Assessment of Pesticide Use in The U.S. Potato Industry

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ABSTRACT

Pesticide use in US fall crop potato production was surveyed for the years 1990 to 1994. The purpose of the study was to provide information about the relative importance of each pesticide and potential alternatives. The objectives were to: (1) inventory pesticides used on potatoes, (2) rank the target pests and (3) estimate the economic value of the major pesticides. Extension specialists working on potatoes in twelve states provided the main source of survey data. The most commonly used pesticides in four categories were: fungicide – chlorothalonil, insecticide – methamidophos, herbicide - metribuzin, and "other" -diquat. The most frequent target pests were: early blight (*Alternaria solani*), late blight (*Phytophthora infestans*), aphids (primarily *Myzus persicae*), Colorado potato beetle (*Leptinotarsa decemlineata*), lambsquarter (*Chenopodium album*), and pigweed (*Amaranthus* spp.). The pesticides that provided the most annual value to potato growers were methamidophos ($281 million), diquat ($86 million), metribuzin ($81 million), CIPC ($56 million) and esfenvalerate ($52 million).

INTRODUCTION

Pest control is vital to potato production. US potato growers use a variety of practices to protect their crop from diseases, insects and weeds. Many growers depend on chemical pesticides to provide low-cost, efficient pest control. They choose from a list of registered pesticides that have met government standards for effectiveness and safety. Growers who use pesticides according to label instructions attest to a reduced risk of pest damage and protection against yield reduction and quality loss. Consumers, in turn, are rewarded with an abundant supply of high-quality, low-priced potatoes.

In recent decades consumers have become more concerned about food safety and environmental quality. Many focus their concerns on agricultural pesticides as possible toxicants. Pesticide opponents claim that pesticide use and misuse create unacceptable risks to human health and the environment. Pesticide proponents claim that without pesticides food would be less abundant, lower quality, higher priced and perhaps less safe because of toxicants associated with pests and disease organisms.

Accurate information about pesticide use, alternatives, risks and benefits is important to consumers, producers, scientists and regulators. Consumers want to know that their food is safe. Growers want to assess the costs, benefits, risks and alternatives when they make pest control decisions. Scientists seek to develop improved pest control practices. Regulators need accurate information to support an economically-viable, safe food industry.

The overall objective of this study was to describe use and impact of pesticides in the US potato industry. Sub objectives were to:

(1) inventory pesticide use by potato growers during the 1990-94 period,

(2) rank the potato pests most frequently targeted for control by pesticides,

(3) estimate the grower value of the most frequently used pesticides.

MATERIALS AND METHODS

Assessment Team—The five authors of this article comprised an assessment team that was established in 1995. The

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team developed specific project objectives, protocols and time lines. The assessment team members represented different academic disciplines and different regions of potato production in the US.

Survey—A survey of extension specialists provided the main data for the project. The survey focused on twelve states (CO, ID, ME, MI, MN, NE, NY, ND, OR, PA, WA, WI), in which growers produce more than 80 percent of the US fall potato crop. Assessment team members implemented the survey in their respective regions.

The survey asked extension specialists to list each pesticide used by potato growers in their state. Since pesticide use varies among potato market channels, the instrument consisted of sections for fresh, processed and seed potatoes. Within each market section, the survey sought information on four pesticide categories: herbicides, insecticides, fungicides and other. The "other" category included defoliants, fumigants and growth regulators.

For each pesticide, respondents listed up to three primary target pests, the application rate, number of applications, percent of acreage treated and up to three substitute control methods if the pesticide were not available. For each substitute, specialists estimated the percent of acres treated, expected yield change and expected quality change. Respondents also indicated whether yield and quality changes represented their expert opinion or were documented in published research.

Specialists in eleven of the twelve states completed surveys, giving a response rate of 92%. A published source (Rinehold & Jenkins,1994) provided limited data for the non-responding state (OR). Following completion, the team made preliminary estimates for each objective. Based on these estimates, team members identified items for additional follow-up with respondents.

Other Data Sources—Potato production statistics were needed to calculate weighted averages in each objective. USDA National Agricultural Statistics Service (NASS) provided these data through National Potato Council Yearbooks (1992-95) and electronically through Cornell University's Mann Library (1995) on the World Wide Web. Potato prices for each state also were obtained from these documents. USDA NASS Agricultural Price Summaries (1990-94) provided prices for most of the pesticides listed in the surveys. These data were augmented by University of Idaho data (Patterson, *et al.*, 1995) and pesticide manufacturers.

Data Management—Research assistants entered survey data into spreadsheet files (Excel 5.0, Microsoft Co.) to facilitate calculations. Since pesticide use varied among potato market classes, they calculated weighted averages. Pesticide use, pest rank and economic value figures for each state were averages weighted by the percentage of acres planted in each market class.

Project personnel also calculated weighted averages for US potato production and pesticide use. Each state's contribution to the US average was based on that state's share of total potato production in all sample states.

The weighted average procedure was followed for all three objectives. The third objective, the economic value estimate, required an additional calculation. Since the surveyed states represented 82% of the fall potato crop, the US total value was estimated by dividing the sample total by 0.82. The underlying assumption was that pesticide use patterns in the 18% not surveyed were similar to the portion included in the survey.

Economic Analysis—Project personnel used partial budgeting to conduct the economic analysis. They constructed 132 partial budgets – one in each of eleven states for each of the 12 pesticides included in the economic analysis.

Partial budgets are farm management tools used to analyze the economic impact of changes in production practices (Castle, *et al.*, 1987). In this project the potato industry in each state rather than an individual farm was the basis of analysis. Each partial budget estimated the economic impact of removing a pesticide from potato growers in a state (Nedrow, 1997).

Three variables in the 132 partial budgets were costs, yields and quality. Cost changes were the difference between the pesticide material and application costs and the costs of the substitute control method. Costs of yield changes were calculated by multiplying the state average potato price times the respondent's estimated yield change (due to use of substitute practices). Quality changes were calculated in a similar manner. Respondents estimated the percent change in price or the percent change in US #1 grade potatoes. With the latter option, the assessment team estimated a price change of $0.01 per cwt. for each percentage change in US #1s, since this is a common price incentive in potato processing contracts.

RESULTS

Pesticide Inventory—The survey found that US potato growers use many pesticides. According to respondents, US growers used 67 different pesticides during the 1990-94 period. Among all the pesticides, the four that growers used most were metribuzin, chlorothalonil, diquat and methamidophos (Table 1).

TABLE 1.—*Pesticides used by US fall-crop potato growers, 1990-94.*

Common name	Trade name	Acres treated Survey (%)*	Acres treated NASS (%)*
Fungicides:			
chlorothalonil	Bravo	50	29
mancozeb	Dithane, Manzate	33	32
EBDC	Maneb	23	
metalaxyl	Ridomil	19	27
thiophanate-methyl	Tops	16	1
triphenyltin hydroxide	Du-Ter	11	9
Herbicides:			
metribuzin	Lexone, Sencor	67	60
EPTC	Eptam	30	28
pendimethalin	Prowl	19	15
metolachlor	Dual	13	11
linuron	Lorox	5	5
sethoxydim	Poast	2	3
Insecticides:			
methamidophos	Monitor	40	24
phorate	Thimet	22	28
esfenvalerate	Asana	18	20
endosulfan	Phaser, Thiodan	18	17
carbofuran	Furadan	15	15
permethrin	Ambush, Pounce	14	15
Other (defoliants, fumigants, growth regulators):			
diquat	Diquat	49	28
chlorpropham (CIPC)	Sprout Nip	40	
metam-sodium	Busan, Metam, Vapam	19	10
maleic hydrazide	MH30	6	6
sulfuric acid	Sulfuric acid	3	8

*Survey % is from extension specialists in the sample states; NASS % is the 1990-94 average from the USDA pesticide use surveys. Missing data in the NASS column were not reported in the USDA NASS survey.

For most pesticides there was little difference between usage from respondents and USDA NASS (Table 1). For chlorothalonil, methamidophos and diquat, the differences were large. One possible reason is that the NASS survey was conducted each year, while the extension specialist survey was conducted once after the five-year period. Extension respondents may have been influenced by the most recent years of the survey period. With the exception of these three materials, close agreement between project data and NASS data indicate that survey methods provided an accurate assessment of actual use.

Target Pests—Early blight (*Alternaria solani*) and late blight (*Phytophthora infestans*), two foliar diseases, are ranked the most frequent targets in the US potato industry (Table 2). Ranked next were two insects: Colorado potato beetle (*Leptinotarsa decemlineata*) and aphids (primarily *Myzus persicae*) followed by three weed pests – lambsquarter (*Chenopodium album*), pigweed (*Amaranthus* spp.) and grasses (primarily annual grasses).

TABLE 2.—*US target pest index, 1990-94.*

Rank	US	Pest type	Index *
(1)	Early blight	disease	4.6
(2)	Late blight	disease	3.9
(3)	Aphids	insect	1.8
(4)	Colorado potato beetle	insect	1.4
(5)	Lambsquarter	weed	1.0
(6)	Pigweed	weed	0.9
(7)	Grasses	weed	0.7
(8)	Potato leafhopper	insect	0.6
(9)	Fusarium rot	disease	0.5
(10)	Nightshade	weed	0.4

*Index refers to the average number of annual pesticide applications for which the pest was a target.

The target pest index, which is the average number of pesticide applications used to control a pest, clearly demonstrated that repeated applications were needed to manage early blight (4.6) and late blight (3.9). This trend was apparent across the whole industry (Table 1), but the severity of foliar blights was less in the Pacific Northwest (2.7, Table 3) than in the rest of the US (6.8, Table 4). The severity of late blight in the Pacific Northwest (PNW) was surprising in light of its minor importance in Idaho during the 1990-94 survey period. Late blight became a serious Idaho problem in 1995.

Significantly fewer pesticide applications were used to manage insect and weed pests (Table 1) with a national average of less than two applications per species. Distinct geographic differences were seen with Colorado potato beetle

TABLE 3.—*Pacific Northwest target pest index, 1990-94.*

Rank	US	Pest type	Index *
(1)	Early blight	disease	3.1
(2)	Late blight	disease	2.2
(3)	Aphids	insect	1.8
(4)	Pigweed	weed	1.2
(5)	Lambsquarter	weed	1.1
(6)	Colorado potato beetle	insect	0.7
(7)	Fusarium rot	disease	0.6
(8)	Nightshade	weed	0.6
(9)	Silver scurf	disease	0.6
(10)	Kochia	weed	0.6

*Index refers to the average number of annual pesticide applications for which the pest was a target.

TABLE 4.—*Target pest index outside the Pacific Northwest, 1990-94.*

Rank	Pest	Pest type	Index *
(1)	Early blight	disease	7.0
(2)	Late blight	disease	6.7
(3)	Colorado potato beetle	insect	2.7
(4)	Aphids	insect	1.9
(5)	Potato Leafhopper	insect	1.7
(6)	Grasses	weed	1.2
(7)	Lambsquarter	weed	0.7
(8)	Broadleaves	weed	0.7
(9)	Pigweed	weed	0.5
(10)	Flea beetle	insect	0.4

*Index refers to the average number of annual pesticide applications for which the pest was a target.

(0.6 in PNW, 2.7 elsewhere) and the potato leafhopper which was a top-ten pest only outside the PNW. This pattern was not seen for aphids, which had similar target pest indices in both regions.

Pesticide Value—The assessment team selected for economic analysis the three most frequently used pesticides in each category. The partial budget analysis revealed that all twelve pesticides provided value to potato growers, ranging from $5 million per year for phorate to $282 million per year for methamidophos (Table 5).

TABLE 5.—*Annual grower value of major-use pesticides, 1990-94.*

Pesticide	Value * ($ million)	Benefit/Cost Ratio
Herbicides:		
metribuzin	81	5.4
EPTC	32	5.1
pendimethalin	20	9.1
Insecticides:		
methamidophos	281	13.9
esfenvalerate	52	11.2
phorate	5	1.6
Fungicides**:		
chlorothalonil	38	2.6
mancozeb	10	2.1
EBDC	20	3.7
Other***:		
diquat	86	5.6
CIPC	56	4.7
metam-sodium	20	1.2

* Value is lost grower profits if the pesticide had not been available in the US during the 1990-94 survey period.
** Mancozeb is considered an EBDC, but was listed separately by survey respondents
*** Other includes defoliants, fumigants, and growth regulators.

With metribuzin applied to 67% of fall potato acreage, EPTC to 30% and pendimethalin to19%, economic benefits of the three herbicides reflect their use frequency. Metribuzin has the highest benefit as well as the highest use. This direct relationship between use and value exists in all four pesticide categories. Chlorothalonil, the most widely used fungicide (50% of acreage) has an economic benefit of $38 million. Methamidophos, the most commonly used insecticide (40% of acreage) provides $281 million in benefits. Diquat, used on 49% of the acreage, provided $86 million in benefits.

DISCUSSION

Pesticide Applications—Results show that during the 1990-94 period, PNW growers made fewer pesticide applications than growers in the rest of the US. This difference resulted primarily from fewer fungicide applications resulting from the lower target pest index for foliar blights in the PNW. Since late blight is now a serious problem in Idaho, it may no longer be true that PNW growers make fewer applications of pesticides in general and fungicides in particular.

Growers outside the PNW used more pesticide applications to control Colorado potato beetle and potato leafhoppers. Similar herbicide applications were used in both regions, but growers in the PNW required more applications to control broadleaf weeds.

The lists of top ten target pests suggest that diseases are more varied in the PNW. Major target pests in the PNW include four diseases – early blight, late blight, fusarium dry rot and silver scurf – while the Non-PNW list only includes two diseases. Target insects appear to be more varied outside the PNW region where Colorado potato beetle, aphids, potato leafhopper and flea beetle were top-ten targets.

Pesticide Value—Availability of substitute pest control methods influenced pesticide benefits. Pesticides for which there are few or poor substitutes had a higher value. For example, methamidophos annual benefits were $281 million, but phorate benefits were $5 million (Table 5). This benefits difference was much greater than the use difference of 40% and 22% (Table 1).

A large portion of methamidophos benefits, $203 million, came from Washington where the respondent listed disulfoton as the methamidophos substitute. Even though disulfoton costs were lower, it provides less effective aphid control in Washington. The respondent estimated yields would decrease 20%, grower fresh-market prices would drop 30%, and processed prices would decline 50% if growers could no longer use methamidophos. The anticipated quality reduction was due to net necrosis, associated with potato leafroll virus (PLRV) which is transmitted by green peach aphids (*Myzus persicae*).

Although phorate was a widely used insecticide, its value was much lower than that of methamidophos because effective substitutes are available. Phorate was used in seven of the eleven states in the sample. Respondents listed carbofuran, dimethoate, disulfoton, endosulfan, esfenvalerate, ethoprop, and methamidophos, as substitutes. None of the respondents said that yields would be affected if phorate were no longer available. Only two respondents said that the absence of phorate would reduce potato quality.

The benefit/cost ratio for each major pesticide also varied widely from metam-sodium's 1.2 to Methamidophos with 13.9 (Table 5). The benefit/cost ratio accounts for differences in pesticide costs. For example, the high cost of a metam-sodium application (> $200 per acre) drives down the benefit/cost ratio of this effective fumigant. At the other extreme, the methamidophos cost (< $20 per acre) was much lower, but the benefits were high.

The value of fungicides likely increased after the 1990-94 survey period. Since late blight became a serious problem for them in 1995, Idaho potato growers began to apply more fungicides than they did for strictly early blight control.

Integrated Pest Management—In nearly all cases, survey respondents listed other pesticides as substitutes if a pesticide were no longer available. This is a reflection of the wide range of pesticide choices for potato growers, rather than a rejection of integrated pest management (IPM). Wise pesticide use is a vital component of IPM for potato. A recent survey found that potato growers widely use IPM strategies (USDA ERS, 1994). Another study found that 90% of Nebraska potato growers use non-chemical pest control and 100% scout insect presence and damage before applying pesticides (Hein, *et al.*, 1992). Although study results show multiple pesticide applications, they were made in the context of real need and their use was integrated with other control methods.

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