Cost of Production Impacts of Restricted Pesticide Use on Fruits and Vegetables

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ABSTRACT

This study estimated the impacts of reduced chemical use on fruit and vegetable crops. Specifically, the yield and per unit cost impacts of eliminating the use of insecticides, fungicides, and herbicides were evaluated, as well as the impacts of an approximate 50% reduction in the number of applications. Nine crops were studied, but the impacts on three crops (onions, sweet corn, and oranges) are discussed in this article. The impacts were generally substantial but highly variable among regions and crops. The fresh market crops tended to experience larger yield reductions than the processed market crops. Sweeping pesticide use reduction involving more than one pesticide category would have more adverse (synergistic) impacts on yield than strategies targeted toward a particular pesticide group.

The 1990s will likely represent a crossroad on the issue of pesticide use in agriculture. Congress amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) in 1988 to require that all pesticides and their uses registered before November 1984 be reregistered to comply with current standards by the end of 1997. It is widely believed that this re-registration requirement could limit the availability of certain pesticides, especially for minor crop uses. The result would likely lead to substantial reductions in productivity for fruit and vegetable crops. The issue is not only the potential removal of a label. As important is the concern that the costs of re-registration may be so substantial that manufacturers would find it prohibitively unprofitable to produce and market certain pesticides. The burden of proof, therefore, may be so costly that certain pesticides would not be available as crop protectants because of regulation costs rather than any science-based concerns about efficacy, residues, or health.

The pesticide issue was made more complex by the decision of the Ninth Circuit Court of Appeals when it ruled that zero tolerance of carcinogenic pesticide residues was inconsistent with the Environmental Protection Agency (EPA) negligible risk policy for pesticide approval under section 409 of the Federal Insecticide, Fungicide,

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and Rodenticide Act (FIFRA) for pesticide labeling. The Clinton administration has proposed a policy which would eliminate consideration of economic benefits in the pesticide review and approval process and establish a standard for registration of "reasonable certainty of no harm" (Browner, et al., 1993).

In the re-registration process, consideration has been given to the impact on productivity, yield, and output levels of a loss of a specific chemical for proposed uses on specified crops. Few studies, however, have been completed on the impact of eliminating a large number of pesticides, a scenario that might occur as a result of the re-registration process. Likewise, little is known about the potential impact of reducing the level of pesticide use from current practices to perhaps 50% of current practices, a change that has been suggested as a possible environmental policy goal.

Previous studies of the impacts of substantial reductions in chemical use fall into the following categories:

1. Studies of the impacts of chemical use approaching zero levels have been completed for major program crops (Knutson et al., 1990; Smith et al., 1990). These studies excluded fruits and vegetables, whereas this study addresses that deficiency.
2. Studies have been conducted of the impacts of imposing relatively high levels of taxes on fertilizer and pesticides as a means of discouraging use. The most recent of these studies (Rendleman, 1993) implies higher levels of farmer responsiveness to increased fertilizer and pesticide prices than had been indicated previously. Questions regarding the long-run impact on the competitiveness of US agriculture have not been studied.
3. Studies of the indirect environmental and economic costs associated with pesticides have been conducted. Included in such assessments are analyses of pesticide impacts on human health, domestic animals, crop pollination and honeybee losses, groundwater and surface water contamination, fish and wildlife, and microorganism losses (Pimental et al., 1991, 1992).
4. Studies of the impacts of eliminating individual chemicals have been completed in conjunction with FIFRA reregistration and related EPA/USDA/FDA regulatory requirements.
5. Studies of the impacts of eliminating individual chemicals or groups of chemicals have been completed on experimental plots throughout the US. The results of such studies need to be considered in drawing conclusions regarding the broader implications of substantial chemical use reduction under commercial conditions, but they are not necessarily the final answer because of the limited purposes for which each experiment was conducted.
6. Studies of organic or sustainable agriculture farms (Cacek and Langer, 1986; Dabbert and Madden, 1986) may have the potential for approximating actual farming conditions more closely than experimental plots. Organic farms and those employing practices identified under the sustainable agriculture umbrella, however, also must be interpreted carefully inasmuch as they are generally conducted on a case farm basis as opposed to widespread commercial applications. In addition, it is not unusual for such farms to use organic chemicals, which have likewise come under question by EPA for their potential adverse impact on health and the environment.
7. Result demonstrations conducted by the Extension Service closely

approximate controlled changes in pesticide use under actual farming conditions. Such studies may be the best source of information on current chemical use farming practices. A coordinated compilation of such demonstrations are difficult to assemble, however.

OBJECTIVES

The overall objective of this study was to estimate the impacts of reduced chemical use on fruit and vegetable crops. Specific objectives were:

1. To evaluate the yield and cost of production impacts of zero use of insecticides, fungicides, and herbicides on a set of fruits and vegetables that collectively represent no less than 80% of the value of fruit and vegetable production in the US.
2. To evaluate the yield and cost of production impacts of approximately a 50% reduction in the number of applications of insecticides, fungicides, and herbicides for the same set of fruits and vegetables.
3. To draw implications for the trade-offs involved in chemical use policy decisions related to fruits and vegetables.

While studies of zero use of pesticides have been posited as irrelevant to the policy issue of chemical use on major program crops (Ayer and Conklin, 1990), they quite clearly are not irrelevant in the case of minor use crops where:

1. The options for control of particular pests have declined, with only one or two chemicals pesticides now available.
2. The pesticide manufacturers, in effect, are limited procedurally (and economically) on the number of crops for which a chemical can be registered if any carcinogenic effects are found.
3. The existence of proposals that would enforce strict compliance to the zero tolerance criterion contained in the Delaney clause (EPA) threaten the use of pesticides on a wide array of crops.

The interest in the 50% reduction option results from the contention by Doering (1991) and others (Ayer, 1991) that the zero option is not only unrealistic but also represents maximum impact. In addition, Doering asserts that the yield response curve associated with reduced chemical use is concave, meaning that there could be substantial reductions in pesticide use with little impacts on yield.

Estimating the impacts of a zero and 50% pesticide application rate provides some insight into the shape of the yield and unit cash cost curve as chemical use is reduced from current commercial farming practices to zero chemical use. In other words, this procedure determines whether the greatest yield reductions are likely achieved in the initial move from the current number of applications to an approximate 50% reduction in the number of applications or in the second move from 50% to zero use. This information is useful in addressing the Doering hypothesis. While having one observation between zero use and commercial practice may not be definitive in determining the exact shape of the yield response curve, it should be decisive on whether the tendency is toward concavity as hypothesized by Doering.

MATERIALS AND METHODS

The current fruit and vegetable study employs a modified application of the procedures developed in the Knutson et al., (1990) study of zero chemical use in program crops. The specific crops on which yield and cost estimates were made accounted for more than 82% of the value of US fruit and vegetable production in 1992. The crops were selected in a manner that represented a cross section of the different levels of chemicals utilized under normal commercial farming conditions. The fruit and vegetable crops analyzed in the study included potatoes, oranges, tomatoes, grapes, apples, lettuce, onions, sweet corn and peaches.

Estimates were made of the yield and unit cash costs of production for the 50% reduction in number of applications and for zero chemical use under the following four chemical use reduction scenarios:

1. No herbicides including growth regulators that generally involve applications of micro quantities of compounds classified as herbicides.
2. No fungicides, natural or synthetic, including fumigants. While fumigants are primarily a means of disease control, they may also act to reduce both insect and weed populations.
3. No natural, synthetic, biological, or chemical insecticides;
4. No herbicides, insecticides, or fungicides as defined above; hereinafter referred to as no pesticides.

Leading horticultural scientists were asked to make these estimates considering the related changes in cultural practices that needed to be made in each of the major production regions. The initial responsibility of each horticultural scientist was to specify a baseline set of horticultural practices for the crop in the region being studied. These practices included the typical number and timing of pesticide applications under normal weather conditions. After specifying the baseline practices, the scientist also indicated any changes in cultural practices occurring as a result of the pesticide reduction scenarios that would minimize the adverse yield and cost impacts.

For most crops, a horticultural economist was asked to work with the horticultural scientist for the purpose of converting the changes in yields and cultural practices into unit cash costs of production for each of the eight chemical use reduction scenarios in each of the major production regions. Preference was given to a horticultural economist located at the same university as the lead horticultural scientist for each crop. The budgets utilized were identified, evaluated, and modified by the horticultural economist based upon the baseline production practices specified by the horticultural scientist. The budgets were analyzed only from the perspective of changes in variable costs. In other words, the cash costs represented in the budgets do not include fixed or overhead costs which are substantial in fruit and vegetable production. Since some of the fixed costs (e.g., requirements for management or machinery replacement) may increase under one or more of the reduced pesticide scenarios, the unit cost results must be considered conservative.

The major points included in the instructions given the scientists for making the yield and cost estimates were as follows:

1. The zero pesticide use option covers all pesticides, organic or inorganic. While a distinction was considered between organic and inorganic pesticides, it was concluded that the distinction from a safety perception and public policy perspective has become sufficiently clouded that the zero

option should be as pure as possible. For cases in which biological pesticides (such as Bt) have become common, the scientists may have provided an indication of the magnitude of impact associated with the elimination of such pesticides as a basis for comparison.

2. The 50% reduction in applications option was made with the understanding that the scientists were to eliminate those applications and those pesticides having the least impact on yields following intensive IPM methods. In all cases, however, the pesticides were to be applied at the rates indicated on the labels. In cases with only one application of a pesticide, the 50% reduction option was declared not applicable (NA) unless the horticultural scientist chose to specify an alternative strategy that was feasible.
3. Current budgets for the geographic areas studied were used as a baseline for the estimates of yields and costs. From this baseline for each budget item, notes were requested from the scientists on the factors, sources, and reasoning that formed the basis for each change from the baseline practices for each chemical use reduction option.
4. Yields were estimated in terms of marketable quality product on commercial farm applications. The scientists were urged to draw on all available research and related information to make this yield decision as objectively as possible. For example, organic farm yields could be a benchmark for making the zero option estimates to the extent that organic pesticides were also removed. What constitutes a marketable yield was left to the judgment of the horticultural scientist interacting with the economist. For example, while consumers arguably might buy wormy sweet corn, apples, peaches or tomatoes in the absence of any alternative, the scientist was instructed to consider and apply current industry standards as influenced by consumer preferences.
5. Changes in cultural practices (e.g., number of trips through the field), crop rotation, amount of labor utilized, and the cost of repairs were specified by the scientists.
6. Synergistic effects such as the impacts of more weeds on insect or fungi problems were considered.
7. If storage was a major consideration (as in potatoes, onions, or apples), the impacts of reducing and eliminating post-harvest applications of growth regulators or sprout inhibitors on marketable yield were considered.
8. Estimates were made in consultation with scientists located in each region analyzed. Sometimes the lead horticultural scientist had experience in more than one region. In other cases, separate lead scientists were retained for each region. In other words, substantial effort was made to accurately capture regional differences in the impacts of reduced chemical use.

RESULTS

The yield and cost impacts generally were substantial but highly variable among regions and crops (Tables 1, 2, 3, and 4). Due to space limitations, it is not possible to discuss the details of all nine of the fruit and vegetable crops studied. Results from three crops that are important to the Southern Region (two vegetables

Table 1. Summary of yield reductions per acre for fresh and processed fruits and vegetables, 1992.

Crop	Herbicides		Fungicides		Insecticides		Pesticides	
	Zero use	50% use	Zero use	50% use	Zero use	50% use	Zero use	50% use
Potatoes								
Idaho	30	15	15	10	25	NA	50	20
North Dakota	30	15	50	15	50	10	65	35
Maine	25	15	100	25	50	25	100	70
Oranges								
Florida	0	0	50	17	15	8	63	25
California	15	15	25	24	0	0	36	35
Tomatoes								
Florida	27	NA	70	28	100	30	100	50
California	25	10	10	4	22	9	37	17
Grapes								
California	50	25	97	44	58	36	66	68
New York	12	5	37	12	10	4	26	21
Apples								
Washington	20	15	6	3	100	14	100	30
Michigan	60	30	100	90	100	75	100	100
Lettuce								
California	13	NA	47	27	53	13	67	14
Onions								
Idaho	46	15	20	NA	12	8	60	45
California	35	25	30	10	10	NA	60	45
Texas	25	10	60	40	40	15	80	60
Sweet Corn								
Florida	8	NA	60	20	100	15	100	30
Wisconsin	50	20	NA	NA	13	7	63	30
Peaches								
California	1	0	45	30	40	25	75	45
Georgia/S.C.	20	0	100	80	100	60	100	100

NA = Not applicable (50% reduction was not possible because only one application is currently used).

Table 2. Summary of total costs per acre for fresh and processed fruits and vegetables, 1992.

Crop	Baseline	Herbicides		Fungicides		Insecticides		Pesticides	
		Zero use	50% use	Zero use	50% use	Zero use	50% use	Zero use	50% use
Potatoes									
Idaho	$744.66	$837.54	$760.78	$744.14	$723.26	$759.08	NA	$781.41	$778.58
North Dakota	$343.62	$403.76	$380.96	$358.34	$330.22	$324.70	$325.90	$365.78	$410.78
Maine	$828.53	$993.30	$867.30	NC	$845.92	$882.16	$830.06	NC	$968.90
Oranges									
Florida	$2,224.93	$2,618.25	$2,236.77	$1,495.72	$1,968.47	$1,903.46	$2,068.19	$1,587.87	$1,826.93
California	$3,874.12	$3,775.86	$3,488.08	$3,811.78	$3,882.85	$3,587.06	$3,730.50	$3,332.74	$3,348.79
Tomatoes									
Florida	$8,450.67	$7,267.36	NA	$4,648.94	$6,951.99	NC	$6,990.41	NC	$5,747.16
California	$891.16	$1,210.67	$1,037.13	$905.03	$905.22	$913.47	$911.06	$1,195.80	$1,098.92
Grapes									
California	$3,826.78	$2,304.48	$3,264.52	$1,508.82	$3,338.80	$2,598.95	$3,110.63	$901.08	$2,667.84
New York	$820.93	$877.81	$840.32	$882.83	$754.93	$822.13	$813.55	$809.30	$760.84
Apples									
Washington	$2,733.25	$3,678.35	$2,733.92	$2,803.32	$2,768.29	NC	$288.79	NC	$2,854.51
Michigan	$1,330.75	$1,521.99	$1,373.87	NC	$811.16	NC	$876.85	NC	NC
Lettuce									
California	$3,755.00	$3,725.00	NA	$2,715.00	$3,265.00	$2,385.00	$3,495.00	$2,310.00	$2,845.51
Onions									
Idaho	$2,076.76	$1,781.91	$2,075.68	$1,701.84	NA	$1,997.30	$1,995.75	$1,309.92	$1,410.61
California	$3,781.85	$3,383.76	$3,403.85	$3,123.25	$3,601.75	$3,495.85	NA	$2,518.84	$2,855.14
Texas	$3,781.85	$2,245.60	$2,386.16	$1,439.58	$1,841.48	$1,853.38	$2,231.91	$1,129.37	$1,626.62
Sweet Corn									
Florida	$1,402.66	$1,357.01	NA	$898.79	$1,230.32	NC	$1,206.62	NC	$1,073.35
Wisconsin	$270.34	$251.38	$264.59	NA	NA	$266.46	$275.63	$242.64	$261.54
Peaches									
California	$2,118.00	$2,161.00	$2,127.00	$1,832.00	$1,975.00	$1,787.00	$1,919.00	$1,568.00	$1,836.00
Georgia/S.C.	$2,078.00	$1,791.00	$2,098.00	NC	$934.00	NC	$1,213.00	NC	NC

NA = Not applicable (50% reduction was not possible because only one application is currently used).
NC = No Crop (100% yield loss).

Table 3. Summary of total costs per unit for fresh and processed fruits and vegetables, 1992.

		Herbicides		Fungicides		Insecticides		Pesticides	
Crop	Baseline	Zero use	50% use	Zero use	50% use	Zero use	50% use	Zero use	50% use
Potatoes									
Idaho	$0.0257	$0.0411	$0.0308	$0.0301	$0.0277	$0.0348	NC	$0.0530	$0.0336
North Dakota	$0.0280	$0.0348	$0.0272	$0.0432	$0.0236	$0.0391	$0.0263	$0.0631	$0.0384
Maine	$0.0377	$0.0602	$0.0464	NC	$0.0613	$0.0602	$0.0419	NC	$0.1468
Oranges									
Florida	$0.0537	$0.0632	$0.0540	$0.0723	$0.0573	$0.0314	$0.0653	$0.1031	$0.0588
California	$0.1564	$0.1794	$0.1657	$0.2043	$0.2064	$0.1448	$0.1506	$0.2088	$0.2088
Tomatoes									
Florida	$0.2414	$0.2844	NA	$0.4428	$0.2759	NC	$0.2853	NC	$0.3284
California	$0.0144	$0.0260	$0.0186	$0.0162	$0.0152	$0.0189	$0.0161	$0.0306	$0.0214
Grapes									
California	$0.2187	$0.2634	$0.2487	$3.4448	$0.3407	$0.3536	$0.2777	$8.8785	$0.4691
New York	$0.0800	$0.0972	$0.0882	$0.1366	$0.0636	$0.0890	$0.0626	$0.1924	$0.0939
Apples									
Washington	$0.0781	$0.1314	$0.0921	$0.0852	$0.0815	NC	$0.0980	NC	$0.1165
Michigan	$0.0665	$0.1902	$0.0961	NC	$0.4056	NC	$0.1754	NC	NC
Lettuce									
California	$0.1001	$0.1146	NA	$0.1368	$0.1187	$0.1363	$0.1075	$0.1748	$0.1423
Onions									
Idaho	$0.0415	$0.0660	$0.0488	$0.0425	NA	$0.1454	$0.0434	$0.0655	$0.0513
California	$0.0945	$0.1301	$0.1135	$0.1115	$0.1000	$0.0971	NA	$0.1574	$0.1298
Texas	$0.1071	$0.1331	$0.1179	$0.1800	$0.1325	$0.1373	$0.1165	$0.2510	$0.1807
Sweet Corn									
Florida	$0.1028	$0.1081	NA	$0.1646	$0.1127	NC	$0.1040	NC	$0.1124
Wisconsin	$0.0225	$0.0419	$0.0276	NA	NA	$0.0254	$0.0246	$0.0539	$0.0311
Peaches									
California	$0.0623	$0.0645	$0.0626	$0.0960	$0.0830	$0.0676	$0.0753	$0.1845	$0.0982
Georgia/S.C.	$0.1732	$0.1866	$0.1748	NC	$0.3892	NC	$0.2527	NC	NC

NA = Not applicable (50% reduction was not possible because only one application is currently used).

NC = No Crop (100% yield loss).

Table 4. Summary of percentage change in total costs per pound for fresh and processed fruits and vegetables, 1992.

	Herbicides		Fungicides		Insecticides		Pesticides	
Crop	Zero use	50% use	Zero use	50% use	Zero use	50% use	Zero use	50% use
Potatoes								
Idaho	59.89	19.95	17.33	7.92	35.60	NA	109.87	30.69
North Dakota	67.14	30.66	107.31	13.26	87.85	26.20	202.83	84.34
Maine	59.79	23.10	NC	36.08	112.86	11.27	NC	289.65
Oranges								
Florida	17.68	0.53	34.45	6.59	1.85	1.04	91.86	9.48
California	14.70	5.96	30.65	32.01	-7.41	-3.70	33.54	33.55
Tomatoes								
Florida	17.80	NA	83.38	14.26	NC	18.17	NC	36.02
California	81.14	29.31	12.84	5.81	31.41	12.35	112.99	48.57
Grapes								
California	20.44	13.74	1475.32	55.80	64.70	27.01	3045.56	114.53
New York	21.51	7.75	70.69	4.50	11.28	3.23	140.42	17.32
Apples								
Washington	68.22	17.87	9.11	4.41	NC	22.90	NC	49.20
Michigan	185.93	47.49	NC	509.55	NC	163.56	NC	NC
Lettuce								
California	14.46	NA	35.57	18.57	36.10	7.40	84.55	42.06
Onions								
Idaho	58.89	17.59	2.43	NA	9.29	4.46	57.69	23.50
California	37.65	20.01	17.98	5.82	2.71		66.51	37.27
Texas	24.24	10.01	49.34	27.35	28.17	8.81	134.31	68.74
Sweet Corn								
Florida	5.16	NA	60.19	9.64	NC	1.23	NA	9.37
Wisconsin	85.97	22.34	NA	NA	12.65	9.24	139.34	38.21
Peaches								
California	3.55	0.42	57.27	33.21	40.62	20.81	196.13	57.61
Georgia/S.C.	7.74	0.96	NC	124.74	NC	45.93	NC	NC

NA = Not applicable (50% reduction was not possible because only one application is currently used).
NC = No Crop (100% yield loss).

and one fruit crop) are discussed, however, to provide insight in to the variation that exists among crops, regions, and the relative importance of each class of pesticides studied. The discussion that follows focuses on onions, sweet corn, and oranges.

Onions

The major production areas identified for this study are the California Imperial Valley where Imperial Sweet spring onions are produced, South Texas where spring onions are produced, and the Idaho-Oregon Malheur Valley region where storage onions are produced. These three production areas account for about 60% of US production of dry onions.

Estimated per acre yield reductions associated with zero pesticide use ranged from 60% in Idaho and California to 80% in Texas. A 50% reduction in the number of applications would result in an estimated 45% reduction in yield per acre in California and Idaho and 60% in Texas (Table 1).

These results suggest that the greatest proportional reduction in yield would be associated with the first 50% reduction in pesticide applications. Using Idaho storage onions as an example, the initial 50% reduction in the number of pesticide applications would lead to a 45% reduction in the estimated yield per acre, while removing the remaining 50% of the pesticide applications would reduce the estimated yield by an additional 15%.

In Texas, the initial 50% reduction in the number of applications would result in the estimated yield per acre falling 13,500 pounds per acre from 22,500 lb to 9,000 lb. Eliminating all pesticide use would lead to an additional yield reduction of only 4,500 pounds. The initial 50% reduction in pesticide use, therefore, resulted in an estimated yield reduction three times greater than that produced by removing the remaining pesticide applications.

While all the reduced pesticide scenarios would result in lower total cash costs per acre than indicated by the baseline budget using conventional commercial farming practices, the estimated cash cost per pound of onions produced would be greater in all cases for each pesticide use reduction scenario (Table 3). The total estimated cash cost increase would go from 4.2 to 6.6 cents per pound in Idaho, 10.7 to 25.1 cents per pound in Texas, and 9.5 to 15.7 cents per pound in California. The total cash cost per pound would, therefore, increase by a projected 67% in California, 58% in Idaho, and 134% in Texas (Table 4).

Herbicides

Eliminating herbicide use scenario would appear to have the largest adverse impact on yields in Idaho and California, reducing the estimated yields by 46 and 35% respectively (Table 1). Despite a doubling of hand weeding, Idaho farmers would experience a projected decline from 50,000 lb per acre to 27,000 lb (Table 1).

The lead scientist felt that California farmers would be unable to keep up with the increased weed population despite two additional cultivations, two weed shreddings, and 5 additional hand weedings. As a result, spring onion yields would drop from an estimated 40,000 to 26,000 lb. Since hand weeding often disturbs the bulbs and disrupts or even curtails plant growth, hand weeding would be a less than perfect substitute for applying herbicides. Under the 50% herbicide reduction scenario, the estimated yield reduction would be comparatively less (15% in Idaho where pre-emergence herbicides were retained (post-emergence applications were eliminated) and hand weeding was nearly doubled. On the other hand, California would experience an estimated 25% yield reduction in spite of retaining pre-emergence herbicides and tripling the amount of hand weeding.

The zero use herbicide scenario projected that yields in Texas would drop by 25% Despite twice as much cultivation and three times more hand weeding, yields would fall from 22,500 to 16,875 lb. Under the 50% scenario, however, Texas would retain pre-emergence herbicides, increase cultivation by about 50% and increase hand weeding by 60% This would result in a projected yield reduction of only 10%.

Eliminating herbicides would increase the cash cost of growing onions in Idaho by an estimated 59% from 4.2 to 6.6 cents per pound. This compares to estimated increases of 38% in California and 24% in Texas. A 50% reduction in herbicide applications would increase the cash cost per pound by a projected 10% in Texas, 18% in Idaho, and 20% in California.

The yield reductions and unit cash cost increases probably understate the full impact of reduced herbicide use because of the reduction in the marketable size of onions caused by increased competition with weeds for moisture and nutrients. As a consequence, this reduction would also affect the quantity determined aspects of market price available to the producer.

Fungicides

The study revealed that reducing fungicide use would likely have the most adverse impact on yields in the more humid Texas climate. Eliminating fungicides would result in Texas spring onion yields declining by an estimated 60% from 22,500 to 9,000 lb per acre. Even with fungicide use cut in half, Texas yields would drop by an estimated 40% to 13,500 lb per acre.

In Idaho the estimated yield would decline by 20% from 50,000 to 40,000 lb per acre under the zero reduction scenario. With only the one application of fumigants, the 50% reduction option would not be applicable. In California, the zero fungicide application option would reduce the yield by an estimated 30% from 40,000 lb to 28,000, while the 50% reduction from two applications to one would result in a 10% yield reduction.

The higher cost associated with zero fungicide use would range from an estimated low of 2% in Idaho (less humid climate) to 49% in Texas. This represented an increase of less than 1 cent per pound in Idaho to more than 5 cents per pound in Texas. With fungicide applications cut by half, the cash cost increase would range from a projected 6% in California to 27% in Texas.

Insecticides

Texas spring onions would be the crop most adversely affected by reduced insecticide use. Estimated yields under the zero insecticide use option would fall by an estimated 40% from 22,500 to 13,500 lb. Reducing the number of insecticide applications from five to two would reduce the yield by an estimated 15% to 19,150 lb.

The estimated yield reduction in Idaho with no insecticides was approximately 12% while cutting applications from the normal two to one would reduce the estimated yield by 8% to 46,000 lb. California, with only one insecticide application, would experience a projected 10% yield reduction under the zero scenario. Since California used only one application, the 50% reduction scenario would not be applicable.

The 40% yield reduction experienced by Texas onions in the no insecticide scenario would result in an estimated 28% increase in the cash cost of production from 10.7 to 13.7 cents per pound. This compares with projected increases of only 9% in Idaho and 3% in California. In contrast, the projected cost per pound would increase by only 4% in Idaho and 9% in Texas after a 50% reduction in normal insecticide applications.

Summary

In all the pesticide reduction cases, the projected yield reductions would be substantial. Under the zero pesticide scenario, the onion yield reduction in all three regions would average an estimated 64%. That figure would drop to 48% if applications were cut by half.

These estimates indicate substantial regional differences with South Texas consistently being the most adversely affected area, except in the loss of herbicides, and Idaho being the least adversely affected, except in the loss of herbicides. The largest estimated yield reductions would result from the loss of herbicides, except in Texas where the loss of fungicides would cause the largest yield reduction.

Estimated unit cost increases would be in the range of 20 to 70% across the chemical use scenarios. Per unit costs in Texas, however, would probably more than double without pesticides.

Although this study does not analyze the impacts of reduced yields and higher costs on the prices and gross receipts to growers, a yield reduction in some scenarios also would mean a reduction in the marketable size of onions. This reduction would be due primarily to the compounding effects of weeds, diseases, and insects on the size of the onion plant leaf area. The consequence would be an increase in the price of large onions relative to small onions.

Each scenario eliminating herbicides assumes that labor can be hired at the normal rate to reduce the weed population. Constraints on labor availability could make it impossible to hire these laborers in some areas. To maintain current onion production under either the no pesticide option or the 50% reduction in applications, onion acreage would have to increase nationwide from 25 to 50%. This increase would mean reduced production of other crops.

Alternatively, imports would need to be increased to meet domestic demand. This increase would likely result in higher consumer prices and provide little assurance of the conditions under which the imported onions were grown.

Sweet Corn

The major production areas identified for this study were Florida and Wisconsin. Florida produces an estimated 30% of the sweet corn utilized in the fresh market. Wisconsin is believed to be representative of the broader Corn Belt region, where sweet corn is grown primarily for processing. While Wisconsin accounts for 23% of the processed sweet corn production, the broader Corn Belt region accounts for about 50%.

Substantial differences in both yield and cash cost impacts were indicated between Florida fresh and Wisconsin processed sweet corn. The study revealed that zero pesticide use would reduce the yield per acre by an estimated 63% in Wisconsin and 100% in Florida (Table 1). In other words, without pesticides, no sweet corn of commercially acceptable quality would be produced in Florida due to the loss of insecticides. Moreover, any scenario that eliminates insecticides in Wisconsin would reduce or possibly eliminate exports of processed products because the resulting lower quality product would not meet the quality standards required by importers.

A 50% reduction in the number of pesticide applications would result in an estimated 30% reduction in yield per acre in both Wisconsin and Florida. These results suggest that from the perspective of all pesticides in Wisconsin, the yield reductions would be shared somewhat equally between the first 50% pesticide reduction and the second 50%.

In Florida, however, the greatest reduction would take place with elimination of the second 50% of the pesticide applications. With a 50% reduction, the Florida yield would fall 30% from an estimated 13,650 lb per acre to 9,550 lb. When the remaining pesticides were removed, zero yield is estimated. This sequential comparative effect of a 50% and 100% reduction would be similar for both fungicides and insecticides, meaning that the second 50% reduction would have the greatest impact. The second 50% of applications may be viewed as necessary in order to avert the risk of losing a crop in which the pre-harvest cash investment in the crop would be more than $670 per acre.

While both the zero and 50% scenarios for Florida indicate lower total cash costs per acre than those indicated by the baseline budget using conventional commercial farming practices (Table 2), the cash cost per pound of sweet corn would be higher in all cases when a crop was produced. For example, under the 50% pesticide option, the total estimated cash cost would fall from $1,403 to $1,073 per acre. However, the total cash cost per pound would increase by 9% in Florida from 10.3 cents to 11.2 cents per pound (Table 3). Because no production would occur under the no pesticide option in Florida, this cost comparison cannot be made (NC). In such instances, the term "NC" in the figures means no crop was produced.

In Wisconsin, the estimated cash cost per acre for all pesticide use reduction scenarios would be less than the baseline option using conventional farming practices, but not substantially less. Like Florida, the cash cost per pound in Wisconsin also would be higher with a lower yield per acre. For example, the baseline cash cost would decrease from $270 per acre (2.25 cents per pound) to $243 per acre (but increase to 5.4 cents per pound) under the zero pesticide option.

Herbicides

In Florida, weeds do not represent nearly as great a threat to reduced sweet corn production as do insects and diseases. For example, the withdrawal of herbicides would reduce the yield by only an estimated 8% under the zero reduction scenario. A 50% reduction would not be possible (already at the minimum application level) and is represented by "NA" in the tables and figures. In Wisconsin, the estimated yield loss would be a much higher 50% from 12,000 lb to 6,000 lb per acre. The 50% reduction in herbicide use would be accomplished in Wisconsin by selective application on areas most vulnerable to weeds and by placing less emphasis on conservation tillage, which would increase soil erosion. This approach would be an environmental trade-off. The lead scientists for this chapter also noted that cultivation would be an imperfect alternative to herbicides due to the risk of crop failure in a wet year.

For both the 50% reduction in herbicides and the zero option, the cash cost of growing sweet corn would decrease on a per acre basis and increase on a per pound basis in both regions. For example, with no herbicides, Table 2 indicated the estimated cash cost in Wisconsin would decrease from $270 per acre (2.25 cents per pound) under baseline to $251 per acre (but increase 4.2 cents per pound). Increased cultivation combined with the lower yield would be the primary contributing factors to the higher unit cost, thus raising some concern about effectiveness. Eliminating herbicide applications would increase the estimated per unit cash cost of growing sweet corn in Florida by only 5% or less than 1 cent per pound.

Fungicides

Fungicides are not commonly used on sweet corn in Wisconsin. However, fungicides are essential in Florida for the prevention of foliar diseases and for harvesting a marketable product. Therefore, reductions in fungicide use would have an adverse impact on sweet corn yields in the more humid Florida climate where sweet corn yields would be reduced by 60% in the absence of fungicides. This would be below the threshold for harvesting the crop since industry norms indicate the crop would not be harvested if more than 35% of the ears were unmarketable. In such instances, a 100% loss would likely be declared. If the remaining 40% of the crop were harvested, however, a 60% increase (6.2 cents) would occur in the cost per pound.

In the 50% fungicide reduction scenario, the yield loss in Florida would be reduced to 20% but more scouting for the detection of disease and more sorting to remove diseased ears in packing would be required. The result would be a drop in the yield from an estimated 13,650 lb to 10,920 lb per acre. The estimated unit cash cost associated with a 50% reduction in applications of fungicides in Florida would be almost 10% higher, rising from 10.3 cents to 11.3 cents per pound.

Insecticides

For sweet corn, insecticides are essential for production in Florida. Therefore, Florida sweet corn production would be adversely affected by reduced insecticide use, and no commercial production is estimated if the zero insecticide use option were used.

This substantial loss was estimated because of the severe damage that ears would experience and the inability of producers to cull out the infested ears so that consumers could reasonably be expected to buy the resulting product. Reducing the number of insecticide applications by 50% would reduce the estimated yield by 15% from 13,650 to 11,600 lb.

The Wisconsin estimated yield with no insecticides would be reduced 13%, dropping from 12,000 lb to 10,500 lb per acre. However, this might result in the product not meeting export standards, thus limiting the market to only domestic outlets. The 50% reductions in applications would result in an estimated 7% yield decline.

The estimated 15% yield reduction experienced by Florida sweet corn producers with a 50% reduction in insecticide application would result in about 1% increase in the expected unit cash cost of production. In contrast, an estimated 13% yield reduction in Wisconsin under the zero insecticide option would increase cost by approximately 13%. The increase in cost would be only 9% if half of he normal insecticide application were used. With no production in Florida in the absence of insecticides, unit cash costs could not be calculated.

Summary

Using weighted averages, sweet corn yield per acre estimates for the production regions of Florida and Wisconsin (with application to Minnesota and Illinois) would fall by 78% without pesticides and 30% if pesticide applications were cut in half. Except for the herbicide scenario, yield reduction estimates would be much larger in Florida than in Wisconsin due to climate and soil conditions and the strict aesthetic and quality requirements of the fresh market.

Because of varied growing conditions, the impacts of different pesticide groups would be substantially different between corn produced for the fresh market and that used by the processed market. In Florida, for example, sweet corn could not likely be produced commercially without insecticides. On the other hand, Wisconsin does not use fungicides to any significant degree in producing sweet corn for the processed market.

The absence of pesticides would create an estimated crop reduction of 63% in Wisconsin, but it would result in a total crop loss in Florida, which produces about 30% of the US production for the fresh market. Although Wisconsin's losses would not be as severe, the estimated cash cost per pound would still increase by 139% under the zero option.

Marketability would be a major concern in both growing areas. Failing to meet quality standards would threaten export markets for Wisconsin growers while Florida producers would face the unwillingness of consumers to buy diseased or insect-infested ears of corn in the fresh market.

Because consumers have demonstrated they are less inclined to buy corn when the end has been clipped to eliminate worm damage, buyers currently will reject a whole truckload of sweet corn based on one or two worm-infested crates. As a result, farmers would have no alternative but to walk away from worm-infested fields.

Oranges

Oranges normally rank as the largest of the fruit crops in terms of value of sales in the US. In 1992, however, the orange industry was still recovering from a series of freezes that destroyed many trees in California, Florida, and Texas. As a result, US orange sales totaled only about $1.6 billion in 1992 and accounted for 12% of fruit and vegetable sales. The major production areas analyzed in this study were California and Florida, which account for about 98% of the value of US production.

Florida produces almost exclusively for the processed (juice) market and accounts for virtually all US orange juice production. California, on the other hand, produces oranges primarily for the fresh market, accounting for 76% of the fresh orange market. Although no California oranges are grown intentionally for juice, about 20 to 30% do not make grade and are processed for juice. The specific area in California for which these estimates are made is the San Joaquin Valley, which represents about 60% of the California production. California estimates are representative of navel orange production only.

Estimating the yield and cost impacts of reduced pesticide use in oranges presents some unique problems. One of the major impacts of pesticide use reduction in oranges for the fresh market is the reduced quality of the marketed products. Specifically, as pesticide usage is decreased, the proportion of the oranges that grade out as #2 quality and juice grade would increase even though the yield may not change by a large percentage. This may result in significantly lower producer returns. While returns to growers are not the primary focus of this analysis, these implications are mentioned in this chapter when they are particularly relevant.

A second problem involves the long-run impact of reduced pesticide use on the survival of trees in the orchard. The estimates in this report consider the five-year average impact of reduced pesticide use on orange yields and costs. The scientists emphasized that the longer-run detrimental effects on the trees are difficult to measure but nonetheless important.

Substantial differences exist between California and Florida oranges in both yield and cost impacts. Yield reductions per acre associated with zero pesticide use would be an estimated 36% in California and 63% in Florida. A 50% reduction in the number of applications would result in an estimated 25% reduction in yield per acre in Florida and a corresponding 35% yield reduction in California.

These results suggest that in Florida, the greatest yield reduction would occur with the second 50% pesticide reduction. That is, in Florida the estimated yield reduction is 10,350 pounds with a 50% reduction in pesticides. When the remaining 50% of the pesticides were removed, the estimated yield would drop an additional 15, 650 pounds per acre. In California, however, the greatest yield reduction would occur with the first 50% reduction in pesticide applications (35% reduction). In fact, removing the second 50% of the applications would result in only one additional percentage point estimated reduction in yield.

While both the zero and 50% pesticide reduction scenarios for Florida indicate lower total cash costs per acre than the baseline budget using conventional commercial farming practices (Table 2), the cash cost per pound would be substantially higher in all but the insecticide case of zero pesticide use. It would be only marginally higher, however, with a 50% reduction in pesticides. Specifically, under the zero pesticide option in Florida, the total estimated cash cost would fall from $2,225 to $1,588 per acre (Table 2). However, the total cash cost per pound would increase by 92% from 5.4 cents to 10.3 cents per pound. With a 50% reduction in applications, the cost per pound would rise by more than 9% to 5.9 cents per pound.

In California, the cash cost per acre for the zero pesticide use reduction scenarios would be lower than the baseline option using conventional farming practices. However, the cash cost per unit would rise due to declines in yield per acre. For example, even though the baseline cost would fall from $3,874 per acre to $3,333 per acre under the zero pesticide option, the estimated per unit cost would increase from more than 15 cents per pound to nearly 21 cents per pound.

Herbicides and Growth Regulators

In Florida, weeds do not represent as great a threat to orange production as fungi. Withdrawing herbicides would not reduce the yield but would require substantially increased cultivation. In California, the yield would drop an estimated 15% from 24,776 lb to 21,052 lb per acre under the zero herbicide/growth regulator option, with all the decrease resulting from elimination of growth regulators. To mitigate the impact that reduced herbicides may have on yields, current water and nitrogen rates would have to double.

A 50% reduction in herbicide use in Florida could be accomplished by reducing the size of the treatment band from the normal 12 to 14 ft to 6 to 7 ft, while increasing mechanical mowing. In both scenarios in Florida, it would be possible to accomplish weed control with no sacrifice in yield per acre. For the zero option, however, grove work would have to be increased about 25 fold from $20 per acre under the baseline to more than $490 per acre. Additionally, the altering of band widths would require the purchase of wider mowers or expanded reach mowers that would increase long-term capital expenditures.

For both the 50% reduction in herbicide applications and the zero option, the cash cost of growing oranges would increase on both a per acre and a per pound basis in Florida. With no herbicides, for example, the cost would increase from $2,225 per acre (5.4 cents per pound) under the baseline to $2,618 per acre (6.3 cents per pound, Table 3). Increased grove work would be the primary contributing factor to the higher cost. With a 50% reduction in herbicide use, the cash cost per pound would increase marginally by less than 1% (Table 4).

In California, the total cash cost would increase 15% under the zero option and 6% under the 50% herbicide/growth regulator option. Although the impacts of reduced herbicides and growth regulators are combined for this analysis, the scientists emphasized that the effects of each in orange production in California would be different. In other words, almost all of the yield reductions occurring in the herbicide scenarios stem from the reduction in the use of growth regulators rather than the decrease in herbicide use.

Fungicides

Eliminating fungicide use would result in an estimated 50% reduction (21,000 lb) in Florida orange yields. Under the 50% fungicide reduction scenario in Florida, the fall fungicide applications would be eliminated, resulting in an estimated 17% yield decline (7,000 lb).

In California, eliminating fungicides from the normal application level would cause the yield to decline by an estimated 25% from 24,776 to 18,658 lb per acre under the zero option. Scientists in California also noted, however, that foreign buyers for export markets would not be willing or able to deal with the excessive levels of rot and spoilage that would occur as a result of the time required for transportation after eliminating post-harvest fungicides. These oranges would be diverted to the domestic market, causing downward pressure on domestic prices. On average, the percent of crop grading #1 would fall from an estimated 50 to 41% under either fungicide scenario. Juice grade oranges would increase from an estimated 31 to 37 % under the fungicide reduction scenarios.

The unit cash cost associated with zero fungicide use would increase by an estimated 34% in Florida from 5.4 to 7.2 cents per pound. With fungicide applications 50% of normal, the cost increase would be nearly 7%. The estimated California cost increase would approach 31 % under the no fungicide option, rising from 15.6 cents to about 20.4 cents per pound.

Insecticides

Mites are classified as insects in this study and are the major insect problem in Florida oranges. Miticides are likewise classified as insecticides. By using a zero insecticide option and eliminating three applications of a miticide, Florida orange production would be reduced by 16% from 41,400 lb to 34,776 lb.

Reducing the number of insecticide applications by 50% through eliminating the postbloom application and limiting the fall application to every other year would reduce the estimated yield by 8% to 38,088 lb.

The California yield would not be greatly affected by eliminating insecticides, although there would be a major adverse effect on the quality of oranges marketed. For navel oranges, researchers estimated that as much as 25 to 30% of the fruit would move from grade #1 to grade #2, and 10% would move from grade #2 to juice. While this would be the only case in which the cash cost per pound would fall, the return to the grower could be expected to fall by even more due to discounting related to reduced marketable quality.

The projected 16% yield reduction that would be experienced by Florida oranges with no insecticides would result in a 2% increase per pound in the unit cash cost of production. With 50% of the normal insecticide applications, the cash cost per pound would increase less than 1%.

Summary

The largest yield reductions would result from the loss of insecticides and fungicides in Florida and from the loss of herbicides and fungicides in California. Orange yields in both Florida and California, which account for 98% of the value of US orange production, would be reduced by an estimated weighted average of 55% under the zero pesticide option and 28% if insecticides and fungicides applications were cut by half. Florida would be the most adversely affected if pesticides were eliminated. Under the zero option, Florida yields per acre would drop 63% and the total cash cost per pound to growers would rise by 92%.

For both production areas, scientists indicated that insect and disease problems could be expected to take their toll over a longer time period by eventually causing trees to become nonproductive and die. Thus, the estimates in this study are believed to be highly conservative. In addition, the adverse impacts of reduced pesticide use on product quality (especially California fresh navel production) may substantially reduce potential returns to growers, impacting the long-run stability and competitiveness of the domestic orange industry.

DISCUSSION

This study follows an earlier study that used similar methodology to evaluate the impact of pesticide use reduction on the major program crops. Although the results for fruits and vegetables are similar to the program crop study, they are more dramatic in that some fruit or vegetable crops would be completely wiped out in certain regions as a result of the absence of pesticides.

The major difference between this study and the earlier study is the inclusion of a 50% pesticide reduction option for fruits and vegetables. The results suggest that a substantial variation exists from crop-to-crop in regard to whether the largest incidence of yield reduction would occur in the first 50% decrease or in the final 50%.

The need to proceed with caution on policies involving the elimination or substantial reduction of pesticides was a major conclusion in the earlier study of major program crops. This inference is even more important in a study of fruits and vegetables because the number of pesticide options are often very limited and the potential yield reductions are large.

Further research and technological innovations will be required before significant reductions in pesticide use will be possible without substantial yield reductions and large cash cost increases. The nation's policymakers will likely want to consider all economic, environmental, nutritional and social tradeoffs as they consider pesticide policy changes that will impact every link of America's food chain for years to come.

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