UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND
TOXIC SUBSTANCES

Memorandum

DATE:

SUBJECT: Biological and Economic Analysis of Endosulfan on Cabbage: Impacts from Changes in the Re-Entry Interval

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SUMMARY

Endosulfan has been identified as posing health risks for workers engaged in post-application activities such as thinning and hand harvesting. The target re-entry interval (REI) following an application of endosulfan as an emulsifiable concentrate (EC) would be extended from the current one (1) day to nine (9) days and be extended to fourteen (14) days for the wettable powder (WP) formulation. For less intensive activities like irrigating or scouting, the REI would be extended to seven (7) days for EC and twelve (12) days for WP. This assumes an application rate 2 lbs active ingredient (a.i.) per acre, the maximum allowed under the

current label.

BEAD's analysis leads us to believe that there will be little or no impacts to the proposed extension in the REI. Endosulfan is widely used on cabbage, but few activities are carried out by hand under current production practices. A potential conflict exists in New York and surrounding states when late-season applications against lepidopterous larvae may be required at the same time as hand weeding. If growers are unable to schedule this activity around an application of endosulfan, they have a number of alternatives that would increase production costs by $1.00 to $7.90/acre, representing 0.1 to 0.5% of net revenues.

Based on BEAD's analysis of endosulfan usage data, as much as 2,100 acres in New York and another 2,000 acres in surrounding states could be affected. Losses to the industry would range from $4,100 to $32,400, less than 0.1% of the region's gross value of production. BEAD believes that impacts in other regions will be even less.

LIMITATIONS AND SCOPE OF ANALYSIS

The scope of this analysis includes an examination of potential per-acre and regional-level impacts associated with an increase in the REI following an application of endosulfan on cabbage. This mitigation scenario is in response to the high health risks to farm workers as identified by the Health Effects Division of the Office of Pesticide Programs. This analysis does not attempt to address impacts associated with mitigation efforts targeted at mixers, loaders or applicators of endosulfan, or potential mitigation for various environmental risks (i.e., risk mitigation for risks to terrestrial plants and organisms or water contamination). Nor does it consider the impacts of a reduction in the allowable application rate.

There are limitations to this assessment. The impacts estimated by this analysis only represent potential short-term impacts on the cabbage production system. State and regional impacts are calculated by simply scaling up the estimated per-acre impacts. We ignore potential changes in price that may result from production changes and we assume that grower impacts will not result in a shift from cabbage to other crops. Per-acre impacts are only broadly representative of impacts to grower income since the area infested by pest or treated with endosulfan may be less than a grower's entire acreage.

Assumptions about production impacts associated with the various scenarios are based on the best professional judgement of BEAD analysts when estimates were not available from other sources. The bases for these assumptions are available USDA crop profiles, state crop production guides, discussions with university extension and research entomologists knowledgeable in cabbage production, and other sources listed. Production of cabbage is a very complex system that can be affected by many parameters (e.g., weather). BEAD's ability to quantitatively capture the wide array of events that could unfold given each hypothetical scenario listed above is very limited. The economic analyses are based on crop budgets prepared by university extension specialists, which do not always include the exact combination of pesticides considered in BEAD's scenarios.

CROP PRODUCTION

Cabbage (*Brassica oleracea*, Family Brassicaceae) is a cool-season plant with a shallow and extensive root system that grows best under moderate temperatures, up to 85EF, and can withstand moderate frosts. Cabbage is adaptable to a wide range of soil types, including heavy soils with poor drainage, and a pH of 6.2 -

6.5. Cabbage requires high nutrient levels, especially nitrogen. Row spacing varies from 24 to 36 inches. In dry seasons, cabbage may require irrigating, since dry periods may result in small head size and tipburn. Cultivation is necessary for weed control and to aerate the soil. Fresh market and storage cabbage are hand-harvested, while processing cabbage is almost entirely machine harvested.

Average U.S. production of fresh cabbage has been over 1.2 million tons in recent years (USDA/NASS, 2002). Table 1 provides average acreage, production and value figures for the nation and selected states. An additional 190,000 tons of cabbage are produced for the processed market. The combined gross value of production is nearly $320 million, with over $310 million coming from the fresh market. New York is the leading producer of fresh cabbage with over 20% of production. Other mid-Atlantic states contribute an additional 12% of production. California produces 18% of total fresh production and Texas contributes just under 15%.

Table 1. Cabbage acreage, production and value, 1998-2001 averages.

Fresh	Harvested Acres	Production (1000 tons)	Yield (ton/acre)	Value ($1000)	Average Price ($/ton)
U.S.	77,370	1,233.1	15.9	310,669	251.95
New York	12,730	269.3	20.8	72,865	270.60
California	13,150	225.4	17.5	72,278	320.60
Texas	9,250	180.9	19.0	53,260	294.40
Georgia	7,700	119.7	15.4	21,983	183.60
Florida	7,950	105.1	13.2	22,612	215.20
Mid Atlantic[1]	14,120	149.0	10.7	29,562	198.40
Midwest[2]	8,620	99.4	11.7	20,223	203.40
West[3]	3,300	77.2	21.2	14,949	193.80
Processed	**Harvested Acres**	**Production (1000 tons)**	**Yield (ton/acre)**	**Value ($1000)**	**Average Price ($/ton)**
U.S.	6,920	183.3	26.5	8,466	46.19
Wisconsin	3,000	86.8	28.9	3,557	40.98
New York	2,730	59.7	21.8	3,424	57.37
Other[4]	1,180	30.7	26.0	1,473	47.92

Source: USDA, Vegetables 2001 Summary, January 2002.

1 Maryland, New Jersey, North Carolina, Pennsylvania and Virginia.

2 Illinois, Michigan, Ohio, and Wisconsin.

3 Arizona, Colorado and Hawaii.

4 Michigan, Ohio, Oregon and Washington.

Exports from the U.S. of fresh cabbage totaled about 40,000 metric tons (MT) annually in 1999 and 2000, with about 35,000 MT bound for Canada (FATUS, 2001). This represents slightly more than 3% of production. Exports were valued at about $17 million each year. At the same time, the U.S. was importing almost the same quantity, 37,000 MT, mostly from Canada but also from Mexico. Imports were valued at about $10 million each year.

ENDOSULFAN USAGE ON CABBAGE

BEAD (2000) estimated annual endosulfan usage on cabbage to be about 17,000 lbs active ingredient (a.i.) on 13,000 acres of fresh cabbage and about 1,000 lbs a.i. on 1,000 acres of processed cabbage, for the years 1990 to 1999. This represented about 14% and 16% of the acreage. The most recent reports from USDA (1999, 2001) suggest a slight decrease in usage on fresh cabbage, driven largely by a drop in total acres cultivated. Previously, fresh cabbage was grown on about 86,000 acres nationally but more recent figures indicate about 77,000 acres. States reporting chemical use to the USDA account for about 88% of fresh acreage and 83% of processed. Table 2 reports the average of the two reporting years. These data indicate less than 9,000 acres of fresh cabbage treated, or about 12.5%, and 1,000 acres of processed, or 16.3%. Extrapolating usage to non-reporting states suggests as much as 10,000 acres of fresh cabbage might be treated annually with 11,200 lbs a.i. We assume that the non-reporting states that produce processed cabbage (Michigan, Ohio, Oregon and Washington) are more similar to Wisconsin than New York. Therefore, the estimated 1,000 acres treated is a reasonable national figure.

Table 2. Reported endosulfan usage on fresh and processed cabbage, 1998 and 2000 averages.[1]

Fresh	Acres Planted	Acres Treated	Percent Crop Treated	lbs. a.i. Applied	Rate (lbs. a.i/acre)
U.S.	70,600	8,850	12.5	9,500	1.1
New York	13,000	2,780	21.4	2,200	0.8
California	13,850	200	1.5	200	1.0
Texas	9,850	2,100	21.3	1,700	0.8
Georgia	8,200	2,100	25.7	2,850	1.4
Other[2]	25,700	1,650	6.4	2,550	1.6
Processed	**Acres Planted**	**Acres Treated**	**Percent Crop Treated**	**lbs. a.i. Applied**	**Rate (lbs. a.i/acre)**
U.S.	6,150	1000	16.3	950	1.0
Wisconsin	3,200	< 20	0.4	< 10	0.4
New York	2,950	980	33.3	950	1.0

Source: USDA, Agricultural Chemical Usage, 1999 and 2001, California EPA.

[1] Only selected states are sampled for chemical usage and not all chemicals are listed in every state.

[2] Florida, Michigan, New Jersey, North Carolina and Wisconsin.

Georgia, New York and Texas are the dominant users of endosulfan on fresh cabbage with over 20% of the acres treated. Georgia also uses the chemical fairly intensively, averaging over 1.3 lbs a.i./acre/year. Rates in New York and Texas are around 0.8 lbs a.i./acre/year. California, where usage is restricted around water, treats only a small fraction of it's acreage. Data is sparse for the other states individually, but suggests that usage is higher in the mid-Atlantic region than elsewhere. USDA (2001) reports 14% of the acreage in North Carolina was treated in 2000, for example. Very few treated acres of processed cabbage are reported outside New York.

EPA data suggest that most of the endosulfan applied to cabbage is in the EC formulation, almost 92%. These data do not distinguish between fresh and processed types, but that is approximately the same percentage of fresh acres treated out of the total. It may be that most fresh cabbage is treated with the EC formulation while the WP is used on processed cabbage. There does not seem to be a difference in the price of the two formulations.

EPA data also indicate between 8 and 10% of the treated acreage is treated at planting or transplanting while multiple foliar applications may be made throughout the growing season.

Target Insect Pests and Control

The main target pests of endosulfan on cabbage are flea beetles, lepidopteran larvae, including the cabbage looper (*Trichoplusia ni*), the imported cabbageworm (*Pieris rapae*), the diamondback moth (*Plutella xylostella*), and the cabbage aphid. Flea beetles chew small holes on cabbage leaves and, when abundant, may stunt or even kill seedlings and young plants. The cabbage looper feeds on leaves and buds, and may bore into the developing head. Feeding damage and contamination with droppings may render cabbage unmarketable. Larvae of the diamond back moth, imported cabbage worm, and other lepidopteran pests feed on the cabbage leaves and the developing head.

In California, where it has limited use because of environmental restrictions (highly toxic to aquatic organisms), endosulfan may be applied as a foliar spray by ground or air, at 0.75 lb a.i./acre, twice before early cabbage head development to control aphids, the diamondback moth (applied as a rotational chemical mainly for resistance management), and occasionally flea beetles in desert areas (USDA Crop Profile for Cabbage in California). In North Carolina, endosulfan is applied to about 5% of the cabbage acreage mainly to control aphids, flea beetles, harlequin bugs, stink bugs, and thrips, but its effectiveness for control of lepidopteran larvae is considered limited. In New York, endosulfan is used to control primarily the imported cabbage worm and flea beetles.

ALTERNATIVE CONTROL METHODS

Alternatives insecticides available for control of the imported cabbageworm, diamondback moth, and cabbage looper include methomyl, carbaryl, esfenvalerate, permethrin, cypermethrin, lambda-cyhalothrin, zeta-cypermethrin, spinosad, and B.t. Alternatives for use on aphids include malathion, acephate, oxydemeton methyl, chlorpyrifos, and imidacloprid.

IMPACTS OF MITIGATION OF CHEMICAL

EPA proposes extending the restricted entry interval (REI) for endosulfan from one day to nine days for the emulsifiable concentrate (EC) and to fourteen days for the wettable powder (WP) formulation. For less intensive activities like irrigating or scouting, the REI would be extended to seven days for the EC and twelve days for the WP. In California, endosulfan use is limited due to severe environmental restrictions associated with potential water contamination and additional impacts are expected to be very small. In Texas, where endosulfan is applied once, early in the season, a nine day REI is not expected to present a problem for farmers, since there is no weeding, thinning, or any other farm worker activity during that stage of the crop cycle (J. Anciso, personal communication). In New York, although endosulfan is used on cabbage for flea beetle control early in the season and later in the season for control of lepidopterous larvae, a nine day REI is not expected to be a problem for the industry either. The only activity that could be affected is an occasional hand weeding and farmers should be able to schedule such work around the chemical or shift to one of several existing alternative insecticides, as needed (C. Petzoldt, personal communication).

Economic Impacts

Per-acre Impacts

Few impacts resulting from a longer REI for endosulfan on cabbage are expected since the usual timing of application does not correspond to the timing of worker activities. However, it is possible that the longer REI could interfere with hand weeding of fields in New York during the latter part of the season. If farmers are unable to arrange this task around applications of endosulfan, they would be forced to use another chemical for control of lepidopterous larvae. Several are available and are listed above. To assess the impact of this change, BEAD uses a partial budgeting approach. Average yield and prices (see Table 2) are used to determine gross revenues. Sample production costs for fresh cabbage were obtained from Rutgers Cooperative Extension program (2002) which are representative of New York production practices (McFaul, personal communication).

Average yields in New York are about 20.4 tons/acre and bring a price of about $252.30/ton, implying gross revenues of around $5,147/acre. Total variable costs, including harvest costs, are over $3,680/acre leaving net cash revenues of about $1,466/acre. From these cash revenues, growers must pay fixed and quasi-fixed costs such as land rental and permanent labor. Thus, this figure overstates returns to the grower's own labor and managerial skills.

Total variable costs include about $270/acre in insecticide costs. Endosulfan may be applied up to two times during the growing season. The second application, usually targeting cabbage worm and other lepidopterous larvae, is the application of concern. EPA data suggest that endosulfan is applied at approximately 0.8 lbs a.i./acre against these pests with an average cost of $8.56/acre. Of the alternatives listed above, some, such as carbaryl, are less expensive than endosulfan. We assume that these alternatives are somehow inappropriate for growers currently using endosulfan. Thus, we focus on alternatives that are more costly than endosulfan. These range in price from cypermethrin at $9.55/acre applied at about 0.1 lbs a.i./acre to spinosad at $16.43/acre for 0.06 lbs a.i./acre. This represents an increase of 11.6 to 91.9% over endosulfan and an increase of 0.4 to 2.9% in total insecticide costs. Net cash returns fall between $1.00 and $7.90/acre, or 0.1 to 0.5%. Table 3 provides a summary of these figures. Processed cabbage obtains a much lower price, but, likely, also is less costly to produce. BEAD assumes that the absolute change in cash returns would be similar to that of fresh cabbage, *i.e.*, $1.00 - $7.90/acre, which may represent a somewhat higher percentage of net revenues.

Industry Level Impacts

Industry level impacts are calculated by simply scaling up the per-acre impacts by the number of affected acres. According to EPA data, about two-thirds of the treated acres in New York are treated for lepidopterous larvae, such as were analyzed in the section above. From Table 2, we see that about 2,200 acres of fresh cabbage are treated on average every year in New York with an additional 950 acres of processed cabbage treated as well. Therefore, BEAD believes that approximately 2,100 acres could be impacted by an increase in the REI for endosulfan such that growers might switch to an alternative. As noted above, per-acre costs could range from $1.00 to $7.90/acre. Total costs to the New York cabbage industry could range between $2,100 to $16,600, representing only a tiny fraction of the combined gross value of the industry of $76.3 million. Actual costs would probably be less as some growers will be able to continue to use endosulfan.

Table 3. Gross returns, production costs and net cash returns with late-season treatment for lepidopterous larvae in New York cabbage.

	Base Scenario endosulfan	Alternative cypermethrin	% Change	Alternative spinosad	% Change
production (tons/acre)	20.4	20.4	0.0	20.4	0.0
price ($/ton)	252.30	252.30		252.30	
gross returns	5,147.00	5,147.00	0.0	5,147.00	0.0
endosulfan	8.56				
cypermethrin		9.55	11.6		
spinosad				16.43	91.9
other insecticide costs	262.00	262.00		262.00	
total insecticide costs	270.00	271.00	0.4	278.00	2.9
other operating costs	3,411.00	3,411.00		3,411.00	
total operating costs	3,681.00	3,682.00	0.0	3,689.00	0.2
net cash returns	1,466.00	1,465.00	-0.1	1,458.00	-0.5

Source: Rutgers Cooperative Extension (2002), BEAD calculations.
Totals may differ from the sum of components due to rounding. All rows denominated in $/acre unless otherwise noted.

It is likely that producers in neighboring states that have similar production and pest systems would incur similar losses. The mid-Atlantic states of Maryland, New Jersey, Pennsylvania and North Carolina together account for just over 14,000 acres of cabbage production. Assuming similar usage of endosulfan, about 3,000 acres would be treated, of which 2,000 acres would be impacted by an increase in the REI for endosulfan. Costs ranging from $2,000 to $15,800 would represent less than 0.1% of the gross value of production from these states. Again, not all growers would have to switch to alternative insecticides.

BEAD believes there would be few impacts in other regions of the country.

CONCLUSION

The proposed increase in the REI for endosulfan to nine days following an application as an emulsifiable concentrate, the preferred formulation, would have very limited impacts. Endosulfan is used early in the season, primarily for control of flea beetles, and later in the growing season against lepidopterous larvae. Few activities are carried out by hand during the early season, and hand weeding late in the season can probably be scheduled around an application. If not, growers could switch to effective alternatives at only modest increases in price. Increases in production costs could range from $1.00 to $7.90/acre, representing between 0.1 and 0.5% of net revenues for fresh cabbage production. About 2,100 acres in New York and perhaps another 2,000 acres in surrounding states could be affected although not all growers would find it necessary to switch to an alternative. Total losses for the region may range from $4,100 to $32,400 out of gross revenues of $105.9 million annually.

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