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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Benefits of Endosulfan in Agricultural Production: Analysis of Usage Information (DP#345930)

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Product Review Panel: October 17, 2007

Summary

Endosulfan is an organochlorine insecticide that is used on numerous crops. Use of endosulfan could provide benefits to agricultural producers because it controls a wide range of pests and it has a relatively long period of activity. Endosulfan may also be important for resistance management of some pests and, depending on the situation, may be less expensive than alternatives. BEAD analyzed usage data and pest control information to reach tentative,

qualitative conclusions about the benefits of endosulfan in some of the crops for which it is registered.

Given the low percentage of acreage treated with endosulfan, BEAD concludes that the chemical provides only low benefits to producers of blueberries, broccoli, Brussels sprouts, cauliflower, celery, nectarines, onions, and sweet corn.

After examining information about target pests and chemical alternatives, BEAD also concludes that endosulfan provides only low benefits to producers of apples, cabbage, cherries, peaches, pears, peppers and potatoes. Although endosulfan is used fairly extensively in some of these crops, it tends to play a minor role in the control of target pests. In the case of apples and cherries, however, endosulfan does appear to play a relatively more important role in the control of some minor pests. Use of endosulfan is relatively low in peaches, but some organophosphates may be less available in the immediate future, which could increase reliance on endosulfan.

Endosulfan may provide low to moderate benefits to producers of melons, including cantaloupes, honeydews, and watermelons. Endosulfan is not the primary control for any single pest, but it provides broad-spectrum control that may not be found in other pesticides.

Endosulfan appears to provide moderate benefits to producers of cucumbers, eggplants, and lettuce. While not the primary means of control, it is commonly used for control of important pests. There seem to be relatively few alternatives, which may be more costly.

Endosulfan also appears to provide moderate benefits to producers of some crops in certain regions of the country: cotton in Arizona and parts of California; tobacco west of the Appalachian Mountains where alternatives are more expensive and rotating alternatives with endosulfan may be important to avoid development of pesticide resistance; and strawberry in the Northeast and Northwest where endosulfan is the primary method of control of certain pests.

Endosulfan likely provides moderate to high benefits to producers of pumpkins and of tomatoes in the eastern United States, where it is relatively important for the control of several major and minor pests. It also may provide high benefits in the production of squash because it is one of the top choices for control of a wide range of pests. The alternatives being used cover a narrower spectrum and may be less effective or provide a shorter period of control.

BEAD has not drawn conclusions as to the benefits of endosulfan on a number of other crops, including ornamental crops, because the databases on which this analysis is based lacked information. The Agency would appreciate information, including quantitative information, from stakeholders who believe that there are high benefits to the use of endosulfan on these sites, as well as any information that would suggest the tentative conclusions given here should be revised.

Introduction

EPA completed the Reregistration Eligibility Decision (RED) process for endosulfan in November 2002. Data submitted to fulfill requirements of the RED have been used to revise risk assessments. This document presents an overview of usage information for endosulfan, a broad-spectrum insecticide registered on a large array of crops. This information is intended to provide a context for revised risk assessments and to provide stakeholders with EPA's tentative conclusions regarding the benefits of endosulfan. BEAD invites comments as to the accuracy of its conclusions as well as qualitative information or quantitative data that would permit the Agency to confirm or revise its assessments.

BEAD examined statistics compiled by the National Agricultural Statistics Service, U.S. Department of Agriculture, to evaluate endosulfan usage since 2002 (USDA NASS, 2000-2006a; 2000-2006b; 2001-2007). The percent of a crop treated or the total pounds of endosulfan applied were used to identify crops for which endosulfan appeared to be important to production. In some cases, regional distinctions in use patterns were identified.

Public data do not specify the pests targeted by an application, so BEAD relied on proprietary data to identify the most important pests targeted by endosulfan for each crop. EPA's proprietary data come from surveys of producers and pesticide applicators who report acres treated with a pesticide and the pests targeted by the application. For this analysis, the proportion of endosulfan-treated acres targeting a pest was used to indicate importance of the pest in the use of endosulfan. The database was then used to estimate the total number of acres treated for that pest by all insecticides, including endosulfan. The number of acres treated with endosulfan as a proportion of the total acres treated for a pest was used to indicate the importance of endosulfan in the overall control of the pest. This information is used to draw some qualitative conclusions as to the magnitude of the benefits endosulfan provides to agricultural production.

There are some limitations to this approach. Identifying specific pests targeted by a chemical may be confounded because multiple chemicals may be applied simultaneously for multiple pests but the survey data does not distinguish which chemical targets which pest. The application of multiple chemicals simultaneously can also make a pest appear more important than it is, since the total acres treated for a pest sums across both pesticides and applications. That is, multiple applications on the same acre are counted in the total as is multiple chemicals applied to the same acre. Finally, estimates in the database may rely on small sample sizes, particularly for small-acreage crops and for small-producing states. Conclusions in this document are therefore tentative, but will help guide the Agency to determine whether additional analysis is needed.

Table 1 presents use information for crops with a low percentage of acres treated with endosulfan. Given the lack of use, BEAD has not analyzed these crops further but tentatively concludes that benefits are low. In addition, under the 2002 RED, use of endosulfan on grapes, green beans, green peas, pecans, and spinach is not allowed. Although use of endosulfan will appear in the data on these crops, BEAD has not included these crops in the analysis.

Table 1. Annual average endosulfan use, low usage crops.

Crop	Acres	% Crop Treated	lb Applied
Blueberry	45,900	1.4	300
Broccoli	133,900	2.3	2,400
Brussels sprouts [1]	4,100	1.2	< 100
Cauliflower	40,600	4.8	2,700
Celery	27,100	3.0	700
Nectarine	36,700	0.2	200
Onion	165,200	reported, not quantified	
Sweet corn	240,900	1.9	6,000

Source: USDA NASS (2002-2006b), USDA NASS (2003-2007b), USDA NASS (2000-2006b), USDA NASS (2001-2007), Cal DPR, 2000-2006.

1 California only.

The remainder of the document is organized in alphabetical order. The crops analyzed are apple, cabbage, cherry, cotton, cucumber, eggplant, lettuce, melons, peach, pear, pepper, potato, pumpkin, squash, strawberry, tobacco, and tomato.

Apples

Apples are grown throughout the United States with production relatively more common in the north, both the Pacific Northwest and across the east from Minnesota to the Atlantic Coast. Endosulfan appears to be relatively important in these two primary production regions (Table 2).

Table 2. Average annual endosulfan use, Apple

Key states/Regions	Acres Cultivated	% Crop Treated	lb Applied
United States	384,000	11.9	58,700
Northwest [1]	164,900	10.7	31,400
East [2]	181,000	16.0	26,600
CA	25,800	< 1.0	< 300

Source: USDA NASS, (2002-2006b), USDA NASS, (2000-2006b), Cal DPR, 2000-2006.

1 Idaho, Oregon, and Washington.

2 Connecticut, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin.

Table 3 presents information on pests targeted with endosulfan. Aphids are targeted on a large proportion of acres treated with endosulfan and, specifically, the woolly apple aphid. Other targeted pests include the leafroller, leafminer, and codling moth. In the Northwest, the lygus bug is also a common target. Endosulfan appears to play a relatively minor role for control of most of these pests, accounting for three percent of less of the acres treated for codling moth, leafroller, leafminer, and aphids, in general. However, it is the primary control of the woolly apple aphid, which appears to be a relatively minor pest, given the relatively small number of acres for which it is treated.

Table 3. Endosulfan target pests and potential alternatives, Apple

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
United States	Codling Moth	12.4	1,586,700	Endosulfan	0.3
	Aphids	67.2	784,500	Endosulfan	3.1
	Woolly Apple Aphid	15.5	14,400	Endosulfan Chlorpyrifos Petroleum Oil Diazinon	38.3 28.3 11.8 9.7
	Leafroller	16.7	853,900	Endosulfan	0.7
	Leafminer	14.9	332,300	Endosulfan	1.6
Northwest [4]	Lygus Bug	12.1	23,600	Chlorpyrifos Formetanate HCl Dimethoate Endosulfan	62.4 11.3 10.7 5.8
	Woolly Apple Aphid	28.4	10,500	Endosulfan Chlorpyrifos Petroleum Oil	30.7 28.5 13.5
Northeast [5]	Woolly Apple Aphid	12.7	2,700	Endosulfan Chlorpyrifos	84.1 13.9

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

4 Oregon and Washington.

5 Michigan, New York, Pennsylvania, and Wisconsin.

Given this information, BEAD tentatively concludes that endosulfan does not provide high benefits to apple producers. For most pests targeted by endosulfan, growers have other chemical control options that seem to be preferred. The exception appears to be the woolly apple aphid. BEAD has not attempted to quantify the benefits of endosulfan. To do so, BEAD would need information on the relative efficacy of the alternatives and the potential for the woolly apple aphid to damage apple production.

Cabbage

Endosulfan is primarily used on cabbage in Georgia, Texas, and along the Atlantic Coast, particularly in New Jersey and New York (Table 4). Use may be declining, but there may simply be year-to-year fluctuations in pest problems. Data are unavailable for Florida, but the situation may be similar to that in Georgia. Recent data are not available for cabbage grown for processing; in 2000, the percent crop treated was somewhat higher for processing than for fresh, but acreage is very limited.

Table 4. Average annual endosulfan use, Cabbage

Key states/Regions	Harvested Acres	% Crop Treated	lb Applied
United States	74,800	7.9	7,800
Atlantic Coast [1]	20,800	10.6	2,100
Florida/Georgia [2]	17,400	26.1	4,000
California	13,200	0.4	< 100
Midwest [3]	8,200	< 1.0	< 100
Texas	8,000	9.8	1,000

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007), Cal DPR, 2000-2006.

1 New Jersey, New York, North Carolina, and Pennsylvania.

2 Usage data from Georgia only.

3 Illinois, Michigan, Ohio, and Wisconsin. Usage data from Michigan and Ohio only.

According to EPA proprietary data, endosulfan appears to play a minor role in the control of some major cabbage pests such as the cabbage looper, diamondback moth, and cabbage worm, accounting for less than three percent of the area treated for these pests. It is used relatively more in the control of the cabbage aphid and thrips, but does not appear critical as imidacloprid and dimethoate are more widely used. This information is presented in Table 5.

Table 5. Endosulfan target pests and potential alternatives, Cabbage

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
United States	Cabbage Looper	36.1	253,300	Endosulfan	2.1
	Diamondback Moth	37.1	220,400	Endosulfan	2.4
	Cabbage Worm	21.9	168,900	Endosulfan	1.9
	Cabbage Aphid	46.9	94,900	Imidacloprid Oxydemeton-methyl Endosulfan	21.4 13.8 6.0
	Thrip	30.4	80,400	Dimethoate Lambda-cyhalothrin Endosulfan	54.9 17.8 5.5
	Armyworm	21.0	79,200	Endosulfan	3.8

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

Because of the relatively minor role endosulfan plays in controlling targeted pests, BEAD tentatively concludes that growers obtain only small benefits from the availability of endosulfan.

Cherry

Washington and Oregon are the principle producers of sweet cherry and the primary users of endosulfan (Table 6). Very little endosulfan appears to be used on tart cherry (USDA NASS 2002-2006b).

Table 6. Average annual endosulfan use, Sweet Cherry

Key states/Regions	Bearing Acres	% Crop Treated	lb Applied
United States	75,800	7.2	7,500
California	25,300	0.1	< 100
Northwest [1]	39,800	10.0	7,300
East [2]	8,800	2.1	200

Source: USDA NASS (2002-2006b), Cal DPR, (2000-2006b).

1 Oregon and Washington.

2 Michigan and New York. Use information limited to Michigan.

EPA proprietary data suggest that endosulfan plays almost no role in the control of the cherry fruit fly, one of the most important pests in cherry production. It is also a rather minor player in the control of pests like leafrollers, mites, and leafhoppers. Endosulfan is relatively more important in the control of minor pests like borers, stink bugs, and various worms, where it is an alternative to the use of the organophosphates, chlorpyrifos and diazinon.

Table 7. Endosulfan target pests and potential alternatives, Sweet Cherry

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Northwest [4]	Cherry Fruit Fly	12.9	192,100	Endosulfan	0.4
	Leafroller	37.2	47,300	Spinosad Chlorpyrifos Endosulfan	28.6 25.8 5.1
	Mites	33.9	38,900	Chlorpyrifos Endosulfan Spinosad	41.9 5.6 4.4
	Black Cherry Aphid	30.3	12,300	Imidacloprid Diazinon Endosulfan	19.0 18.9 15.9
	Leafhopper	11.1	10,900	Carbaryl Spinosad Endosulfan	40.6 9.0 6.6
	Green Fruitworm	13.6	4,500	Endosulfan Chlorpyrifos Methoxyfenozide	19.4 16.7 10.5
	Cutworm	9.2	3,500	Chlorpyrifos Endosulfan	55.2 16.9
	Stink Bug	7.2	1,100	Endosulfan Diazinon Chlorpyrifos	43.0 11.1 8.6
	Borers	9.2	1,000	Endosulfan Chlorpyrifos	60.2 7.2

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

4 Oregon and Washington.

On the basis of this information, BEAD tentatively concludes that endosulfan does not provide high benefits to cherry production. For the more important pests, measured by acres treated, there are alternatives that appear to be preferred by growers. Pests for which endosulfan is the primary control seem to affect a relatively small number of acres. BEAD has not quantified the benefits of endosulfan. To do so, BEAD would need information on the potential for pests like borers, stink bugs, and worms to damage cherry and the relative efficacy of alternatives for these pests.

Cotton

As shown in Table 8, endosulfan appears to be important only in the desert southwest, which accounts for less than 13% of U.S. production, but includes nearly all the high-value Pima cotton. Arizona is a key user and produces about 3% of the U.S. total cotton fiber.

Table 8. Annual average endosulfan use, Cotton

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied
United States	12,802,000	1.1	258,900
South [1]	6,431,000	< 1.0	6,000
Arizona, California	894,000	10.1	139,000
OK, TX	4,997,000	1.0	65,500

Source: USDA NASS (2001-2007a), USDA NASS (2000-2006), Cal DPR (2001-2005)

1 Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, and Virginia.

According to EPA proprietary data, whitefly and Lygus bug are the main drivers of endosulfan use in Arizona and parts of California. There are alternatives, including organophosphates, synthetic pyrethroids, carbamates, neonicotinoids, and growth regulators, that can be used for control of these pests individually.

Table 9. Endosulfan target pests and potential alternatives, Cotton

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Arizona, California	Aphids	10.6	485,600	Endosulfan	1.6
	Lygus Bug	46.1	467,900	Imidacloprid Cyfluthin Oxamyl Endosulfan	14.7 14.0 12.8 7.3
	Whitefly	59.0	372,800	Pyriproxyfen Acetamiprid Endosulfan Thiamethoxam	25.2 17.9 11.7 10.7
	Plant Bug	6.2	51,700	Naled Acephate Aldicarb Endosulfan	45.0 19.3 12.3 8.9
	Cabbage Looper	8.6	47,000	Bifenthrin Chlorpyrifos Tebufenozide Endosulfan	27.0 27.0 19.1 13.5

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

BEAD previously assessed the benefits of endosulfan in cotton and suggested that there were moderate benefits to its use in cotton production in Arizona (Chiri *et al.*, 2002). This was based on the increased cost of alternatives. Usage data from 2002-2006 suggest that these newer, more expensive products, such as pyriproxyfen, have been adopted, but it appears that endosulfan continues to provide benefits in the desert southwest because it is less expensive, provides control of adults, and offers a unique chemistry that may be important for management of pest resistance to other pesticides.

Cucumber

Florida and Georgia are the leading states in production of fresh cucumber and the primary users of endosulfan. Data indicate that growers in the Northeast also rely relatively heavily on endosulfan (Table 10). Use, however, appears small in California and North Carolina, two other relatively large producers of fresh cucumber (USDA NASS, 2003-2007b). Data show very little usage of endosulfan on cucumbers for processing.

Table 10. Average annual endosulfan use, Cucumber

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied
United States	55,400	29.2	26,100
Florida, Georgia	14,800	44.2	20,800
Michigan	6,000	31.8	2,500
New Jersey, New York	7,600	14.5	2,600

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007).

Endosulfan does not appear to be the dominant control measure in cucumber production. However, for pests like aphids, cucumber beetle, and pickle worm that appear to require multiple applications throughout the growing season, endosulfan appears to be one of a relatively few number of chemicals on which growers rely (Table 11).

Table 11. Endosulfan target pests and potential alternatives, Cucumber

States/Regions	Primary Target Pests	% Endosulfan-Treated Area[1]	Total Area Treated for Pest[2]	Stated Chemical Controls	% Area Treated for Pest[3]
United States	Pickle Worm	75.8	209,600	Esfenvalerate Methomyl *Bt* Endosulfan	39.3 12.8 13.3 8.5
	Cucumber Beetle	75.3	153,200	Esfenvalerate Endosulfan Permethrin *Bt*	32.7 11.3 10.1 9.1
	Aphids	39.8	100,200	Esfenvalerate Methomyl Endosulfan	25.8 25.2 9.2

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

BEAD tentatively concludes that endosulfan generates moderate benefits for producers of fresh cucumbers. While not the dominant means of control, endosulfan appears to play an important role in the control of several pests for which multiple applications are needed throughout the season.

Eggplant

The data on eggplant are sparse and somewhat dated. USDA is not currently collecting data on production, including acreage. Data on harvested acres are from 2000 and 2006, when select states were surveyed for the chemical usage report.

Table 12. Average annual endosulfan use, Eggplant

Key states/Regions	Acres Harvested[1]	% Crop Treated	lb Applied
United States	3,600	25.4	1,300
California	1,000	6.1	< 100
Florida	1,800	42.0	1,100
New Jersey	800	11.0	200

Source: USDA NASS (2001-2007b), Cal DPR (2001-2005).

[1] Collection of production data was discontinued in 2001. A limited number of states were surveyed for chemical usage.

According to the crop profile for New Jersey (Kline and Walker, 2004), endosulfan is used for control of the Colorado potato beetle, flea beetles and the green peach aphid. In Florida, endosulfan is used against thrips, whitefly, armyworms, and mites (CREES, 2002). A number of alternatives appear to be available and some may be relatively broad-spectrum, like endosulfan, however EPA proprietary data do not provide information on the extent of use of endosulfan and other chemicals in eggplant production.

Given the extent of use, BEAD tentatively concludes that growers derive moderate benefits from the use of endosulfan. Information on the advantages of endosulfan, including relative efficacy of endosulfan to available alternatives, would be needed to quantify the extent of the benefits.

Lettuce

Arizona and California account for the vast majority of lettuce production in the United States As shown in Table 13, Arizona uses endosulfan at a substantially higher level than does California and endosulfan is used more extensively in head lettuce than in leaf lettuce.

Table 13. Average annual endosulfan use, Lettuce

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied
U.S., total	303,600	8.0	23,900
California [1]	312,700	5.1	21,700
Arizona	73,600	22.8	15,600
U.S., head lettuce	180,000	10.3	18,600
California [1]	171,000	7.0	17,000
Arizona	48,600	26.1	12,400
U.S., leaf lettuce	123,600	4.4	5,300
California [1]	141,700	2.8	4,800
Arizona	25,000	15.3	3,200

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007), Cal DPR (2001-2005).

[1] California Pesticide Use Reports (Cal DPR, 2001-2005) indicate significantly higher acreage than do USDA statistics (2003-2007). Both sources report similar percent of crop treated with endosulfan, but California data report higher application rates per year and more total lb of endosulfan applied. U.S. totals are not adjusted.

According to EPA proprietary data, the majority of acres to which endosulfan is applied are treated for aphids (Table 14). Leafminers and loopers are also important pests targeted by endosulfan. Of these, loopers appear to be the major lettuce pest and there are many alternatives, such as spinosad, that seem to be preferred to endosulfan. For control of aphids and leafminers, however, endosulfan is one of the top choices. Imidacloprid, another top choice, is substantially more expensive than endosulfan.

Table 14. Endosulfan target pests and potential alternatives, Lettuce

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Arizona	Cabbage Looper	31.6	260,600	Spinosad Endosulfan	27.5 3.1
	Aphids	53.0	87,900	Imidacloprid Endosulfan Methoxyfenozide	39.2 15.3 14.5
	Leafminer	37.9	35,900	Endosulfan Spinosad Imidacloprid	26.8 17.4 11.8

Source: EPA proprietary data, 2002-2006, summarized for publication.

[1] Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

[2] Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

[3] Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

BEAD tentatively concludes that endosulfan provides moderate benefits in the control of aphids and leafminers in lettuce production. These benefits are the result of the lower cost of endosulfan. There may also be differences in yields, but BEAD has not reviewed data on the comparative efficacy of alternatives for pest control.

Melons

Melon production, including cantaloupe, honeydew, and watermelon, is concentrated in California and Arizona, with significant production in Texas, Florida, and Georgia. Cantaloupe and honeydew, in particular, are cultivated in California and Arizona, but watermelon production is more widely distributed. Endosulfan appears to be used throughout the production areas (Table 15), although data are lacking for regions such as the Eastern Seaboard (e.g., the Carolinas) and the Midwest.

Table 15. Average annual endosulfan use, Melons

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied [1]
U.S., total	256,400	13.3	35,500
Arizona, California	109,500	15.9	21,000
Florida, Georgia	55,900	9.3	8,100
Texas	37,100	27.9	14,200
U.S., cantaloupe	88,100	13.5	12,200
Arizona, California	67,900	19.2	13,400
Michigan, Pennsylvania	2,200	45.9	900
Texas	7,000	31.3	3,600
U.S., honeydew	23,000	9.1	2,100
Arizona, California	21,800	10.8	3,500
U.S., watermelon	145,000	13.9	21,300
Arizona, California	19,900	12.7	4,100
Florida, Georgia	49,700	10.3	8,000
Texas	28,900	29.2	10,600

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007), Cal DPR (2001-2005).

1 Different states were surveyed in different years so that the average of US total lb applied differs from the sum of the state averages.

According to EPA proprietary data, presented in Table 16, endosulfan appears to be used primarily for control of aphids. In California and Arizona, however, applications more frequently target whitefly, while rindworm control appears important in Texas. Aphids appear to be a common pest in melons and there are a number of alternatives that seem to be preferred over endosulfan by melon growers, including imidacloprid and diazinon. Imidacloprid can also be used against whitefly, but it is more expensive. *Bacillus thuringiensis* (*Bt*) is the dominant means for control of rindworm.

Table 16. Endosulfan target pests and potential alternatives, Melons.

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
United States	Melon Aphid	33.1	224,400	Imidacloprid Diazinon Endosulfan	21.0 15.0 5.7
	Cucumber Beetle	14.7	135,800	Esfenvalerate Permethrin Carbaryl Endosulfan	26.6 23.0 18.0 4.2
	Whitefly	37.9	113,300	Imidacloprid Endosulfan Bifenthrin	40.7 13.0 9.9
	Rindworm	14.8	80,000	*Bt* Esfenvalerate Methomyl Endosulfan	39.7 11.3 11.3 7.2
Arizona, California [4]	Melon Aphid	21.6	118,400	Imidacloprid Diazinon Endosulfan	25.2 24.2 3.8
	Whitefly	69.5	81,700	Imidacloprid Endosulfan Bifenthrin	39.9 17.6 11.3
Florida, Georgia [5]	Melon Aphid	49.9	41,700	Esfenvalerate Imidacloprid Endosulfan	31.0 11.2 9.1
	Rindworm	33.1	36,300	*Bt* Esfenvalerate Endosulfan	42.3 21.7 6.9
	Cucumber Beetle	11.2	16,200	Carbaryl Esfenvalerate Endosulfan	44.4 27.0 5.2
Texas	Melon Aphid	44.3	28,700	Imidacloprid Esfenvalerate Endosulfan	42.2 19.9 6.4
	Rindworm	74.5	14,100	*Bt* Endosulfan	64.1 21.8

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

4 Primarily cantaloupe.

5 Primarily watermelon.

BEAD concludes that endosulfan may provide low to moderate benefits in melon production. It is not the predominant means of control for the pests targeted with applications of endosulfan, but it controls a broad spectrum of pests that might otherwise require different insecticides and it is often less expensive than alternatives like imidacloprid and *Bt*.

Peach

California is home to nearly half the U.S. peach acreage, but growers use very little endosulfan. Southern states, particularly South Carolina and Georgia, produce somewhat more than 10% of U.S. peaches. USDA data on the use of endosulfan in peach production are only available for Georgia, but indicate that there is relatively low usage. Endosulfan appears more important in northeastern states of Michigan, New Jersey, New York, and Pennsylvania. Use may be similar in the surrounding states of Indiana, Illinois, Kentucky, Maryland, and Ohio. Bearing acres for this region total over 23,000 acres of peaches. Data are presented in Table 17.

Table 17. Average annual endosulfan use, Peach

Key states/Regions	Bearing Acres	% Crop Treated	lb Applied
US	142,300	5.1	14,600
California	66,700	0.3	500
Georgia	11,800	3.4	900
Northeast [1]	18,700	15.5	6,800

Source: USDA NASS (2002-2006), USDA NASS (2000-2006b).

[1] Michigan, New Jersey, New York and Pennsylvania.

EPA proprietary data, shown in Table 18, suggest that endosulfan does not play a major role in pest control in peaches. A large proportion of endosulfan treatments target pests like peach tree or twig borers and San Jose scale. These are very important pests in peach production, based on the total area treated for their control; however, endosulfan plays a very minor role in the control of borers and scale, which are typically targeted with organophosphates such as phosmet. Endosulfan is relatively more important in the control of secondary pests such as aphids and plant bugs, but again appears secondary to other chemicals, including oganophosphates. BEAD notes that the use of azinphos-methyl on peach was phased out during this period and endosulfan may currently play a more important role than is indicated by these data. Further, phosmet usage will be subject to additional constraints, such as a longer restricted entry interval. However, BEAD assessments suggest that synthetic pyrethroids, not endosulfan, would be the likely alternatives if phosmet use were infeasible (Wyatt and Chiri, 2006).

Table 18. Endosulfan target pests and potential alternatives, Peach

States/Regions	Primary Target Pests	% Endosulfan-Treated Area[1]	Total Area Treated for Pest[2]	Stated Chemical Controls	% Area Treated for Pest[3]
United States	Borer	32.8	264,200	Endosulfan	1.7
	San Jose Scale	23.0	182,600	Endosulfan	1.7
	Plant Bug	36.0	83,800	Phosmet Azinphos-methyl Esfenvalerate Endosulfan	46.6 16.6 16.5 5.8
	Aphids	13.1	30,000	Azinphos-methyl Imidacloprid Endosulfan	14.9 12.8 6.0
Northeast[4]	Oriental Fruit Moth	22.9	84,700	Endosulfan	1.2
	Plant Bug	20.4	29,900	Endosulfan	3.1
	Borer	35.6	25,700	Azinphos-methyl Chlorpyrifos Phosmet Endosulfan	32.2 15.3 15.1 6.2
	Aphids	24.5	13,900	Imidacloprid Azinphos-methyl Endosulfan Pyridaben	26.6 16.6 7.9 7.4

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

4 Illinois, Michigan, New Jersey, and Pennsylvania.

BEAD tentatively concludes that endosulfan is currently providing only low benefits in the production of peaches. Overall use is relatively low and endosulfan appears to play a secondary role, at most, in the control of target pests. Given the uncertainties surrounding the availability and feasibility of organophosphates, however, this conclusion is subject to additional uncertainty. In order to quantify the extent of benefits, BEAD would appreciate information on the relative efficacy of endosulfan and the alternatives and the potential for pests such as aphids and plant bugs to damage peach production.

Pear

Pears are primarily grown on the West Coast although there is scattered production across the northern United States and even parts of the south. As shown in Table 19, endosulfan is rarely used in California, but usage is high in Oregon and Washington. EPA does not have information about use of endosulfan in pear production in other states.

Table 19. Average annual endosulfan use, Pear.

Key states/Regions	Bearing Acres	% Crop Treated	lb Applied
US	62,800	35.7	45,400
California	16,800	0.3	100
Northwest [1]	41,800	43.3	42,600

Source: USDA NASS (2002-2006), USDA NASS (2000-2006b).

1 Oregon and Washington.

While widely used, endosulfan appears to play a minor role in the control of some common pests of pear (Table 20). A major proportion of the area treated by endosulfan is treated for pear psylla, a major pest, but there appear to be preferred options available to growers. Endosulfan accounts for only four percent of the area treated for pear psylla.

Table 20. Endosulfan target pests and potential alternatives, Pear

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Northwest [3]	Pear Psylla	77.6	380,800	Endosulfan	4.0
	Mite	31.0	216,300	Endosulfan	2.8
	San Jose Scale	18.0	72,900	Endosulfan	4.8

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

3 Oregon and Washington.

Based on this information, BEAD tentatively concludes that endosulfan generates relatively low benefits in pear production. Alternatives appear to be preferred for the control of major pests, such as the pear psylla. The primary benefit of endosulfan may be lower cost.

Pepper

California and Florida produce nearly 80% of the bell peppers in the United States (USDA NASS, 2003-2007b). Endosulfan use in these states is relatively low (Table 21). Data are sparse for other states. USDA surveyed producers in Ohio in 2002 and found over half the acreage treated with endosulfan. In North Carolina, data suggest that around 8% of the pepper acreage is treated with endosulfan.

Table 21. Average annual endosulfan use, Pepper

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied
US	55,600	8.9	3,700
California	29,900	5.0	1,800
Florida	17,800	3.0	400

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007), Cal DPR (2001-2005).

Endosulfan is a broad-spectrum insecticide, but it does not appear to play a critical role in the control of major pests in pepper, such as aphids, flea beetle or loopers (Table 22). It is relatively more important in the control of the broad mite, but that appears to be a relatively minor pest, except in Texas.

Table 22. Endosulfan target pests and potential alternatives, Pepper

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
US	Aphid	39.5	209,400	Endosulfan	1.0
	Flea Beetle	15.2	63,600	Endosulfan	1.5
	Looper	13.3	56,700	Endosulfan	1.5
	Broad Mite	48.8	12,900	Dicofol Abamectin Endosulfan	43.0 24.9 23.7

Source: EPA proprietary data, 2002-2006, summarized for publication.

1. Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.
2. Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.
3. Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

Because there appear to be other pesticides preferred over endosulfan for control of major pests such as aphids, flea beetle, and loopers, BEAD tentatively concludes that pepper producers obtain relatively low benefits from the use of endosulfan.

Potato

Endosulfan use on potatoes appears to be declining. Table 23 presents an average of usage from 1999 to 2005, where potatoes were surveyed biennially. Nationally, endosulfan has shown a fairly steady decline across this period from 16% crop treated to 2% crop treated in 2005. The two principle production regions, the Pacific Northwest and the Northern Plains, both show similar declines with area treated in the Pacific Northwest at 1.4% in 2005 and 2.2% in the Northern Plains. However, the decline may be overstated as a result of several states reporting use, but not quantifying the extent of use, in recent surveys.

Table 23. Average annual endosulfan use, Fall Potato

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied [1]
US	1,028,700	7.8	84,500
Pacific Northwest [2]	545,700	7.3	11,400
Northern Plains [3]	286,000	17.3	75,300

Source: USDA NASS (2003-2007a), USDA NASS (2000-2006a).

1 Different states were surveyed in different years so that the average of US total lb applied differs from the sum of the state averages.

2 Idaho, Oregon, and Washington.

3 States reporting on chemical usage from this region are Colorado, Minnesota, North Dakota, and Wisconsin.

According to EPA proprietary data (Table 24), endosulfan applications primarily target the Colorado potato beetle, a major pest in potato cultivation. In the overall control of the potato beetle, however, endosulfan plays a very minor role, accounting for less than three percent of the total acreage treated for the pest. Similarly, endosulfan plays a minor role in aphid and leafhopper control, two other pests frequently targeted with endosulfan.

Table 24. Endosulfan target pests and potential alternatives, Fall Potato

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
US	Colorado Potato Beetle	81.6	1,194,300	Endosulfan	2.6
	Aphid	27.0	883,900	Endosulfan	1.2
	Potato Leafhopper	10.6	372,900	Endosulfan	1.1

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

Given the low percentage of area treated with endosulfan for its primary target pests, BEAD tentatively concludes that the benefits of endosulfan are low in potato production.

Pumpkin

Illinois and California are the leading producers of pumpkins and, as shown in Table 25, do not seem to rely on endosulfan. However, other producing states of Michigan, New York, Ohio, and Pennsylvania, which together account for over 60% of pumpkin acreage and over 40% of total production, appear to use endosulfan relatively heavily. Moreover, usage may have increased since 2002, to nearly 30% of acreage in 2006 (USDA NASS, 2001-2007). EPA proprietary data suggest that surrounding states, including Indiana, Maryland, New Jersey, and Virginia, have similarly high usage.

Table 25. Average annual endosulfan use, Pumpkin

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied [1]
US	42,600	12.2	5,700
Illinois	11,100	reported, not quantified	
California	5,200	1.6	100
Other [2]	26,300	23.3	8,100

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007), Cal DPR (2001-2005).

1 Different states were surveyed in different years so that the average of US total lb applied differs from the sum of the state averages.

2 Michigan, New York, Ohio, and Pennsylvania.

Pest and chemical control information, based on EPA proprietary data, are shown in Table 26. The relative importance of pests and alternative chemical controls appears similar across the eastern states. Cucumber beetles appear to be a major pest and are the most common target of an application of endosulfan. Alternatives include permethrin and carbaryl, which are relatively less expensive than endosulfan, and bifenthrin, which is relatively more costly. Aphids and squash bugs are other important targets. In general, bifenthrin and permethrin seem to be the principle alternatives. Carbamates and organophosphates play a minor role.

Table 26. Endosulfan target pests and potential alternatives, Pumpkins.

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
United States	Cucumber Beetle	84.4	148,700	Permethrin Carbaryl Endosulfan Bifenthrin	20.2 18.9 14.2 7.9
	Squash Bug	18.6	38,200	Bifenthrin Permethrin Endosulfan	39.4 22.7 12.2
	Aphids	33.2	36,000	Bifenthrin Endosulfan Permethrin	25.8 23.1 10.1
	Squash Vine Borer	19.3	14,100	Endosulfan Bifenthrin	34.3 23.7
	Plant Bug	6.8	3,100	Endosulfan Permethrin	55.5 20.3

Source: EPA proprietary data, 2002-2006, summarized for publication.

[1] Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

[2] Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

[3] Proportion of total area treated for pests (Column 4) treated with specified chemical. Where endosulfan use is low, alternatives are not reported.

Based on the usage information shown here, BEAD tentatively concludes that there are moderate to high benefits to the use of endosulfan in pumpkin production. As a broad-spectrum, cost-effective insecticide, endosulfan plays a relatively important role in control of multiple pests, including the cucumber beetle. Efficacy data and information on potential pest damage will be needed to quantify the benefits of endosulfan.

Squash

Squash production is fairly widely distributed throughout the United States, with California, Florida, Georgia, and Michigan as the top producing states (USDA NASS, 2001, 2007). By usage, endosulfan appears to be fairly important in most regions, with the exception of California (Table 27).

Table 27. Average annual endosulfan use, Squash.

States/Regions	Acres Harvested	% Crop Treated	lb Applied
US [1]	23,700	27.8	31,400
California	7,700	3.7	200
Florida	9,700	33.1	10,600
Southeast [2]	13,000	60.2	21,700
North [3]	19,200	12.4	3,700

Source: USDA NASS (2002-2006b), USDA NASS (2001-2007), Cal DPR (2001-2005).

1 Different states were surveyed in different years so US averages differ from the sum of the state/regional averages.

2 Georgia, South Carolina, and Tennessee.

3 Michigan, New Jersey, New York, North Carolina and Ohio.

An examination of data on target pests and chemical controls used by growers suggests that pests are similar in Florida and the states of the southeast, although whitefly may be somewhat more important in Florida. Endosulfan is one of the top chemical controls indicated by growers for a number of pests including aphids, worms, and cucumber beetles (Table 28). Esfenvalerate appears to be another common control option, except for whitefly and mites. In the north, the cucumber beetle appears to be the primary pest targeted by endosulfan and, given the extent of acres treated, is likely an important pest in squash. Endosulfan is one of the top control measures in this region as well. Synthetic pyrethroids, like esfenvalerate and permethrin, are also common control measures.

Table 28. Endosulfan target pests and potential alternatives, Squash.

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Florida and the Southeast [4]	Worm	48.5	55,200	*Bt* Endosulfan Esfenvalerate	25.0 23.6 22.6
	Aphid	70.5	53,000	Endosulfan Esfenvalerate Pymetrozine Imidacloprid	35.7 15.0 5.9 5.3
	Cucumber Beetle	39.7	31,500	Endosulfan Esfenvalerate Lambda-cyhalothrin	33.8 24.0 9.3
	Whitefly	28.1	25,800	Endosulfan Bifenthrin Imidacloprid	29.3 21.9 11.1
	Mites	8.9	6,200	Endosulfan Abamectin	62.6 25.3
North [5]	Cucumber Beetle	82.1	54,200	Esfenvalerate Endosulfan Permethrin Imidacloprid	25.3 21.7 17.5 3.3
	Aphid	41.5	16,800	Endosulfan Esfenvalerate Permethrin	35.4 24.8 16.4
	Plant Bug	30.7	11,600	Permethrin Endosulfan	44.1 38.0
	Squash Bug	17.9	5,900	Endosulfan Permethrin	43.5 30.4
	Spider Mite	15.6	2,500	Endsosulfan Bifenthrin	88.6 7.4

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical.

4 Georgia, South Carolina, and Tennessee.

5 Michigan, New Jersey, New York, North Carolina and Ohio.

Based on this usage data, BEAD concludes that the benefits to endosulfan in squash production may be high. Endosulfan is one of the top chemicals used for control of a wide range of insect pests in most areas of production. Synthetic pyrethroids, like esfenvalerate and permethrin, are also used for some, but not all, of the same pests. A cursory review indicates that these products may be less expensive than endosulfan, which suggests that endosulfan has some advantage over synthetic pyrethroids. Other alternatives, such as imidacloprid and abamectin, only appear to target a subset of those targeted by endosulfan and they may be substantially more expensive.

Strawberry

California produces over 85% of total U.S. strawberry production (USDA NASS, 2002-2006b). Florida produces about 8% of total production but accounts for nearly 100% of winter production. Neither state appears to rely on endosulfan for pest control (Table 29). High usage is reported in Oregon and Washington and in the Northeastern states of Michigan, New York, Pennsylvania, and Wisconsin, but data have not been collected or quantified in every year (USDA NASS, 2001-2007).

Table 29. Average annual endosulfan use, Strawberry

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied
US	50,600	5.3	3,900
California [1]	56,700	< 0.1	< 100
Florida	7,100	reported, not quantified	
Oregon, Washington	5,000	40.4	3,500
Northeast [2]	5,400	42.9	3,800

Source: USDA NASS (2002-2006b), USDA NASS (2001-2007), Cal DPR (2001-2005).

[1] California Pesticide Use Reports (Cal DPR, 2001-2005) indicate significantly higher acreage than do USDA statistics (2002-2006b). Acres in table are based on California data.

EPA proprietary data suggest that use of endosulfan on strawberry targets plant bugs, spittle bugs, and the strawberry bud weevil, pests that are found mainly in the Northeast and, in the case of the spittle bug, in the Northwest. These insects do not appear to be a problem in the major producing states of California and Florida. Control of aphids and mites is more likely to rely on endosulfan in the Northeast and Northwest as well, although these may be secondary pests controlled with applications for the bugs and weevil. BEAD also notes that carbaryl, which is an alternative for control of spittle bugs, will no longer be available for use on strawberry.

Table 30. Endosulfan target pests and potential alternatives, Strawberry.

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Northeast [4]	Aphid	29.6	2,500	Azinphos-methyl Endosulfan Lambda-cyhalothrin	32.7 27.9 11.2
	Plant Bug	37.1	1,800	Endosulfan Fenpropathrin	49.1 30.5
	Mites	16.8	1,700	Endosulfan Bifenthrin	22.9 13.8
	Spittle Bug	26.1	1,300	Endosulfan Malathion Carbaryl Bifenthrin	48.0 19.5 12.7 9.4
	Strawberry Bud Weevil	16.3	1,000	Chlorpyrifos Endosulfan	55.8 36.7
Oregon, Washington	Aphid	43.3	2,300	Diazinon Oxydemeton-methyl Endosulfan	35.1 19.5 19.1
	Mites	29.7	1,500	Diazinon Endosulfan Oxydemeton-methyl	46.5 19.8 12.1
	Spittle Bug	69.9	900	Endosulfan Diazinon Chlorpyrifos	82.5 7.3 6.4

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical.

4 Michigan, New York, Ohio, Pennsylvania, and Wisconsin.

BEAD tentatively concludes that endosulfan provides moderate to high benefits to producers of strawberries in the Northeast and Northwest. However, because the major producing states of California and Florida do not appear to face the pest problems that endosulfan targets, the benefits to national strawberry production are low.

Tobacco

Endosulfan is used primarily by producers of burley tobacco, which is grown west of the Appalachian Mountains in the Ohio River Valley area. Producers in states along the Eastern Seaboard primarily cultivate flue-cured tobacco varieties and buyers discourage the use of endosulfan as it may leave residues (Mosz and Wyatt, 2002). Maryland may or may not be an exception. Data suggest a relatively high percent of the Maryland tobacco crop is treated with endosulfan, but that may represent growers of burley tobacco in the western part of the state. USDA NASS has not surveyed tobacco production recently for chemical usage. The percentage of the tobacco crop treated and the amount of endosulfan supplied are based on EPA proprietary data.

Table 31. Average annual endosulfan use, Tobacco

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied [1]
US	376,500	7.9	27,300
Eastern Seaboard [1]	227,000	1.8	4,700
Ohio River Valley [2]	141,500	15.8	22,500

Source: USDA NASS (2003-2007a), EPA proprietary data (2003-2006) summarized for publication.

1 Georgia, Maryland, North Carolina, South Carolina, and Virginia.

2 Indiana, Kentucky, Ohio, Pennsylvania, and Tennessee.

According to EPA proprietary data, shown in Table 32, applications of endosulfan primarily target aphids, bud worms, and hornworms. Endosulfan is also used for control of flea beetle and cutworm. Acephate is the most common insecticide used on tobacco and controls the same pests as endosulfan. Imidacloprid is commonly used against aphids as well as flea beetle and cutworm. Endosulfan is a distant second in control of bud worm and hornworm, followed by lambda-cyhalothrin and *Bacillus thuringiensis*.

Table 32. Endosulfan target pests and potential alternatives, Tobacco.

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Ohio River Valley [4]	Aphids	62.1	137,600	Acephate Imidacloprid Endosulfan	57.8 25.6 13.2
	Hornworm	47.4	131,300	Acephate Endosulfan *Bt*	75.8 10.5 4.7
	Bud worm	35.5	78,700	Acephate Endosulfan Lambda-cyhalothrin	74.4 13.2 4.2

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical.

4 Indiana, Kentucky, Ohio, Pennsylvania, and Tennessee.

Endosulfan would appear to provide moderate benefits to growers of burley tobacco. While acephate dominates insect control measures in tobacco, endosulfan may play an important role in rotating chemicals to avoid insect resistance and it is substantially less expensive than imidacloprid. This is consistent with BEAD's 2002 assessment (Mosz and Wyatt, 2002). However, BEAD has not reviewed any efficacy studies to determine if endosulfan could provide some benefits through improved yields.

Tomato

While most tomatoes are produced in California, endosulfan is used mainly in tomato production in eastern states (Table 33). Florida is the dominant user of endosulfan, but large percent crop treated is reported in Michigan, Ohio, and Tennessee as well. Its use is relatively low in California, where it is used more on processed tomato than on fresh tomato.

Table 33. Average annual endosulfan use, Tomato

Key states/Regions	Acres Harvested	% Crop Treated	lb Applied [1]
US, total	423,400	3.7	106,500
California	317,800	5.7	20,300
US, fresh tomato	125,800	29.9	96,200
California	39,400	2.0	1,200
Florida	41,700	56.1	73,900
Southeast [2]	16,700	35.7	21,200
Northeast [3]	15,900	19.7	4,700
US, processed [4]	297,600		
California	278,400	6.2	19,100

Source: USDA NASS (2003-2007b), USDA NASS (2001-2007), Cal DPR (2001-2005).

1 USDA NASS do not survey the same states every period. Therefore, the US average may not equal the sum of the state and regional averages.

2 Alabama, Georgia, North Carolina, South Carolina, and Tennessee.

3 New Jersey, New York, Ohio, and Pennsylvania. USDA NASS statistics on acreage and production (USDA NASS, 2003-2007b) only report data for processed tomato in Michigan, but statistics on chemical usage (USDA NASS, 2001) report endosulfan use on about 64% of 2,500 acres in fresh tomato production.

4 California Pesticide Use Reports (Cal DPR, 2001-2005) indicate greater endosulfan use in processed tomato than do USDA NASS statistics, which rarely survey states other than California for chemical use in processed tomato. USDA NASS report about 10,000 lb of endosulfan on California processed tomato.

According to EPA proprietary data, the primary pests targeted by an application of endosulfan are aphids and, in Florida, whitefly (Table 34). In Florida and California, stink bugs are also important target pests, while in the Northeast, the cucumber beetle and hornworm are targeted. EPA data do not identify use of endosulfan in the Southeast. In Florida, endosulfan plays an important role in control of all the targeted pests, particularly stink bugs, although stink bugs are a relatively less important pest. In California, its role is relatively less important than in Florida, even for stink bugs. In the Northeast, endosulfan plays a major role in control of aphids and cucumber beetles, but relatively less for control of hornworm.

Table 34. Endosulfan target pests and potential alternatives, Tomato.

States/Regions	Primary Target Pests	% Endosulfan-Treated Area [1]	Total Area Treated for Pest [2]	Stated Chemical Controls	% Area Treated for Pest [3]
Florida	Whitefly	85.3	224,200	Imidacloprid Endosulfan Esfenvalerate	22.4 18.5 9.9
	Aphid	50.4	167,400	Imidacloprid *Bt* Endosulfan	36.2 19.6 14.7
	Stink Bug	30.1	16,700	Endosulfan Cyfluthrin	87.8 12.2
California	Aphid	72.0	216,900	Dimethoate Imidacloprid Endosulfan	39.7 12.8 5.0
	Stink Bug	53.1	57,000	Methamidophos Esfenvalerate Endosulfan	31.1 18.1 14.0
Northeast [4]	Hornworm	39.7	14,200	Lambda-cyhalothrin Esfenvalerate Endosulfan	52.0 16.1 10.1
	Aphid	84.5	9,900	Endosulfan Zeta-cypermethrin	30.5 23.8
	Cucumber Beetle	34.3	5,200	Cyfluthrin Endosulfan Esfenvalerate	24.3 23.8 22.7

Source: EPA proprietary data, 2002-2006, summarized for publication.

1 Proportion of area treated with endosulfan that targets specified pest. Column will not sum to one hundred because multiple pests may be targeted with single application.

2 Annual average area treated with all active ingredients (a.i.), including endosulfan, for specified pest. Acres may be treated multiple times for the same pest and acres treated with multiple a.i. will be counted once for each a.i.

3 Proportion of total area treated for pests (Column 4) treated with specified chemical.

4 Michigan and Ohio.

On the basis of usage information, BEAD tentatively concludes that moderate to high benefits accrue to producers of tomato from the use of endosulfan. Benefits appear lower in California. Endosulfan is important in the control of whitefly in Florida and in the control of aphids and cucumber beetles in the Northeast. It is a less expensive alternative in the control of whitefly and may be valuable for resistance management. BEAD would need to evaluate comparative efficacy data to quantify the benefits of endosulfan in tomato production.

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