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OFFICE OF
PREVENTION, PESTICIDES
AND
TOXIC SUBSTANCES

Memorandum

SUBJECT: Biological and Economic Impact Analysis of Methyl Parathion on Sweetpotatoes

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SUMMARY

Methyl parathion is used on sweetpotatoes (*Ipomoea batatas*) under a Special Local Needs (SLN) label in Alabama, Arkansas, Louisiana, Mississippi, and Texas. The main target pest of concern in Louisiana, Mississippi and Alabama is the sweetpotato weevil. There is zero tolerance for weevil infested tubers, and these states have quarantined infested sweetpotato growing regions in so-called "red-tag" areas. Frequent insecticide applications, along with cultural practices intended to sanitize

fields and harvest, are required for the harvest from the "red tag" areas to be certified as "weevil-free". In all the states that have the SLN label, other soil-inhabiting insects are also controlled by methyl parathion, though perhaps to a lesser extent in Arkansas and Texas. These include larvae of the white-fringed beetle and cucumber beetle, which also damage tubers and reduce harvest quality. While cultural practices will probably eliminate the danger of harvest rejection due to weevil contamination, the loss of methyl parathion could result in a decrease in harvest quality from these regions, since it would create a gap in control of migrating beetles and weevils during the growing season. This will be more likely after risk mitigation and concomitant reductions in applications go into effect for endosulfan, which is also used for the same purposes as methyl parathion in sweetpotato. These impacts may be particularly acute in Alabama, Louisiana, and Mississippi, where sweetpotatoes appear to be colonized by these pests more frequently during the growing season. For these insects, only phosmet and endosulfan have a residual activity similar to that of methyl parathion. While these are not the only alternative insecticides available to growers, BEAD believes that growers will not be able to replace all of the methyl parathion applications effectively over the growing season. If methyl parathion is not available for control of these insects, economic analysis suggests that growers could lose as much as $1,106 in per acre net cash returns, and total losses in the states involved could be as high as $17.3 million. The estimated losses arise from the lower price received for the sweetpotatoes harvested due to increased pest damage without methyl parathion available for use, and from using higher cost insecticides in place of methyl parathion.

LIMITATIONS AND SCOPE OF ANALYSIS

The scope of this analysis includes an examination of potential regional-level impacts associated with lack of availability of methyl parathion in sweetpotato production. This mitigation scenario is in response to the high health risks to mixers, loaders and applicators 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 workers reentering fields treated with methyl parathion, or potential mitigation for various environmental risks (i.e., risk mitigation for risks to terrestrial plants and organisms or water contamination).

There are limitations to this assessment. The impacts estimated by this analysis only represent potential short-term – 1 to 2 years – impacts on the sweetpotato production system. Assumptions about yield and quality losses associated with the various scenarios are based on the best professional judgement of BEAD analysts when estimates were not available from other sources. The basis for these assumptions is knowledge acquired from reviewing available USDA crop profiles, state crop production guides, discussions with university extension and research entomologists knowledgeable in sweetpotato production, and other sources listed. Production of sweetpotato 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. This analysis will focus solely on operation costs, ignoring overhead and other opportunity costs, which can be difficult to measure and are beyond the scope of this exercise. Thus, net cash returns overstate actual profits to the grower.

CROP PRODUCTION AND VALUE

There are an average of 90,400 acres of sweetpotatoes harvested per year in the U.S., producing nearly 675,000 tons of sweetpotatoes valued at more than $215 million. Table 1 summarizes sweetpotato production statistics for the U.S. and the major producing states and regions. The major states of production are North Carolina, Louisiana, California and Mississippi. Together they account for more than 92% of total U.S. sweetpotato production. The major U.S. production region is the Southern Region, which produces more than 40% of total U.S. sweetpotato production.

Table 1. Sweetpotato Production Statistics by State[1]

State	Area Harvested (Acres)	Yield (tons /acre)	Production (tons)	Percent of Total U.S. Production	Price ($/ton)	Value of Production ($1,000)
U.S.	90,400	7.4	673,300	--	322	217,000
Southern Region	39,000	7.0	273,900	41%	307	84,200
AL	3,100	7.4	22,900	3%	332	7,600
LA	23,000	7.1	163,300	24%	283	46,200
MS	12,900	6.8	87,700	13%	347	30,400
CA	10,200	12.0	122,400	18%	555	67,900
NC	34,000	7.3	248,200	37%	224	55,600
TX	4,600	2.8	12,900	2%	335	4,300
Other States [2]	2,600	6.1	15,900	2%	316	5,000

1. Based on USDA/NASS Agricultural Statistics, 1998-2000.
2. Other states include: AR (164 acres harvested in 1997), GA, NJ, SC, VA.

USE AND USAGE OF METHYL PARATHION ON SWEETPOTATOES

The estimated usage of methyl parathion on sweetpotatoes is summarized in Table 2. Approximately 17% of the U.S. sweetpotato acreage is treated with methyl parathion and nearly 17,000 pounds of methyl parathion are applied. The states where methyl parathion is being used on sweetpotatoes include Alabama, Louisiana and Mississippi. Each state treats an estimated 40% of their sweetpotato acreage with methyl parathion (see Table 2). The estimated usage in Mississippi and Alabama is based on usage estimates for Louisiana due to the similarities in sweetpotato target pests and methyl parathion use patterns in the three states. The available data do not indicate that methyl parathion is used on sweetpotatoes in Arkansas or Texas.

Table 2. Methyl Parathion Usage on Sweetpotatoes.

State	Acres Harvested	Acres Treated	Percent Crop Treated	Pounds Active Ingredient Applied
U.S.	90,400	15,640 [1]	17%	16,560 [1]
Southern Region	39,000	15,640 [1]	40%	16,560 [1]
Alabama	3,100	1,240	40% [2]	1,860
Louisiana	23,000	9,200	40% [2]	6,900
Mississippi	12,900	5,200	40% [2]	7,800

Source: Personal communication with A. Hammond, 2002 (Louisiana only).
1. Total for the U.S. and Southern Region based on the sum of usage for three states. There is no information available on the usage of methyl-parathion in any other states.
2. Estimates of percent of crop treated for Mississippi and Alabama are based on estimates of usage in Louisiana. Due to the similarities in sweetpotato target pests and methyl parathion use patterns in the Mississippi, Louisiana and Alabama, usage estimates for Mississippi and Alabama are based on usage estimates for Louisiana.

INSECT PESTS TARGETED BY METHYL PARATHION, AND POTENTIAL ALTERNATIVES

In sweetpotato, methyl parathion is available only in Alabama, Arkansas, Louisiana, Mississippi, and Texas under a Special Local Needs (SLN) registration. It is used to control the sweetpotato weevil (*Colas formicarius elegantulus*), the white-fringed beetle (*Graphognathus* spp.), and the cucumber beetle (*Diabrotica* spp.). Of these, the sweetpotato weevil is arguably the most critical pest, in that the industry requires tubers to be certified free of this introduced, tropical insect if the harvest originates from potentially infested regions (A. Hammond, personal communication). To achieve this certification, Louisiana, Alabama, and Mississippi (where weevil populations have occurred most often) have designated “red-tag” areas within their growing regions where insecticide sprays must be made at 7-10 day intervals in fields where weevil adults have been detected in pheromone traps that growers are required to maintain (A. Hammond and R. Poret, personal communication). In Mississippi, a large portion of the sweetpotato acreage has been moved to the northern part of the state, which is not under quarantine (A. Hammond, personal communication). BEAD believes that the current and future threat posed by the sweetpotato weevil is highest in Louisiana, where a significant acreage (approximately 10,000 acres) still exists in the quarantined areas. In northern parts of the state, spraying for weevils is done if 4 or more weevils are found in a trap (A. Hammond, personal communication). The weevil is capable of causing great destruction to tubers, both by direct feeding and by reducing the quality of the yield, which tastes bitter even after weevils have left. Both adults and larvae can cause damage (adults can also reduce yield if they feed uncontrolled on foliage). However, larvae are considered the most injurious stage; even low numbers can reduce sweetpotato quality and marketable yield (USDA 2001a). They can also be serious pests of stored tubers, and thus must be prevented from entering the harvest.

This insect persistently occurs south of a line that roughly parallels Interstate 20 across Louisiana and Mississippi. Infestations are occasionally found as far as 20 miles north of this line. The insect is a limiting factor in commercial sweetpotato production south of I-20, so this area is under a quarantine. The insect is the most economically important arthropod pest of sweetpotatoes worldwide (USDA 2001b). Isolated populations have also been found in Texas and along the Arkansas border (NAPIS 2000). Cultural practices can often suppress or prevent weevil infestations. These practices include removal of tubers and harvest debris from fields, which removes overwintering sites the weevil can use, and preventive spraying of storage areas with phosmet (USDA 2001a, b). These practices usually rid the harvest of weevil contamination, though they do not guarantee that tubers will not be damaged during the growing season (A. Hammond, personal communication, USDA 2001b). In southern parts of Louisiana, Alabama and Mississippi, where weevil populations are highest, the presence of wild host plants in the genus *Ipomoea* (e.g., morning-glory) appear to foster more frequent infestation of sweetpotato fields during the growing season (A. Hammond, personal communication).

The other insects targeted are also potentially serious sources of damage. Whitefringed beetle grubs feed on roots and cause irregular scars and holes in tubers. Cucumber beetle grubs eat small holes in tubers and form irregular cavities under the skin (Averre et al. 1997). White-fringed beetle, cucumber beetles, and weevils all feed on foliage as adults, though it is the larvae that do the economically significant damage. However, this habit means they can be affected by foliar insecticide sprays.

Foliar insecticide sprays for these insects are made after scouting reveals the presence of adults or larvae, a practice common to all the sweetpotato production in these states. No effective biological control agents are commercially available for any of the insects targeted by methyl parathion (USDA 2001b). There is some research underway that is examining the feasibility of soil-inhabiting nematodes for use against the grubs, but these organisms are unlikely to substitute for insecticides in the near future. Adult weevils and beetles are probably preyed upon by birds and large, predatory insects, but BEAD found no evidence that these are effective control agents.

Endosulfan, phosmet, and carbaryl are all sometimes used for the same purpose as methyl parathion in sweetpotatoes. Endosulfan and phosmet are approximately equal to methyl parathion in effectiveness against the target insects mentioned here (Story et al. 2001), but frequent sprays of multiple chemicals are often required to suppress these insects across the growing season (typically May to July). Of these, methyl parathion appears to be the longest lasting foliar insecticide available (Hammond et al. 2001, Seal 2001, Story et al. 2001). Thus, endosulfan and phosmet may not be able to adequately substitute for methyl parathion, despite their comparable efficacy. Louisiana and Mississippi also acquired bifenthrin, a synthetic pyrethroid, under an emergency exemption this year. However, only two applications are allowed per season, and BEAD is unable to assess its efficacy relative to that of methyl parathion.

It should also be noted that carbaryl is often reserved for use against other insect pests (e.g., leafhoppers) that can unexpectedly become problems during the growing season (USDA 2001b). The number of methyl parathion applications per season used across Louisiana is estimated to be 4 - 8, with 8 being more typical in the "red-tag" areas (A. Hammond, R. Poret, personal communication). Since growing conditions and pest pressures are similar, BEAD assumes a similar level of methyl parathion use in Alabama and Mississippi. Since the growing season is typically 12 weeks long and foliar insecticidal sprays are usually made on a weekly basis (A. Hammond, R. Poret, personal communication), these figures suggest that methyl parathion forms the largest component of these insecticide applications.

BIOLOGICAL IMPACTS OF ELIMINATING METHYL PARATHION IN SWEETPOTATO PRODUCTION

BEAD believes there may be an increase in tuber damage in southern parts of Alabama, Louisiana, and Mississippi due to sweetpotato weevil damage, if methyl parathion is removed from the set of insecticides used to manage this insect. Reductions in quality will probably also occur in most of the other sweetpotato growing regions due to diminished control of white-fringed and cucumber beetle grubs. In general, this would result in more of the harvest being assigned sub-premium grades, which fetch much lower prices than top-graded tubers.

Populations of the white-fringed and cucumber beetles appear to be on the rise in sweetpotatoes in Louisiana, Alabama, and Mississippi. They are often major pests in these states (USDA 2001b). This may be due to an increase in nearby soybean and pasture acreage (A. Hammond, personal communication). These areas provide good habitat for fostering large numbers of these insects, which are highly mobile as adults and easily move into soybean plants to feed and lay eggs.

If methyl parathion use is unavailable, growers will be forced to turn to some combination of the available alternatives. BEAD believes that they will probably increase their use of carbaryl, endosulfan, and phosmet. Endosulfan and phosmet will be used as much as possible since they are known to be similar to methyl parathion in terms of efficacy. Phosmet can only be applied a maximum of five times per season. Endosulfan use will also be reduced from three to two applications per season due to risk mitigation included in its recent reregistration. This will create a need for additional use of another insecticide. For this, growers will probably use carbaryl (despite some evidence of lower efficacy), because they are familiar with the product and can target sporadic infestations of other insects also on its label. Furthermore, this would allow some rotation of insecticidal chemistries to offset resistance evolution in the insect pests. Since this insecticide combination is not likely to offer the same level of control as methyl parathion, BEAD concludes an increase in tuber damage is probable.

Methyl parathion use in Texas and Arkansas is either currently nonexistent or at a low level that does not warrant formal reporting (see Table 2). Texas extension service publications indicate that soil-inhabiting grubs (including white-fringed and cucumber beetles) are usually kept under adequate control with the application of chlorpyrifos to the ground at planting (Holloway et al. 2000). However, these publications do list methyl parathion also as an alternative insecticide option for beetle adults, grubs, and other foliage-feeding insects (Sparks 1997, Holloway et al. 2000).

If populations of these insects increase in the future, growers in this state may also need to rely more heavily on methyl parathion. Since Arkansas sweetpotato habitat and growing conditions are likely to be similar to that of Texas, BEAD presumes that the situation regarding these insects is likely to be similar also. Soybean is widely grown in the same areas as sweetpotato in both states, so an increase in populations of these insects remains a possibility. The other target of methyl parathion applications, the sweetpotato weevil, is rarely reported in these states. Therefore, BEAD believes it will not increase in importance as a pest in these regions if this insecticide is restricted.

ECONOMIC IMPACTS OF ELIMINATING METHYL PARATHION IN SWEETPOTATO PRODUCTION

The per acre dollar impact of the unavailability of methyl parathion on sweetpotatoes is estimated in Table 3. As described above, impacts are expected in the Southern Region of the U.S., which includes the states of Alabama, Louisiana, and Mississippi. Methyl parathion is critical for the control of sweetpotato weevil and white-fringed and cucumber beetles in this region. Table 3 lists the production, price, gross revenues, operating costs and net cash returns for sweetpotatoes in the Southern Region for two scenarios (the "base" and "alternative" scenarios), and the percentage change in each of these items between the two scenarios. The base scenario assumes that methyl parathion is still available for use on sweetpotatoes, and the alternative scenario assumes that methyl parathion is not available for use on sweetpotatoes. Under the alternative scenario, it is assumed that without methyl parathion available for use, growers would apply some combination of carbaryl, endosulfan and phosmet in an attempt to control the pests targeted with methyl parathion applications, and to avoid a complete loss of the crop. Impacts are measured in terms of the percentage change in per acre net cash returns between the base and alternative scenarios, where per acre net cash returns are equal to per acre gross revenues minus per acre total operating costs.

Losses in sweetpotato yields in the Southern Region are not expected if methyl parathion is not available for use. However, if methyl parathion is unavailable on sweetpotatoes, growers in the Southern Region could face reductions in the quality of their harvested sweetpotatoes due to increased pest damage as a result of inadequate season-long control of sweetpotato weevils and white-fringed and cucumber beetles. The quality of the sweetpotatoes harvested could drop from U.S. one to U.S. two grade, which carries with it a 50% drop in the price received. The price received would fall from \$308 per ton to \$154 per ton, and gross revenues would decline to \$1,078 per acre from \$2,156 per acre (see Table 3).

Without methyl parathion available for use on sweetpotatoes, growers in the Southern Region could also face an increase of \$28 per acre (or 140%) in pesticide control costs due to the increased cost of the alternatives to methyl parathion for the control of sweetpotato weevils and white-fringed and cucumber beetles (see Table 3). The analysis assumes that at least four applications of methyl parathion are made per season to control these pests in the Southern Region, and that four applications of a combination of carbaryl, phosmet, and endosulfan would be made to replace methyl parathion. (Since phosmet is the most expensive of the three alternatives to methyl parathion, we assume that no more than two of the applications would be made with phosmet).

The $28 per acre increase in pesticide control costs would result in a 2% increase in total per acre operating costs. This increase in per acre costs when combined with the decline in per acre gross revenues of $1,078, results in a decline in per acre net cash returns of 180%. Per acre net cash returns would decline from $615 per acre to net losses of $491 per acre (see Table 3).

This assessment is a worst case scenario. More than likely, not every sweetpotato harvested on each acre would suffer losses in grade, and not every acre harvested would incur increased insect control costs. However, in the worst case, without the use of methyl parathion, growers could face these per acre losses and cost increases.

Table 3. Per Acre Gross Returns, Production Costs and Net Returns to Sweetpotato Growers in the Southern U.S. with In-season Control of Sweetpotato Weevils and White-fringed and Cucumber beetles.

	Base Scenario: methyl-parathion	**Alternative: carbaryl/ phosmet / endosulfan**	**% Change Between Base and Alternative Scenarios**
production (tons/acre)	7	7	0%
price ($/ton)	308	154	-50%
gross revenues ($/acre)	2,156	1,078	-50%
insecticide costs ($/acre)			
methyl-parathion [1]	20		
carbaryl/phosmet/endosulfan [2]		48	140%
other insecticides	53	53	
other operating costs ($/acre)	1,468	1,468	
total operating costs ($/acre)	1,541	1,569	2%
net cash returns ($/acre)	615	-491	-180%

Source: USDA, Auburn University and Alabama A&M University, Louisiana State University, Mississippi State University.

1. The estimated cost of methyl parathion is $5 per acre. The assessment assumes an average of four applications of methyl parathion per acre per season to control sweetpotato weevil and white-fringed and cucumber beetles.

2. The estimated cost of carbaryl and endosulfan is $9 per acre, and phosmet is $15 per acre. The assessment assumes two applications of a combination of carbaryl and endosulfan and two applications of phosmet to replace the four applications of methyl parathion.

The impacts if methyl parathion is not available for sweetpotato production in Alabama, Louisiana, and Mississippi, as well as in the Southern Region, are estimated in Table 4. An estimated 40 % of the acreage grown in each state in the Southern Region is treated with methyl parathion for the control of sweetpotato weevils and white-fringed and cucumber beetles, and the impact as described above is assumed to occur on every treated acre. This results in a total impact ranging from $1.4 million in Alabama to $10.2 million in Louisiana. Losses for the Southern Region could be as high as $17.3 million, which is 20 % of the total value of sweetpotato production in the region (see Table 4) (and 8 % of the total value of sweetpotato production in the U.S.).

As mentioned above, this assessment is a worst case scenario. It is not expected that every acre previously treated with methyl parathion would suffer these losses without methyl parathion, but information was not available at the time of the assessment to indicate the likelihood of the losses per farm. These estimated losses serve as an upper bound of the impacts of the lack of availability of methyl parathion on sweetpotatoes.

Table 4. State and Total Impacts of No Longer Having Methyl Parathion Available for Use on Sweetpotato in the Southern Region.

State	Acres Impacted[1]	Cost Increase ($/acre)[2]	Gross Revenue Decrease ($/acre)[3]	Total Impact[4] ($1000)	Total value of Production ($1000)	Total Impact as a % of Total Value of Production
Alabama	1,240	28	1,078	1,371	7,600	18%
Louisiana	9,200	28	1,078	10,175	46,200	22%
Mississippi	5,200	28	1,078	5,751	30,400	19%
Southern[6] Region	15,640	28	1,078	17,297	84,200	20%

1. Acres Impacted is the number of acres treated in the state (see Table 2).

2. Cost Increase is an estimate of the increase in production costs due to increases in the cost of chemical control (see Table 3).

3. Gross Revenue Decrease is the estimated decline in per acre gross revenues due to a reduction in the quality of the sweetpotatoes harvested (see Table 3).

4. Total impact is equal to the acres impacted multiplied by the sum of the per acre cost increase and the per acre gross revenue decrease (e.g. the total impact in Alabama = (1,240 acres) x (28 +1,078)).

5. Total Impact as a % of Total Value of Production is equal to the total impact divided by the total value of production.

6. The Southern Region impact is a sum of impacts in the 3 states listed.

IMPACT SUMMARY

Methyl parathion is critical for the control of the sweetpotato weevil and white-fringed and cucumber beetles on sweetpotatoes in the Southern Region of the U.S. (Louisiana, Alabama and Mississippi). If it is unavailable for use in sweetpotatoes, growers in the Southern Region could face losses of up to $1,106 in per acre net cash returns from losses in the quality of the sweetpotatoes harvested (i.e., a reduction in the price received), and increases in the cost of pest control from using higher cost alternatives to methyl parathion in an effort to avoid complete crop loss from infestations of sweetpotato weevils and white-fringed and cucumber beetles. Losses in the Southern Region could be as high as $17.3 million.

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