Northwest, it is generally not considered as effective but varies by region, pest, soil type, and type of application equipment available to apply the chemical (Jensen,1992; Santo, 1992; Thorton, 1992). Crop specialists considered metam-sodium most effective when applied through a sprinkler irrigation system although attaining an adequate depth of application is a problem. Ethoprop is not considered effective as a single form of nematode control, but is considered useful as a supplement to preplant fumigation (Ref). The limited amount of available information regarding oxamyl indicates it is less effective than 1,3-D for control of nematodes (Ref).

Usage Summary

Approximately 91,000 to 92,000 acres or 7 to 8% of the 1.4 million potato acres harvested in the U.S. are treated with 1,3-D (DCI). Annual use of 1,3-D between 1988 and 1990 is estimated at 16 to 17 million pounds active ingredient (a.i.), primarily based on DCI data from the registrant.

The annual value of U.S. potato production has decreased an average of approximately $300 million each year between 1989 and 1991. Growers in the U.S. produced 370 to 418 million cwt of potatoes with an average annual value of $2,428 million during the same period on 1.3 to 1.4 million acres.

Washington, Idaho and Oregon account for approximately 80% of the potato acres treated. Approximately 30, 34, and 5.5% of the potato acres are respectively treated in these states (DCI). Growers in Florida, Nevada, Alabama, Arizona and Michigan account for the remaining 20% of acres treated. The general trend among states using 1,3-D has been an increase in use during the period from 1988 to 1990. The cause of the trend is unknown.

Market Projections for Alternatives to Replace 1,3-dichloropropene

Metam-sodium and ethoprop are presently used on about 30% of the harvested potato acreage in states using 1,3-D. No recorded use of oxamyl on potatoes was found in 1,3-D usage states during the period from 1988 to 1990.

Based on the current use of alternatives and crop specialist opiinion, BEAD projected metam-sodium to replace 1,3-D use on 52,000 acres or 53% of the total which is about 12 to 13 million pounds a.i. Ethoprop and oxamyl are available for control of nematodes but at a reduced level of effectiveness. Ethoprop is estimated to replace 41,000 acres or 46% of the treated acres and oxamyl use is estimated on less than 2,000 acres or less than 1% of the treated acres.[5] BEAD projected annual increases in the use of ethoprop by 300,000 to 400,000 pounds a.i. and 10,000 to 12,000 pounds a.i. for oxamyl use.

Potential Impacts with the Loss of 1,3-dichloropropene

The change in the cost for chemical treatments replacing 1,3-D with alternatives is estimated at about $4 million annually. BEAD projected metam-sodium to replace 1,3-D at $474 per acre treatment cost, nearly double the cost of 1,3-D ($242 to $318 per acre treatment) (Ref). Ethoprop and oxamyl both cost less than 1,3-D ($93 and $150 per acre, respectively).

Based on findings from discussions with potato pest management specialists and an assessment of DCI and other performance tests, BEAD projected yield effects associated with all of the alternatives. Yield losses for replacement with metam-sodium are estimated between 5 and 10% in the Pacific Northwest (Ref). In other minor use states, reduced yield effects from the use of metam-sodium are not expected (Ref). However, for the use of ethoprop or oxamyl, yield losses up to 15% are estimated (Ref). The availability of efficacy data for oxamyl was not as extensive as metam-sodium or ethoprop.

Total production losses associated with estimated yield effects are between approximately 2 and 5 million cwt with a value of $9 to $22 million annually based on the yield losses stated above, which is less than 1% of the average value of U.S. gross revenues between 1988 and 1990. The greatest potential losses may occur in Washington where production is estimated to decrease by 1 and 2 million cwt annually. Even though these losses are the highest compared to the other states using 1,3-D, they are less than 4.0% of the total value of production between 1988 and 1990.

Long-run effects from the loss of 1,3-D are not known. It is possible that other alternatives may be developed in the future.

Overall impacts to the consumer in the short run will probably be negligible. Production losses associated with 1,3-D cancellation in relation to total U.S. potato production do not exceed 1%. This would indicate that potential impacts on the price of potatoes would be minimal in the short run. Other economic effects such as macroeconomics, social/community and trade effects are not expected to be significant.

Limitations of the Analysis

This analysis was limited by three primary factors. First, the lack of confirmed usage data to support the registrant's DCI data. Secondly, the limited amount of comparative performance data from relevant potato producing states for the alternatives. Conversations with crop specialists

[5] Some acres are projected to be treated with more than one alternative.

indicated states, as well as areas within individual states, vary widely in terms of efficacy of available alternatives on key target pests. This factor combined with the number of tests available limited precise quantification of yield effects. In addition, it made use projections for the alternatives extremely difficult and limited the time frame of the economic analysis to the short term.

Conclusions

Without the use of 1,3-D, BEAD's projections for market shifts to alternatives were made based on existing use of the alternatives, comparative product performance data and crop specialist opinions. About 52,000 (53%) of the treated acres were projected to shift to metam-sodium use, 41,000 (46%) to ethoprop and 2,000 or (1%) to oxamyl. Average increases in chemical treatment costs were estimated to be about $4 million annually. Production impacts on users could range from $9 to $22 million, making the total value of impacts from $13 to $25 million annually.[6] These potential losses are 0.6 to 1.0% of the total value of production in the states currently using 1,3-D and are considered to be negligible when considering aggregate production.

Moderate cost impacts are, however, expected in Washington where the total value of impacts are estimated between $9 and $13 million, which is more than 50% of the estimated total U.S. impacts. Washington growers may incur the largest impacts; the value of these impacts are 3 to 4.0% of the total value of their production. Other potential impacts on consumers, macroeconomics, social/community and trade are expected to be negligible.

Cotton

Use and Recommendations

1,3-D, a preplant soil fumigant, is registered for use on cotton to control plant-parasitic nematodes and Fusarium wilt by suppressing the root-knot nematodes associated with this disease/nematode complex. The three most common nematode populations found in cotton plots are the root-knot (*Meloidogyne incognita*), reniform (*Rotylenchulus reniformis*), and Columbia lance (*Hoplolaimus columbus*). Other types of plant-parasitic nematodes controlled by 1,3-D are burrowing, cyst, dagger, pin, ring, spiral, sting, and stubby root.

Nematodes attack the roots of cotton plants and sometimes stimulate the production of root galls. These galled and injured roots are deficient in their ability to absorb nutrients and water, and provide wounds for fungi, particularly (Fusarium) and other disease-producing organisms to enter the plant. Physical manifestations of nematode damage to cotton include loss of vigor, stunting, wilting or chlorosis (UC, IMP Pest Management Guidelines, 1991).

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[6] Potential revenue losses were calculated from the average price per cwt received during the period from 1989 to 1991.

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Two formulations of 1,3-D are registered for use on cotton, Telone® II and Telone® C-17. However, according to contacts made to those states using 1,3-D products on cotton, only Telone® II is currently used to control plant-parasitic nematodes. Cotton acres were treated once per year at a typical broadcast rate of 29 to 57 pounds of a.i. per acre; usually two weeks prior to planting.

Alternatives

The major chemical alternatives available for nematode control on cotton are fenamiphos and aldicarb. However, aldicarb is under Special Review and its continued market availability is unknown. Considerable quantities of aldicarb are applied in the southeastern states and the High Plains area of Texas. Growers in some areas (notably California) are trying metam-sodium, an alternative not typically used for cotton pests. At the time of this analysis, no new chemical alternatives are known to be in the process of development.

Non-chemical cultural controls currently utilized as supplemental controls include non-host rotation crops with peanuts, small grains, alfalfa, cow peas or rapeseed; sub-soiling with long shanks to destroy subsoil vegetation; and fallowing or trap crops. Disease-resistant cultivars of cotton have been established for Fusarium wilt, but no nematode-resistant cultivars exist. Another cultural method tried experimentally is solarization, although this method has not been proven to be economical on a commercial basis.

Usage Summary

Between 1988 and 1990, about 1.4 to 1.7 million pounds a.i. of 1,3-D was applied to approximately 30,000 to 31,000 acres of cotton according to the DCI usage information (DowElanco DCI). Less than 0.3% of the U.S. cotton acreage was treated with 1,3-D during this time. This usage estimate dramatically decreased without the use in California.[7]

In 1990, U.S. growers harvested about 11.5 million acres of cotton and produced 15.6 million bales. The total value of the U.S. crop was $5.1 billion in 1990. The cotton growing states are made up of four regions; southeast, Delta, southwest, and west. 1,3-D is used in all regions, but the majority is used in the southeast and west regions. Growers in the southeast region (Alabama, Florida, Georgia, North Carolina, and South Carolina) applied about 630,000 to 631,000 pounds of a.i. In the west region (Arizona), growers applied about 540,000 to 541,000 pounds a.i. The other two regions, which include Mississippi and New Mexico, used relatively minor quantities of 1,3-D.

Market Projections for Alternatives to Replace 1,3-dichloropropene

Presently, aldicarb has about 88% of the market in all treated acres. Approximately .5 to 1.0 million pounds a.i. were applied to about 525,000 acres annually. Growers applied 500 to 1,500 pounds a.i. of fenamiphos, the other major alternative, to less than 10,000 acres or less than

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7 California's use was estimated at 1.0 to 1.6 million pounds a.i. of 1,3-dichloropropene use on about 20 to 33 thousand acres in 1990.

2% of the treated acres. Treatments of both aldicarb and fenamiphos cost less than 1,3-D treatments per acre.

Without the use of 1,3-D based and assuming that aldicarb is available, BEAD estimated 98% (30,000 acres) of treated acres to shift to aldicarb treatments. Aldicarb use is projected to increase by 15,000 to 45,000 pounds a.i. The remaining 2% (500 acres) would shift to fenamiphos applications, adding 250 to 750 pounds a.i. annually to the current usage. These projections are based on current market use patterns.

Potential Impacts with the Loss of 1,3-dichloropropene

Users will likely incur cost and yield impacts which will vary depending on the availability of aldicarb. Treatment costs are not expected to increase and, possibly, could decrease with the use of aldicarb. Estimates of yield impacts with aldicarb and fenamiphos were made based on a limited number of performance studies submitted to support the DCI, published journal articles and discussions with state crop specialists. Assuming that aldicarb is available, yield losses are expected to be 2 to 8% with a value from $0.3 to $1.0 million annually.

Production losses are estimated on less than 1% of the total U.S. cotton acreage. This should have a minimal effect on overall cotton supplies and prices. If yield effects were anticipated to be significant, increased production pressure from domestic and foreign sources, notably China, India, and Pakistan, could more than offset these losses.

Non-users, which account for approximately 99% of the harvested acres, and other markets could expect negligible impacts. Economic effects on consumers and social/community are expected to be negligible.

Limitations of the Analysis

This study was limited by several factors. The relatively small number of usage and efficacy studies on 1,3-D and its alternatives was the primary constraint. Second, efficacy studies by cotton-growing states and yield impact studies contained very wide ranges of possible effects, making precise estimates of possible regulatory scenarios impossible. Professional judgement, in coordination with communication with cotton growers and crop specialists were used in absence of extensive, published data or assessments on performance of chemical and non-chemical alternatives. Finally, the uncertainty of the market availability of aldicarb coupled made estimating total impacts difficult. If the registration of aldicarb is no longer available to growers, the results of this analysis will change.

Conclusions

Aldicarb and fenamiphos are registered alternatives for these pests; however, aldicarb is currently under Special Review. Assuming that aldicarb is available, growers are projected to shift about 98% of the treated acres to aldicarb and 2% to fenamiphos uses. Potential yield losses with the use of these alternatives were estimated at $0.3 to $1.0 million annually. The impacts are

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expected to have negligible impacts on cotton production and markets since less than 1% of U.S. cotton acreage is treated with 1,3-D. Additionally, negligible impacts are expected for consumers, macroeconomies, social/community and trade.

Crucifers

Use and Recommendations

1,3-D is a preplant soil fumigant labeled for the control of various plant parasitic nematodes on broccoli, Brussels sprouts, cabbage, cauliflower, and radish.[8] Major target pests on crucifers are cyst nematodes, *Heterodera schactii* and *Heterodera cruciferae,* and root-knot nematodes, *Meloidogyne incognita*, *Meloidogyne hapla*, *Meloidogyne javanica,* and *Meloidogyne arenaria*. Additional target pests include root-lesion, *Pratylenchus* spp.; sting, *Belonolaimus* spp.; and stubby-root, *Paratrichodorus* (*Trichodorus*) spp., nematodes.

The biology and damage caused by cyst-forming and root-knot nematodes are similar. Both feed on root systems of the plant, interfering with the transport of water and nutrients through the plant. Above ground symptoms associated with both nematodes include wilting under temperature or moisture stress, stunted growth, and slow maturity.

Labeled recommendations for application ranges vary according to soil texture and application type, either broadcast or row. The broadcast rate of 1,3-D (Telone® II) ranges from 86 to 345 pounds a.i. per acre, with the mid to upper range of application for muck soils. Based on row spacings of 36 inches, a row application for mineral soil would range from 60 to 115 pounds a.i. per acre. Labeled use recommendations for the 1,3-D/chloropicrin formulation (Telone® C-17) for broadcast treatment are 103 to 420 pounds a.i. per acre depending on the soil type.

Alternatives

The only chemical alternative labeled for all crucifers is metam-sodium. Methyl bromide or methyl bromide/chloropicrin are fumigants labeled for use on broccoli and cauliflower. Non-fumigant nematicides include ethoprop which is labeled for cabbage and fenamiphos which is labeled for Brussels sprouts and cabbage. CA was issued an emergency exepmption for fenamiphos for use on broccoli and cauliflower. Methyl bromide is projected to be phased out by the year 2000 because the Agency found it to be an ozone depleter. **No new chemical controls were discovered during this analysis.**

Non-chemical practices, such as crop rotation, weed control, and sanitation, are available

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[8] Cruciferous vegetables included in the registration are crops such as broccoli, Brussels sprouts, cabbage, cauliflower, collards, horseradish, kale, kohlrabi, mustard greens, radishes, rutabaga, and turnips.

which may reduce or control nematode populations in crucifers. Rotating away from crucifers and beet crops may be an effective means of sugarbeet cyst control. ?

Usage Summary

Data was available from the DCI indicating 1,3-D use on crucifers, primarily broccoli, cauliflower, and cabbage in Arizona, California, Florida, and Hawaii. Single crop use data were not available. Estimates for Arizona include 1,3-D use on broccoli and cauliflower. The figures for Florida and Hawaii include use statistics for other crops, in addition to brassica.

According to the DCI data, approximately 11,000 to 21,000 acres of crucifers or 2 to 4% of the U.S. acres were treated with .7 to 1.2 million pounds a.i. of 1,3-D excluding California and Florida.[9] [10] These values cannot be verified because of inconsistencies in the usage data for Arizona. Arizona's usage estimates, which accounts for about 98% of the acres treated and pounds applied, cannot be supported by published state statistics and crop specialists. Without usage in Arizona, 1,3-D usage on crucifers is negligible.

Comprehensive production information on crucifer crops other than broccoli, cauliflower, cabbage and radish was not available. Acres harvested for these four crucifers range between 247,000 and 282,000 annually between 1988 and 1990. Growers produced a total of 19 to 23 million cwt of these crops with the value ranging from $580 to $678 million annually.

Market Projections for Alternatives to Replace 1,3-dichloropropene

Metam-sodium and methyl bromide are fumigants available for nematode control at a significantly higher per acre treatment cost. Methly bromide/chloropicrin costs about $740 per acre and metam-sodium costs about $540 per acre. Neither metam-sodium nor methyl bromide can be applied by the same method of application as 1,3-D with comparative efficacy. Metam-sodium requires application through an irrigation system and methyl bromide requires a tarp covering.[11] Ethoprop and fenamiphos are available for control of nematodes both at a cost less than 1,3-D ($48 and $82, respectively) but are considered to have a reduced level of effectiveness according to crop experts (Ref).

Projections for alternatives were not made because use in major crucifer producing states

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[9] According to the DCI data, growers in California were the largest user of 1,3-D on crucifers prior to 1990. About 2.6 to 3 million pounds a.i. of 1,3-D were applied to 30,000 to 36,000 acres annually. According to CA reported pesticide use, 1,3-D was applied on cruciferous crops other than broccoli and cauliflower including Brussel sprouts, cabbage, horseradish, kale, radish, mustard, and turnip. Total use for all crucifers in 1988 was about 2.5 million pounds a.i. applied to 41,000 acres.

[10] Despite reported use of 1,3-D on vegetables in Florida, it is no longer sold in southern Florida and use on crucifers is negligible.

[11] Another distinction between 1,3-dichloropropene and methyl bromide, is that methyl bromide is only labeled for broccoli and cauliflower.

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other than California is either unverified or negligible.[12] Growers in many other states practice crop rotation primarily for control of the sugarbeet cyst nematode which requires at least a three year rotation out of crucifer and beet crops.

Potential Impacts with the Loss of 1,3-dichloropropene

In most crucifer growing states, no significant impacts associated with the cancellation of 1,3-D use on crucifers were estimated. Use in California, Florida and Arizona is either discontinued, negligible or unverifiable. Other major producing states primarily including Texas, Michigan, and New York, do not use 1,3-D. In other states where use was reported, the estimates for crucifers were part of a major vegetable crop grouping. Thus, actual use in these states is negligible.

Crop rotation is an option which some growers may not use primarily because of economic reasons. Perhaps the use of the lower cost contact nematicides combined with appropriate crop rotations for targeted pests could produce acceptable results. This, however, would depend on a broader registration of ethoprop or fenamiphos on crucifer crops. Continuous production of crucifers without effective controls or rotations out of host crops will likely result in nematode problems. However, information from other crucifer producing states show that crucifers can be produced without the use of 1,3-D.

Neither commodity or other market impacts are expected from the cancellation of 1,3-D use for crucifers. Short run consumer impacts are expected to be minimal. Negligible social and/or community impacts are predicted in the short run.

A primary factor to consider for the long run in the cancellation of 1,3-D use on crucifers is the availability of an economically effective control for all crucifer crops. Although growers may not currently be using 1,3-D, it would be the primary alternative in the event a nematode problem did occur.[13]

Limitations of the Analysis

This analysis is limited by two primary factors. First, the lack of confirmed usage data, specifically in Arizona, to support the DCI data. Secondly, comparative product performance data for each of the sites were generally not available or did not include comparisons of 1,3-D to currently available alternatives.

Conclusions

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[12] The suspension of 1,3-D use permits in April 1990 resulted in increased usage of fenamiphos and metam-sodium. Use of ethoprop and methyl bromide did not increase significantly.

[13] For example, those California growers who do have a nematode problem on crucifers applied 1,3-D. The suspension of 1,3-D and existing nematode problems forced growers to use alternatives. California growers were granted a special emergency exemption registration to use fenamiphos on broccoli and cauliflower due to high chemical costs and other factors related to metam-sodium and methyl bromide.

Projections for market shifts to alternatives were not made, since use in major crucifer producing states other than California is either unverified or negligible. Impacts on producers are expected to be minimal. Depending on the crucifer and specific pest, growers may switch to crop rotation combined with a granular nematicide. All other economic impacts are expected to be negligible in the short run. In the long run, without an economical control for all crucifer crops, there is potential for future nematode problems.

Peanuts

Use and Recommendations

1,3-D is a pre-plant, broad spectrum soil fumigant capable of controlling several species of plant-parasitic nematodes on peanuts. Formulations combined with chloropicrin also aid in the suppression of pod rot in peanuts.

The peanut root-knot nematode is the most widespread nematode that causes the greatest crop loss to peanuts in the United States. Damage associated with peanut root-knot nematode feeding includes plant stunting, chlorosis, and wilt. In some areas, yield losses greater than 1,000 pounds per acre (50 % of the crop) have occurred from peanut root-knot nematode infestations. In some cases, northern root-knot, lesion, and sting nematodes can also be economically important in peanut production.

1,3-D (Telone® II) labeled broadcast application rates for the control of nematodes range from 57 to 115 lbs. a.i. per acre in mineral soils. Pest control recommendations in Alabama, Georgia, Florida, North Carolina, Texas, and Oklahoma list 1,3-D for use on peanuts. Several state guidelines recommend using less than labeled rates (38 to 67 lbs. a.i.) of 1,3-D for nematode control on peanuts. Applications are dependent upon soil moisture, soil temperature, and planting date. In the Southeast and in Virginia-North Carolina, 1,3-D is commonly applied to peanuts in March, April, and May. In Texas, it is usually applied in April, May, and June.

Alternatives

Registered chemical alternative nematicides include aldicarb, fenamiphos, ethoprop, metam-sodium, and oxamyl. Aldicarb, the most popular peanut nematicide, is currently in Special Review. One experimental ~~product~~ has provided superior nematode control on peanuts in university field ~~trials in~~ Texas (Fosthiazate®). It has only been used experimentally for two years. At the time of this analysis, ~~no~~ new ~~chemical~~ alternatives are known to be in the process of development.

Non-chemical methods of nematode control on peanuts include crop rotation, disking under crop residues, and planting non-host winter cover crops. Crop rotation can be as effective as chemical nematicides for the control of peanut root-knot nematode in some situations. The most effective rotational crops include Bahiagrass, American jointvetch, partridge pea, velvetbean, and cotton. Unfortunately, there are few crops that are not hosts of lesion or sting nematodes and a nematicide is generally necessary if these nematode populations are economically damaging.

Usage Summary

Less than 1% of national peanut acreage or 12,000 to 13,000 acres of peanuts were treated with 1,3-D between 1988 and 1990. Approximately 0.7 and 0.8 million pounds a.i. were applied annually during this time. When viewed separately, all of the three peanut producing regions (the Southeast, the Southwest, and Virginia-North Carolina) applied 1,3-D to less than 1% of their respective peanut acreages.

Growers produced 3.6 to 4.0 million pounds of peanuts on 1.7 to 1.8 million acres from 1988 to 1990 (USDA, 1991). Average yields range between 2,000 and 2,500 pounds per acre for a total value of $1.1 to 1.2 million (USDA, 1992). Georgia, Texas, Alabama and North Carolina comprise about 80% of U.S. production.

Market Projections for Alternatives to Replace 1,3-dichloropropene

1,3-D use use as a nematicide on peanuts is limited because of the widespread availability of economical alternatives. Nationally, 20% of total peanut acreage is treated annually with nematicides. Aldicarb was used on 64% of the nematicide-treated peanut acreage, fenamiphos on nearly 13%, ethoprop on almost 8%, metam-sodium on over 7%, 1,3-D on over 4%, carbofuran on 4%, and chloropicrin on less than 1%.

Compared with the non-fumigant nematicide alternatives, 1,3-D is more expensive than aldicarb, fenamiphos, or ethoprop, even when 1,3-D is applied at lower than labeled rates. 1,3-D costs nearly $105 per acre at the labeled midpoint application rate, while state recommended lower than labeled rates average almost $70 per acre. Treatment costs for the three granular nematicides range from $35.10 per acre to $49.70 per acre. Treatment costs for metam-sodium are the highest of all alternatives at $443 per acre. Oxamyl is also relatively expensive at $107 per acre. Even at lower than labeled rates, 1,3-D is almost $20 more per acre than aldicarb.

Approximately 80% (11,000 acres) of treated acres are expected to shift to aldicarb use. An additional 24,000 to 34,000 pounds of aldicarb would be applied. Of the remaining treated acres, 14% (1500 acres) and 1% (400 acres) would shift to fenimphos and ethoprop use, respectively. The chemical cost for alternatives would not increase and, may possibly decrease in the long run because the costs of the alternatives are lower than 1,3-D.

Potential Impacts with the Loss of 1,3-dichloropropene

If 1,3-D was cancelled for use on peanuts, it is estimated that aldicarb would be the primary replacement with some fenamiphos and ethoprop also used. Production impacts due to these substitutions were not found to be significant. The results of a relatively large number of efficacy studies conducted in the Southeast, found no statistically significant difference in yields between peanut plots treated with 1,3-D, aldicarb, ethoprop, or fenamiphos. However, results from four Southwest trials proved inconclusive as to the comparative efficacy of 1,3-D verses aldicarb and

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fenamiphos.

Short run impacts are estimated to be negligible to commodity/markets, consumers, social/communities and trade. Long run impacts may be dependent upon the continued market availability of aldicarb, due to the relatively unknown ability of fenamiphos and ethoprop to control nematodes effectively on a commercial scale.

Limitations of the Analysis

This analysis relied heavily on usage data from the DCI, due to the lack of published pesticide usage estimates on peanuts. Consequently, this analysis relies heavily on usage estimates from the DCI, both for 1,3-D and its alternatives. Secondly, this analysis was based on the assumption that aldicarb remains available for use on peanuts. Aldicarb and carbofuran are both under Special Review by the Agency. Aldicarb is the most popular nematicide for use on peanuts with a 64% market share. The cancellation of aldicarb would likely require revisions to this analysis. While carbofuran is used to a limited degree in only a few states (North Carolina, Virginia, Oklahoma), its cancellation would require some revisions in the reported findings.

Conclusions

About 83% of the market is projected to shift to aldicarb use and the remaining acres to fenamiphos and ethoprop. The treatment costs are not expected to increase. Production impacts resulting from the use of alternatives were found to be negligilbe. The results of this analysis will change if the market available of aldicarb changes. Impacts on commodity/markets, consumers, and trade are expected to be negilible.

Tomatoes

Use and Recommendations

1,3-D is a pre-plant, broad spectrum soil fumigant capable of controlling several species of plant parasitic nematodes, garden centipedes, and wireworms on tomato plants. When combined with other chemicals, at least one 1,3-D formulation also helps to control certain weeds. However, when 1,3-D is applied to fields where tomatoes are to be grown, nematode control is the primary objective.

The root-knot nematode (*Meloidogyne* spp.) is the most widely spread genus of nematode that causes the greatest crop damage and forces many growers to attempt either chemical or non-chemical control. It is the only economically important nematode genus affecting tomato crops. Damage from root-knot nematode feeding includes root galling, retarded plant growth, yellowing, wilt, leaf drop, and leaf curl. All contribute to poor yields and depending upon the severity of infestation levels, total crop loss is possible.

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For use on tomatoes, 1,3-D is listed in the state pest control recommendations of Alabama, Florida, Michigan, New Jersey and Pennsylvania, although it may be only used in some of the northern counties of Florida. Because tomatoes are planted from January to June in the U.S., 1,3-D has a wide range of common application dates that are dependent upon location and planting dates. Rates for broadcast application, which is commonly used for pole tomatoes, range from 86 to 173 pounds a.i. per acre depending on the soil type. Row treatment, the more prevalent method with processed tomatoes, rates range between 52 and 99 pounds a.i. per acre.

Alternatives

Metam-sodium, methyl bromide, methyl bromide/chloropicrin formulations, and oxamyl are the registered alternatives for nematode control on tomatoes. Efficacy studies and crop specialists reported excellent root-knot nematode control with methyl bromide/chloropicrin formulations. Methyl bromide/chloropicrin has the added benefit of also controlling plant-parasitic pathogens, some insects, and weeds. In comparison to 1,3-D, metam-sodium applied through drip irrigation systems in experimental trials has provided equivalent root-knot nematode control. Results are mixed, however, when metam-sodium is applied by other methods, i.e., soil injection, furrow, flood, or sprinkler irrigation. Oxamyl, a non-fumigant nematicide/insecticide alternative, does not provide effective nematode control. At the time of this analysis, no new chemical alternatives are known to be in the process of development.

Non-chemical methods of nematode control on tomatoes are widely used. Some of the more popular controls include crop rotation with non-host plants and fallow, and the use of nematode-resistant varieties. Several sources report that the use of nematode-resistant tomato cultivars, coupled with crop rotation is as effective as chemical fumigants for the control of nematode damage. Not all tomato varieties offer nematode-resistance and resistant varieties have not been developed for three of the five species of root-knot nematodes commonly associated with the production of tomatoes.

Usage Summary

Tomatoes are the single highest valued vegetable crop in the United States. A total of 490,000 acres of tomatoes were harvested in the U.S. at a value of $1.6 billion in 1990 (USDA, 1991). California (CA) growers produced about 91% of processed tomatoes, while growers in Florida and CA produced 48 and 28%, respectively, of fresh market tomatoes.

Approximately 2,000-2,200 acres of tomatoes nationwide have been annually treated with 200,000 to 400,000 pounds a.i. of 1,3-D.[14] This represents only 1% of total U.S. tomato acreage treated with 1,3-D. Current users are generally small scale tomato growers in Alabama, Tennessee, and New Jersey, that cannot afford methyl bromide/chloropicrin formulations and/or do not believe metam-sodium provides adequate control.

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[14] Prior to April 1990, growers in CA applied 1 to 2 million pounds a.i. of 1,3-D to about 21,000 to 34,000 acres which is 6 to 10 percent of CA's tomato crop. CA's usage increased the total treated acres to 5.0 to 7.0 percent in the U.S.

Market Projections for Alternatives to Replace 1,3-dichloropropene

The most viable chemical alternatives are methyl bromide/chloropicrin formulations and metam-sodium, both cost nearly three times as much as 1,3-D (Telone® II). Total treatment costs per acre range from $30.31 for oxamyl, $417.25 which includes tarping for methyl bromide/chloropicrin treatments and $443.00 for metam-sodium. The difference in total treatment costs of alternatives relative to 1,3-D range from a savings of $121.29 to an increase of $291.30 per acre.

Producers could switch to an alternative chemical control product (methyl bromide/chloropicrin or metam-sodium).[15] However, the cost of these chemicals may not be economical, especially for small growers. Without the availability of 1,3-D, the Agency projects that many growers will depend entirely upon non-chemical nematode control methods which will likely cost less than alternative treatment costs.[16]

Potential Impacts with the Loss of 1,3-dichloropropene

Short run adverse impacts without the use of 1,3-D on tomatoes is expected to be minor in the aggregate. California tomato growers have not used 1,3-D for two years and little or no yield or quality effects have been noticed. Very little 1,3-D is applied to Florida tomato crops. Together, California and Florida account for 85% of U.S. tomato production. The remaining tomato producing states are relatively small producers and most growers use methyl bromide/chloropicrin for nematode control. However, many small scale growers in certain areas of Alabama, Tennessee and New Jersey cannot afford to use methyl bromide/chloropicrin and depend upon 1,3-D to provide affordable, effective nematode control. Without 1,3-D, these producers may quit growing tomatoes for commercial production.

Social/community impacts are possible in the short run in those areas of southern Alabama, eastern Tennessee and New Jersey. Tomato farms in these areas are small, producers cannot afford to use the current chemical alternatives, and nematode pressure is great enough that non-chemical controls are not effective. These producers are predicted to quit producing their tomato crop if 1,3-D is cancelled which will affect their gross revenues and, ultimately, their income. The degree of these impacts are unknown because it depends on the rotating crop that growers select for this land in place of tomatoes.

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[15] Since the suspension of 1,3-D in California, crop specialists in CA estimated that approximately 80% of the tomato growers who were using 1,3-D for nematode control, have substituted nematode-resistant varieties used in conjunction with crop rotation (Miyao, 1992; May, 1992). The remaining 20% have switched to either metam-sodium and methyl bromide/chloropicrin formulations to control nematodes (Laemmlen, 1992; Westerdahl, 1992). Annual usage of metam-sodium in CA is estimated to have increased from between 400,000 lbs. a.i. to over 1.6 million lbs. a.i. with an associated nematicide treatment cost increase of between $0.9 to nearly $1.5 million. The use of methyl bromide/chloropicrin formulations is predicted to have risen by between 285,000 lbs. a.i. to 615,000 lbs. a.i., increasing nematode treatment costs from between $280,000 to $450,000

[16] While this analysis does not give an estimate for projected changes in cost for non-chemical controls, there are costs associated with these kinds of management options. For example, the prices for nematode-resistant and the non-nematode-resistant varieties differ and leaving otherwise productive land fallow can be quite costly.

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Long-run impacts from the loss of another soil fumigant, especially methyl bromide, could be potentially severe if nematode-resistant tomato varieties become ineffective against nematode damage.

Limitations of the Analysis

There are important questions that cannot be currently answered about the three major alternatives to 1,3-D. The effectiveness of metam-sodium as an equivalent nematicide alternative to 1,3-D is questionable without further research. The future availability of methyl bromide is uncertain. And, the ability of nematodes to break nematode-resistant tomato varieties is believed by many to be a possibility. Until the effectiveness and availability of these alternatives is established with greater certainty, the quantitative estimates in this study--especially the impacts of 1,3-D cancellation--could vary considerably.

Conclusions

Metam-sodium and methyl bromide are two alternatives, but at much higher costs than 1,3-D. The potential impacts on the tomato industry are expected to be negligible because only 1% of the acreage is treated with 1,3-D. Short run adverse impacts without the use of 1,3-D on tomatoes are expected to be negligible in the aggregate. However, for many small scale growers in certain areas of Alabama and Tennessee, chemical alternatives are not economical; thus the adverse impacts are expected to be minor **(4-9% of gross revenues)**. These growers may quit producing tomatoes for commercial production. Social/community impacts are possible in the short run in those areas of southern Alabama, eastern Tennessee and New Jersey.

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