ECONOMIC IMPACTS OF THE ELIMINATION OF ORGANOPHOSPHATES AND CARBAMATES ON TEXAS AGRICULTURE

AFPC Policy Working Paper 99-3

Ronald D. Knutson, Agricultural Economist, Texas A&M University
Edward G. Smith, Agricultural Economist, Texas A&M University

Agricultural and Food Policy Center
Department of Agricultural Economics
Texas Agricultural Experiment Station
Texas Agricultural Extension Service
Texas A&M University

April 1999

College Station, Texas 77843-2124
Telephone: (409) 845-5913
http://afpc1.tamu.edu/pesticides.htm

Pesticides and registered trade names included in this report are not intended to be a complete listing. The trade names are included merely as some examples of the pesticides. They are not an endorsement of any particular chemical company's product or an indication that any such product is the exclusive trade name used for any particular purpose.

ECONOMIC IMPACTS OF THE ELIMINATION OF ORGANOPHOSPHATES AND CARBAMATES ON TEXAS AGRICULTURE

During 1998, the Agricultural and Food Policy Center (AFPC) faculty at Texas A&M University conducted a study of the impacts of the elimination of organophosphates and carbamates on US agriculture. This study was financed by the American Farm Bureau Federation (AFBF), for which the Texas Farm Bureau was a major contributor.

This publication reports on the implications of this study for Texas agriculture. In the overall study, 14 commodities were studied--two of which are not an important component of commercial production in Texas agriculture. The 12 commodities receiving emphasis in this report include:

- Cotton
- Wheat
- Grain sorghum
- Corn
- Rice
- Peanuts
- Soybeans
- Oranges
- Carrots
- Peaches
- Potatoes
- Tomatoes

Implications will be drawn for the Texas livestock and poultry industries as the indirect impacts of higher feed prices on livestock and poultry are evaluated.

Assumptions

Specific yield effects due to the loss of organophosphates and carbamates on Texas agriculture were evaluated for cotton, wheat, grain sorghum, corn, rice, peanuts, and carrots. For soybeans, oranges, peaches, potatoes, and tomatoes, a judgmental assumption was made regarding the yield and cost changes in the areas that are most comparable to Texas:

- Orange estimates will use Florida (predominantly juice).

- Peach estimates will use Georgia fresh.
- Soybean estimates will use the Delta.
- Potato estimates will use Idaho.
- Tomato estimates will use Florida fresh.

In evaluating the aggregate economic effects, Texas impacts will be assumed to accrue in proportion to the importance of the State, relative to United States' agriculture.

Science-Based Results

Regulations must be "science based" whether under the Food Quality and Protection Act, the Clean Water Act, or sanitary and phytosanitary rules affecting trade under the World Trade Organization (WTO). This report is based on available science related to the use of organophosphates and carbamates and their alternatives. Supporting it are the individual reports produced by recognized applied crop scientists--utilizing the latest research results. These individual reports are summarized in a base book publication by AFPC for AFBF. These reports are available on the AFPC home page at http://afpc1.tamu.edu/pesticides.htm.

Most Commonly Used Organophosphates and Carbamates

Table 1 indicates the 10 most commonly used organophosphates and carbamates for the Texas crops studied and the pests they control. Those chemicals include methomyl, carbaryl, chlorpyrifos, methyl parathion or ethyl parathion, dimethoate, carbofuran, diazinon, aldicarb, malathion, and phorate. These 10 chemicals are predominantly used to control the pests indicated in Table 1, most of which are important to Texas agriculture.[1]

[1]The pests listed in Table 1 are identified as important to Texas from the scientists' reports for all major US production areas. The list is not intended to be an exhaustive listing of all pests but, rather, is representative of Texas pest pressure.

Commodity Impacts

The following discussion summarizes the effects of the elimination of organophosphates and carbamates for the 12 commodities produced commercially in Texas. Table 2 summarizes these impacts in terms of the percentage change in yields and costs that would result from the elimination of organophosphates and carbamates. The detailed yield and cost impacts for the commodities included in this paper are reported in the Appendix (Tables A1-A13).

Cotton

The Texas commodity most adversely affected by the elimination of organophosphates and carbamates is cotton. This is a result of the combination of the importance of cotton as the largest crop produced in Texas (in sales) and the existence of the boll weevil as cotton's primary pest. The presence of the boll weevil makes cotton chemically-dependent. The most important of these chemicals for boll weevil eradication purposes is malathion, an organophosphate.

The yield impacts of eliminating organophosphates and carbamates on cotton were estimated for the South Plains region, for which Texas is the major component. Yields in the South Plains were estimated to fall by 19 percent from the baseline while variable costs per pound of lint would increase by nearly 28 percent. Substitutes for malathion in controlling the boll weevil are both less effective and higher in cost. This is not to imply that the boll weevil is the only pest affecting cotton production. Other cotton pests include thrips, the cotton fleahopper, bollworms/tobacco budworms, aphids, nematodes, and stink bugs. For all these pests, except bollworms/tobacco budworms, organophosphates and carbamates are the primary control--with pyrethroids being the primary substitute chemical.

With few cost-effective substitutes for malathion and the potential for developing secondary pest resistance to pyrethroids, efforts to eradicate the boll weevil would be dealt a death blow by

the elimination of malathion. As a result, Southern Plains' variable costs per pound are estimated to increase by 28 percent while chemical costs would rise by 123 percent. Such cost increases hold the distinct probability of making Texas and, for that matter, the United States, noncompetitive in the world market for cotton.

Corn

From a sales perspective, corn is the second most important crop produced in Texas. While dryland corn production has increased in recent years, the majority of the production continues to be irrigated.

Estimates of the effects of eliminating organophosphates and carbamates on corn were made with Texas as a component of the Plains region. Within this region, Texas averages approximately 11 percent of the production.

The elimination of organophosphates and carbamates on the Plains was estimated to result in nearly a 3 percent reduction in corn yields. Variable costs would increase by 4 percent per bushel while chemical costs would rise by 15 percent. Except for stink bugs, several substitute chemicals exist for the major insect pests on corn. However, they are higher priced, thus reducing the US comparative advantage in world markets for corn--the largest US agricultural export commodity.

Grain Sorghum

Next to cotton, grain sorghum is the second most adversely impacted Texas commodity if organophosphates and carbamates were eliminated from use in agriculture. This adverse impact results from the close competitive relationship with corn, as a feed grain, and the greater impact of the elimination of organophosphates and carbamates on grain sorghum.

Southern Plains' yield reductions of 14 percent were estimated to occur if organophosphates and carbamates were eliminated. Only two other states, Oklahoma and Arkansas, are included in the Southern Plains--making Texas by far the largest grain sorghum producer in the region.

Variable costs per bushel in the Southern Plains would increase by nearly 13 percent. No pesticide substitutes for organophosphates and carbamates were identified for the Southern Plains' corn rootworm, spider mites, and greenbugs on grain sorghum.

Because of the increase in costs of producing grain sorghum relative to corn, with the elimination of organophosphates and carbamates, it was concluded that Texas would no longer be competitive in grain sorghum production. Grain sorghum is a drought-tolerant crop grown in areas with relatively low rainfall as a rotation crop with cotton and/or wheat. Land currently producing grain sorghum would likely be diverted to wheat or cotton--or it could revert to grassland. Eliminating this rotation option would increase pest problems and aggravate the yield effects for cotton and wheat.

Wheat

A wide range of organophosphates and carbamates is used to control 10 categories of insect pests that adversely impact the production of wheat. The yield reduction from eliminating organophosphates and carbamates is only 2 percent for the Central and Southern Plains--with an estimated 1 percent increase in variable costs per bushel.

The problem is that only two pesticides were identified as being available as substitutes for existing organophosphates and carbamates. These two pesticides are Cyhalothrin (Warrior) and Lindane. The development of pest resistance could be a serious problem in both of these instances. For the Hessian fly and midge, no effective alternative controls were identified.

Peanuts

The Texas effects of eliminating organophosphates and carbamates on peanut yields and costs were estimated as part of the Southern Plains region, which included Oklahoma. Within this region, Texas is clearly the dominant peanut-producing state with approximately 75 percent of the regional production.

Favorable growing conditions, combined with region shifts from traditional production areas to West Texas, result in the Southern Plains being the region least adversely affected by the elimination of organophosphates and carbamates. Yield reductions in the Southern Plains approach 4 percent with variable cost per cwt increases of just over 2 percent per cwt.

The number of chemicals available to control insect pests in peanuts is limited. In the absence of organophosphates and carbamates, no alternative treatments were identified for control of nematodes and rootworms. For the other insect pests, resistance could be anticipated to become a greater problem.

Rice

The Upper Gulf Coast region, composed of Texas and Southwest Louisiana, has the highest cost of producing rice in the United States. Production in this region would be seriously jeopardized by the elimination of organophosphates and carbamates.

Rice yield reductions of 15 percent were estimated for the Upper Gulf Coast if organophosphates and carbamates were eliminated. The result would be a 23 percent increase in chemical costs and a 17 percent increase in total variable cost for each cwt of rice produced.

No alternative control treatments were identified for leafminers or stink bugs. Only one or two options exist for treatment of other insect pests affecting rice. It was concluded that the Upper Gulf Coast would be seriously disadvantaged by the elimination of organophosphates and

carbamates--with resulting large acreage reductions. Alternative crops are severely limited and/or untested for this region. It is anticipated that much of the acreage would revert to grassland, although cattle do not grow well in hot and humid climates where wet soil conditions often exist.

Soybeans

Soybeans are viewed by some as being a viable alternative crop for Texas farmers with sales doubling from 1994 to 1997. Continued Texas growth is unlikely if organophosphates and carbamates were eliminated.

Texas was not included in any of the regions studied. However, its production conditions are believed to most closely approximate those of the Delta where insect pests are a particular problem. In this region, soybean yields were estimated to decline by nearly 8 percent on a per acre base. Variable costs were estimated to increase by over 15 percent per bushel, with a 41 percent increase in chemical costs.

While there are alternative treatments for the major insect pests (stink bugs and spider mites), their costs would likely make Texas soybeans prohibitively high relative to other regions.

Carrots

Texas competes in the market for both fresh and processed carrots. Its major competitors for fresh carrots include California, Colorado, Michigan, and Washington. In the case of processed carrots, the major competitor is Washington. In fresh carrots, Texas and Washington are both at a comparative disadvantage relative to the other states, although--except for California--the window of market opportunity is different. In processed carrots, Texas is at a comparative disadvantage relative to Washington.

The elimination of organophosphates and carbamates would reduce yields on fresh market carrots by 25 percent, due primarily to decreased control over soil insects. There is no effective

substitute for diazinon which is the only control available for soil insects. Fresh market carrot costs per cwt increase by 3 percent while processed costs rise by 8 percent on a cwt basis. In both cases, chemical costs rise by 20 percent per cwt. A specific concern regarding carrots for processing relates to the resulting adverse impacts on the ability to produce the quality of carrot that would meet processor standards.

Oranges

Texas orange production largely has an end use of juice. As a result, Texas yield and cost impacts were measured using Florida data. In juice oranges, external appearance is not as important as it is for grapefruit.

While a number of organophosphates and carbamates are used to produce juice oranges, they are increasingly viewed as an important second line of defense. As a result, both yield and cost impacts were estimated to be zero in the three- to five-year time horizon.

The results are quite different for oranges produced for the fresh market where packout, external appearance, and fruit quality are very important. In this case, California orange production for the fresh market was estimated to be reduced by 15 percent without organophosphates and carbamates. California variable cost increases would be 14 percent, with little change in chemical costs. These same general fresh market relationships would be expected to hold for Texas production of grapefruit for the fresh market. That is, Texas grapefruit production--which is primarily for the fresh market--would be much more adversely impacted than juice-oriented orange production.

Tomatoes

Texas tomatoes are produced primarily for the fresh market. The prevailing competition is from Mexico and Florida. Estimates of the impacts of the elimination of organophosphates and carbamates on Texas tomatoes were based on the Florida fresh tomato market. The decline in yield was estimated to be nearly 21 percent. Variable costs increased by nearly 20 percent per cwt while chemical costs rose by 25 percent.

Eliminating organophosphates and carbamates creates serious problems for the treatment of insects such as mole crickets and nematodes. While substitutes theoretically exist for such pests, the timing for treatment is critical. The alternatives are not nearly as effective in a timing context.

Reduced Texas Output, Income, and Employment

Lower output of Texas agricultural products has effects that extend throughout the economy as the income of agribusiness falls and employment related to the production, handling, export, and processing of agricultural products declines. These effects spread throughout both the Texas and US economy.

While economists have the ability to measure these direct, indirect, and induced economic effects, how these effects would be distributed throughout the US economy is more difficult to discern. The impacts of higher corn and soybean prices on livestock, poultry, and milk producers would be expected to be concentrated in the areas where these products are produced. The indirect effects on agribusiness firms would also tend to be concentrated in those areas where agribusiness activity is most prevalent–in rural communities; rural business centers such as Lubbock, Amarillo, or Abilene; and in processing, distribution, handling, and exporting in business centers such as the Metroplex, Houston, Galveston, Freeport, Corpus Christi, and Brownsville.

The distribution of the induced effects on the Texas and US economy is more difficult to ascertain.

While a regional study of output, income, and employment was not conducted in the overall analysis, it is assumed that all of the national effects are distributed in relation to Texas' share of the production of those crops studied and of livestock produced in Texas. Because of the complexity of the economy, this may be an heroic assumption and should only be interpreted as a proxy for the extended economic impacts of these types of yield reduction. However, it is the best that could be done within the constraints of time and budget.

Table 3 indicates the magnitude of these overall economic effects as estimated for the US economy. The Texas share of production of the 12 crops, livestock, poultry, and milk was found to average 7.65 percent over the period, 1994-97--the most recent years for which these data were available (Appendix Table A1).

Table 3 indicates that Texas output (GDP) would decline by $1.3 billion. The number of jobs would drop by nearly 16,000.

Conclusion

The loss of organophosphates and carbamates will have a significant adverse impact on the economics of many Texas commodities. This impact is not limited to just Texas producers. All segments of the food and fiber system will be affected. Both economic and health considerations should be carefully evaluated before decisions are made that prevent the use of any approved pesticide.

Table 1. Pests on Texas crops controlled by most frequently used organophosphates and carbamates.

Organophosphates and Carbamates	Pests Controlled	Commodities Affected
Methomyl (Lannate)	Leafhopper Rootworm European Corn Borer Plant bug Bollworm Tobacco budworm Aphid Thrip Foliage feeder Midge Spider mite Cutworm Armyworm	Carrots Corn Cotton Oranges Peaches Peanuts Grain sorghum Soybeans Tomatoes Wheat

Table 1. Pests on Texas crops controlled by most frequently used organophosphates and carbamates–continued.

Organophosphates and Carbamates	Pests Controlled	Commodities Affected
Carbaryl (Sevin)	Rootworm European corn borer Boll weevil Thrip Plant bug Stink bug Pink bollworm Mite Scale Peach twig borer Foliage feeder Spider mite Grasshopper Cutworm Armyworm	Carrots Corn Cotton Oranges Peaches Peanuts Rice Soybeans Wheat

Table 1. Pests on Texas crops controlled by most frequently used organophosphates and carbamates–continued.

Organophosphates and Carbamates	Pests Controlled	Commodities Affected
Chlorpyrifos (Lorsban)	Rootworm Cutworm Wireworm Grub European corn borer Plant bug Aphid Pink bollworm Whitefly Mite Miscellaneous fruit feeders Leafcutting fire ant Oriental fruit moth Peach twig borer Omnivorous leafroller San Jose scale Stink bug Lesser cornstalk borer Spider mite Greenbug Chinch bug Armyworm Thrip Grasshopper	Corn Cotton Oranges Peaches Peanuts Grain sorghum Soybeans Tomatoes Wheat

Table 1. Pests on Texas crops controlled by most frequently used organophosphates and carbamates–continued.

Organophosphates and Carbamates	Pests Controlled	Commodities Affected
Methyl Parathion (Penncap-M) or Ethyl Parathion (Parathion)	Cutworm Wireworm Grub Stink bug Boll weevil Plant bug Bollworm Tobacco budworm Aphid Pink bollworm Plum curculio Leafminer Armyworm Greenbug Spider mite Thrip Grasshopper Armyworm Mite	Carrots Corn Cotton Peaches Rice Grain sorghum Soybeans Wheat
Dimethoate (Cygon)	Rootworm Thrip Plant bug Aphid Leafhopper Spider mite Grasshopper Mite	Corn Cotton Oranges Potatoes Grain sorghum Soybeans Wheat

Table 1. Pests on Texas crops controlled by most frequently used organophosphates and carbamates–continued.

Organophosphates and Carbamates	Pests Controlled	Commodities Affected
Carbofuran (Furadan)	Rootworm Cutworm Wireworm Grub European corn borer Aphid CPB (Colorado potato beetle) Leafhopper Rice water weevil Greenbug Chinch bug Spider mite Thrip	Corn Cotton Potatoes Rice Grain sorghum Soybeans Wheat
Diazinon (Spectracide)	Soil insect Cutworm Wireworm Grub European corn borer Ant Oriental fruit moth Omnivorous leaf roller San Jose scale Stink bug Mole cricket	Carrots Corn Oranges Peaches Tomatoes
Aldicarb (Temik)	Thrip Nematode Aphid CPB Greenbug	Cotton Oranges Peanuts Potatoes Grain sorghum

Table 1. Pests on Texas crops controlled by most frequently used organophosphates and carbamates–continued.

Organophosphates and Carbamates	Pests Controlled	Commodities Affected
Malathion (Fyfanon)	Aphid Flea beetle Leafhopper Rootworm Boll weevil Mediterranean fruit fly Armyworm Greenbug Grasshopper Wheat storage	Carrots Corn Cotton Grain sorghum Wheat
Phorate (Thimet)	Rootworm Thrip CPB Leafhopper Wireworm Grub Hessian fly	Corn Peanuts Potatoes Grain sorghum Wheat

Table 2. Summary of impacts of the elimination of organophosphates and carbamates on yields and variable costs, Texas and United States.

Commodity	Yield Impacts		Variable Cost Impacts	
	Texas	United States	Texas	United States
	---------- percent change ----------			
Cotton[2/]	-19.00	-14.32	27.94	22.05
Corn[2/]	-2.69	-3.55	4.00	5.31
Grain sorghum[2/]	-14.37	-11.54	12.82	9.89
Wheat[2/]	-1.72	-1.34	0.92	0.81
Peanuts[2/]	-3.69	-9.08	2.38	6.84
Rice[2/]	-14.77	-8.16	17.02	7.96
Soybeans[3/]	-7.70	-5.10	15.27	8.88
Potatoes[3/]	0.00	-3.37	5.57	6.83
Tomatoes[3/]	-20.54	-15.32	19.61	13.19
Oranges[3/]	0.00	-2.60	0.00	1.80
Peaches[3/]	-16.67	-1.75	18.85	2.96
Carrots (per cwt)[1/]	-25.00	-7.45	5.39	4.13

[1/]Directly estimated by scientists for Texas.
[2/]Regional estimates of which Texas was a component.
[3/]Regional estimate considered most appropriate to Texas.

Table 3. Impacts of the elimination of organophosphates and carbamates on the Texas and US economy.[1/]

Aggregate Effect	United States	Texas
Output (mil $)	-17,271	-1,321
Total value added (mil $)	-10,423	-797
Employee compensation (mil $)	-4,821	-369
Proprietor income (mil $)	-720	-55
Other property income (mil $)	-3,696	-283
Employment (# of jobs)	-208,882	-15,979

[1/]Texas average value of production as a percent of total US production for the crops and livestock analyzed is 7.65 percent.

Appendix

Appendix Table A1. Texas and US Value of Production, Crops, and Livestock, 1994-1998.

	1994		1995		1996		1997		Sum
	Texas	US	Texas	US	Texas	US	Texas	US	TX/US
	-- 1,000 dollars --		-- 1,000 dollars --		-- dollars --		-- dollars --		-- percent --
Grain sorghum	332,878	1,323,801	375,840	1,395,413	550,848	1,986,316	434,889	1,408,909	27.71
Cotton	1,668,206	6,796,654	1,625,741	6,574,612	1,399,310	6,408,144	1,508,408	5,975,585	24.08
Peanuts	172,587	1,229,012	154,980	1,013,323	170,872	1,029,774	199,782	1,002,703	16.33
Rice	151,314	1,336,570	173,213	1,587,236	199,422	1,690,270	155,216	1,758,136	10.66
Carrots	10,143	295,311	14,850	394,356	5,027	39,526	4,836	38,396	4.54
Wheat	242,788	7,968,237	316,764	9,787,213	375,492	9,782,238	386,425	8,286,741	3.69
Corn	599,087	22,992,309	690,954	24,117,503	632,386	25,149,013	661,710	22,351,507	2.73
Peaches	5,811	314,699	6,480	404,990	3,836	389,894	5,600	444,137	1.40
Potatoes	35,315	2,590,257	28,302	2,991,722	34,687	2,425,263	47,687	2,621,733	1.37
Tomatoes	4,277	1,029,282	8,064	891,343	5,544	947,031	8,840	1,040,382	0.78
Oranges	5,044	1,541,296	4,828	1,632,414	7,310	1,821,579	7,563	1,834,089	0.68
Soybeans	35,175	13,756,328	39,120	14,616,758	49,140	17,439,971	70,896	17,372,628	0.31
Crops Subtotal	3,258,348	58,603,178	3,429,136	63,774,469	3,433,874	69,109,019	3,491,852	64,132,946	5.33
Cattle	4,721,080	26,861,431	4,802,861	24,822,009	4,179,538	22,276,583	4,340,827	24,892,648	18.25
Eggs	198,147	3,789,834	216,691	3,892,912	290,646	4,776,252	267,904	4,539,929	5.73
Broilers	659,453	11,371,723	646,316	11,762,222	726,264	13,903,479	774,595	14,158,926	5.48
Dairy	834,150	20,161,937	794,690	20,127,259	924,120	23,043,699	790,216	21,191,120	3.96
Livestock Subtotal	6,412,830	62,184,925	6,460,558	60,604,402	6,120,568	65,000,013	6,173,542	64,782,623	10.00
TOTAL	$9,671,178	$120,788,103	$9,899,694	$124,378,871	$9,554,442	$133,109,032	$9,665,394	$128,915,569	7.65

Source: USDA.

Appendix Table A2. Yields and Costs for Producing Upland Cotton With and Without Organophosphates and Carbamates

	United States[a]			Southeast			Delta			Southern Plains			Southwest		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (lbs/planted acre)[b]	583.51	499.94	-14.32%	640.84	563.94	-12.00%	687.99	632.95	-8.00%	401.92	325.56	-19.00%	1163.32	923.67	-20.60%
Variable Cash expenses ($/acre):															
Chemicals	$55.14	$82.85	50.24%	$86.20	$135.85	57.60%	$92.14	$122.54	32.99%	$21.73	$39.33	80.99%	$60.40	$96.64	60.00%
Other variable cash expenses	$320.07	$309.51	-3.30%	$306.09	$294.29	-3.86%	$374.07	$365.42	-2.31%	$235.46	$227.22	-3.50%	$646.88	$618.33	-4.41%
Total, variable cash expenses[c]	$375.21	$392.36	4.57%	$392.29	$430.14	9.65%	$466.21	$487.96	4.67%	$257.19	$266.55	3.64%	$707.28	$714.97	1.09%
Variable Cash expenses ($/lb):															
Chemicals	$0.09	$0.17	75.34%	$0.13	$0.24	79.11%	$0.13	$0.19	44.59%	$0.05	$0.12	123.29%	$0.05	$0.10	101.54%
Other variable cash expenses	$0.55	$0.62	12.87%	$0.48	$0.52	9.25%	$0.54	$0.58	6.18%	$0.59	$0.70	19.14%	$0.56	$0.67	20.37%
Total, variable cash expenses[c]	$0.64	$0.78	22.05%	$0.61	$0.76	24.60%	$0.68	$0.77	13.77%	$0.64	$0.82	27.94%	$0.61	$0.77	27.31%

[a] Upland cotton states included represent 89% of the acreage planted to cotton and 83% of the production in the 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[c] Variable cash expenses including capital replacement from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A3. Yields and Costs for Producing Wheat With and Without Organophosphates and Carbamates

	United States[a]			North Central			Southeast			Northern Plains			Central and Southern Plains			Pacific		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (bu/planted acre)[b]	36.25	35.77	-1.34%	61.90	61.83	-0.11%	45.90	43.79	-4.60%	30.20	29.83	-1.23%	32.06	31.51	-1.72%	63.60	63.05	-0.86%
Variable Cash expenses ($/acre):																		
Chemicals	$6.42	$6.00	-6.45%	$0.96	$0.93	-3.12%	$7.61	$6.59	-13.40%	$8.48	$8.34	-1.65%	$3.14	$2.45	-21.97%	$16.41	$16.08	-2.01%
Other variable cash expenses	$90.08	$89.99	-0.12%	$107.33	$107.30	-0.03%	$111.74	$110.94	-0.72%	$79.70	$79.53	-0.21%	$81.86	$81.86	0.00%	$156.73	$156.47	-0.17%
Total, variable cash expenses[c]	$96.52	$95.99	-0.55%	$108.29	$108.23	-0.06%	$119.35	$117.53	-1.52%	$88.18	$87.87	-0.35%	$85.00	$84.31	-0.81%	$173.14	$172.55	-0.34%
Variable Cash expenses ($/bu):																		
Chemicals	$0.18	$0.17	-5.18%	$0.02	$0.02	-3.02%	$0.17	$0.15	-9.23%	$0.28	$0.28	-0.43%	$0.10	$0.08	-20.61%	$0.26	$0.26	-1.16%
Other variable cash expenses	$2.49	$2.52	1.23%	$1.73	$1.74	0.09%	$2.43	$2.53	4.07%	$2.64	$2.67	1.02%	$2.55	$2.60	1.75%	$2.46	$2.48	0.70%
Total, variable cash expenses[c]	$2.66	$2.68	0.81%	$1.75	$1.75	0.06%	$2.60	$2.68	3.22%	$2.92	$2.95	0.88%	$2.65	$2.68	0.92%	$2.72	$2.74	0.53%

[a] Wheat states included represent 80% of the acreage planted to wheat and 88% of the production in the 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[c] Variable cash expenses including capital replacement from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A4. Yields and Costs for Producing Grain Sorghum With and Without Organophosphates and Carbamates

	United States[a]			Central Plains			Southern Plains		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (bu/planted acre)[b]	60.91	53.88	-11.54%	68.00	61.19	-10.01%	51.00	43.67	-14.37%
Variable cash expenses ($/acre):									
Chemicals	$12.70	$10.04	-20.97%	$15.03	$12.93	-13.97%	$9.44	$5.99	-36.55%
Other variable cash expenses	$101.93	$101.40	-0.52%	$93.74	$93.34	-0.43%	$113.38	$112.66	-0.64%
Total, variable cash expenses[c]	$114.63	$111.43	-2.79%	$108.77	$106.27	-2.30%	$122.82	$118.65	-3.40%
Variable cash expenses ($/bu):									
Chemicals	$0.21	$0.19	-10.66%	$0.22	$0.21	-4.40%	$0.19	$0.14	-25.90%
Other variable cash expenses	$1.67	$1.88	12.45%	$1.38	$1.53	10.66%	$2.22	$2.58	16.04%
Total, variable cash expenses[c]	$1.88	$2.07	9.89%	$1.60	$1.74	8.58%	$2.41	$2.72	12.82%

[a] Grain sorghum states included represent 88% of the acreage planted to grain sorghum and 91% of production in the 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[c] Variable cash expenses including capital replacement from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A5. Yields and Costs for Producing Corn With and Without Organophosphates and Carbamates

	United States[a]			Northeast			Southeast			North Central			Plains States		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (bu/pl acre)[b]	118.31	114.11	-3.55%	69.51	68.81	-1.00%	97.67	92.42	-5.38%	123.63	118.90	-3.83%	114.81	111.72	-2.69%
Variable Cash expenses ($/ac)															
Chemicals	$27.56	$30.76	11.61%	$26.80	$29.80	11.19%	$32.24	$39.74	23.26%	$27.96	$30.96	10.73%	$25.80	$28.80	11.63%
Other variable cash	$175.91	$175.91	0.00%	$145.35	$145.35	0.00%	$179.82	$179.82	0.00%	$158.85	$158.85	0.00%	$224.31	$224.31	0.00%
Total, variable cash expenses[c]	$203.47	$206.67	1.57%	$172.15	$175.15	1.74%	$212.06	$219.56	3.54%	$186.81	$189.81	1.61%	$250.11	$253.11	1.20%
Variable Cash expenses															
Chemicals	$0.23	$0.27	15.71%	$0.39	$0.43	12.32%	$0.33	$0.43	30.27%	$0.23	$0.26	15.14%	$0.22	$0.26	14.71%
Other variable cash	$1.49	$1.54	3.68%	$2.09	$2.11	1.01%	$1.84	$1.95	5.69%	$1.28	$1.34	3.98%	$1.95	$2.01	2.76%
Total, variable cash expenses[c]	$1.72	$1.81	5.31%	$2.48	$2.55	2.77%	$2.17	$2.38	9.42%	$1.51	$1.60	5.65%	$2.18	$2.27	4.00%

[a] Corn states included represent 94% of the acreage planted to corn for all purposes and production 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[c] Variable cash expenses including capital replacement from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A6. Yields and Costs for Producing Rice With and Without Organophosphates and Carbamates

	United States[a]			Mississippi River Delta			Gulf Coast[a]			California		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwt/planted acre)[b]	57.53	52.83	-8.16%	54.35	51.48	-5.28%	50.77	43.28	-14.77%	80.02	72.73	-9.11%
Variable Cash expenses ($/acre):												
Chemicals	$69.38	$68.11	-1.82%	$67.62	$68.53	1.34%	$63.68	$67.00	5.21%	$84.85	$68.26	-19.55%
Other variable cash expenses	$355.16	$352.81	-0.66%	$308.68	$307.99	-0.22%	$372.94	$368.45	-1.20%	$504.07	$498.71	-1.06%
Total, variable cash expenses[c]	$424.54	$420.92	-0.85%	$376.30	$376.52	0.06%	$436.62	$435.45	-0.27%	$588.92	$566.97	-3.73%
Variable Cash expenses ($/cwt):												
Chemicals	$1.21	$1.29	6.90%	$1.24	$1.33	6.98%	$1.25	$1.55	23.45%	$1.06	$0.94	-11.49%
Other variable cash expenses	$6.17	$6.68	8.17%	$5.68	$5.98	5.34%	$7.35	$8.51	15.92%	$6.30	$6.86	8.86%
Total, variable cash expenses[c]	$7.38	$7.97	7.96%	$6.92	$7.31	5.63%	$8.60	$10.06	17.02%	$7.36	$7.80	5.92%

[a] Rice states included represent 100% of the acreage planted to rice and 100% of the production in the 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[C] Variable cash expenses including capital replacement from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A7. Yields and Costs for Producing Peanuts With and Without Organophosphates and Carbamates

	United States[a]			Virginia/North Carolina			Southeast			Southern Plains		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwt/planted acre)[b]	23.76	21.60	-9.08%	26.13	21.58	-17.41%	23.87	21.74	-8.95%	22.15	21.33	-3.69%
Variable Cash expenses ($/acre):												
Chemicals	$105.60	$96.90	-8.24%	$149.61	$131.61	-12.03%	$123.35	$114.35	-7.30%	$43.00	$40.30	-6.28%
Other variable cash expenses	$258.02	$256.33	-0.65%	$277.84	$275.76	-0.75%	$255.86	$254.15	-0.67%	$251.08	$249.68	-0.56%
Total, variable cash expenses[c]	$363.62	$353.23	-2.86%	$427.45	$407.37	-4.70%	$379.21	$368.50	-2.83%	$294.08	$289.98	-1.40%
Variable Cash expenses ($/cwt):												
Chemicals	$4.44	$4.49	0.92%	$5.72	$6.10	6.51%	$5.17	$5.26	1.82%	$1.94	$1.89	-2.69%
Other variable cash expenses	$10.86	$11.87	9.27%	$10.63	$12.78	20.18%	$10.72	$11.69	9.09%	$11.34	$11.71	3.25%
Total, variable cash expenses[c]	$15.31	$16.35	6.84%	$16.36	$18.87	15.39%	$15.89	$16.95	6.73%	$13.28	$13.60	2.38%

[a] Peanut states included represent 92% of the acreage planted to peanuts and 92% of the production in the 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[c] Variable cash expenses from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A8. Yields and Costs for Producing Soybeans With and Without Organophosphates and Carbamates

	United States[a]			North Central			Northern Plains			Southeast			Delta		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (bu/planted acre)[b]	38.07	36.12	-5.10%	41.08	38.63	-5.96%	35.53	35.53	0.00%	30.12	29.32	-2.65%	29.11	26.87	-7.70%
Variable Cash expenses															
Chemicals	$25.58	$29.03	13.46%	$26.94	$29.94	11.14%	$20.55	$20.55	0.00%	$24.21	$31.71	30.98%	$24.88	$32.38	30.14%
Other variable cash expenses	$78.04	$78.04	0.00%	$72.71	$72.71	0.00%	$79.04	$79.04	0.00%	$100.22	$100.22	0.00%	$92.36	$92.36	0.00%
Total, variable cash expenses[c]	$103.62	$107.07	3.32%	$99.65	$102.65	3.01%	$99.59	$99.59	0.00%	$124.43	$131.93	6.03%	$117.24	$124.74	6.40%
Variable Cash expenses ($bu):															
Chemicals	$0.67	$0.08	19.57%	$0.66	$0.78	18.18%	$0.58	$0.58	0.00%	$0.80	$1.08	34.54%	$0.85	$1.21	41.00%
Other variable cash expenses	$2.05	$2.16	5.38%	$1.77	$1.88	6.34%	$2.22	$2.22	0.00%	$3.33	$3.42	2.72%	$3.17	$3.44	8.34%
Total, variable cash expenses[c]	$2.72	$2.96	8.88%	$2.43	$2.66	9.54%	$2.80	$2.80	0.00%	$4.13	$4.50	8.91%	$4.03	$4.64	15.27%

[a] Soybean states included represent 95% of the acreage planted and 96% of the production over the 1993-1997 period.

[b] Average yields calculated for the 1993-1997 crop years with the US average weighted by the regions included.

[C] Variable cash expenses including capital replacement from ERS/USDA budgets for 1996 adjusted to 1998 using USDA Baseline.

Appendix Table A9. Yields and Costs for Producing Oranges With and Without Organophosphates and Carbamates

	United States[a]			Florida Processed			California Fresh		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (lbs/planted acre)[b]	38,441.12	37,441.14	-2.60%	42,933.00	42,933.00	0.00%	25,648.00	21,800.00	-15.00%
Variable Cash expenses ($/acre):									
Chemicals	$185.88	$169.10	-9.03%	$99.97	$99.97	0.00%	$430.55	$365.99	-14.99%
Other variable cash expenses	$1,490.95	$1,493.54	0.17%	$1,548.51	$1,548.51	0.00%	$1,327.00	$1,337.00	0.75%
Total, variable cash expenses	$1,676.82	$1,662.65	-0.85%	$1,648.48	$1,648.48	0.00%	$1,757.55	$1,702.99	-3.10%
Variable Cash expenses ($/lb):									
Chemicals	$0.0048	$0.0045	-6.60%	$0.0023	$0.0023	0.00%	$0.0168	$0.0168	0.01%
Other variable cash expenses	$0.0388	$0.0399	2.85%	$0.0361	$0.0361	0.00%	$0.0517	$0.0613	18.54%
Total, variable cash expenses	$0.0436	$0.0444	1.80%	$0.0384	$0.0384	0.00%	$0.0685	$0.0781	14.00%

[a] Orange regions included represent 94% of the acreage bearing oranges and 95% of the production during the 1993-1997 period.

[b] US yields and costs are derived by weighting the analyzed region's planted acreage by their respective yield.

Appendix Table A10. Yields and Costs for Producing Fresh and Processed Carrots Combined With and Without Organophosphates and Carbamates

	United States[a]			California Fresh			Colorado Fresh			Michigan Fresh			Texas Fresh			Washington Fresh			Texas Processed			Washington Processed		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwts/acre)[b]	429.88	397.86	-7.45%	400.00	384.00	-4.00%	660.00	660.00	0.00%	385.00	385.00	0.00%	220.00	165.00	-25.00%	540.00	432.00	-20.00%	290.00	217.50	-25.00%	800.00	640.00	-20.00%
Variable Cash expenses ($/acre):																								
Chemicals	287.06	279.89	-2.50%	341.97	341.30	-0.20%	63.95	63.95	0.00%	226.62	226.62	0.00%	149.73	89.36	-40.32%	367.74	363.49	-1.16%	149.73	89.36	-40.32%	149.00	144.75	-2.85%
Other variable cash expenses	3261.24	3139.57	-3.73%	4022.09	3899.09	-3.06%	2468.00	2468.00	0.00%	2003.30	2003.30	0.00%	2372.54	1857.46	-21.71%	1083.35	1029.35	-4.98%	576.71	497.33	-13.76%	1056.63	976.63	-7.57%
Total, variable cash expenses	3548.29	3419.45	-3.63%	4364.06	4240.39	-2.83%	2531.95	2531.95	0.00%	2229.92	2229.92	0.00%	2522.27	1946.82	-22.81%	1451.09	1392.84	-4.01%	726.44	586.69	-19.24%	1205.63	1121.38	-6.99%
Variable Cash expenses ($/cwt):																								
Chemicals	0.67	0.70	5.35%	0.85	0.89	3.96%	0.10	0.10	0.00%	0.59	0.59	0.00%	0.68	0.54	-20.43%	0.68	0.84	23.56%	0.52	0.41	-20.43%	0.19	0.23	21.43%
Other variable cash expenses	7.59	7.89	4.02%	10.06	10.15	0.98%	3.74	3.74	0.00%	5.20	5.20	0.00%	10.78	11.26	4.39%	2.01	2.38	18.77%	1.99	2.29	14.98%	1.32	1.53	15.54%
Total, variable cash expenses	8.25	8.59	4.13%	10.91	11.04	1.21%	3.84	3.84	0.00%	5.79	5.79	0.00%	11.46	11.80	2.91%	2.69	3.22	19.98%	2.51	2.70	7.68%	1.51	1.75	16.26%

[a] Carrot regions included represent 78% of the acreage and 78% of the production during the 1995-1997 period.

[b] US yields and costs are derived by weighting the analyzed regions' planted acreage by their respective yield.

Appendix Table A11. Yields and Costs for Producing Fresh and Processed Peaches Combined With and Without Organophosphates and Carbamates

	United States[a]			California Fresh			Georgia Fresh			California Processed		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwt/acre)[b]	285.02	280.02	-1.75%	340.00	340.00	0.00%	120.00	100.00	-16.67%	340.00	340.00	0.00%
Variable Cash expenses ($/acre):												
Chemicals	$196.29	$218.74	11.44%	$191.00	$230.00	20.42%	$286.00	$266.00	-6.99%	$140.00	$174.00	24.29%
Other variable cash expenses	$1,751.31	$1,751.31	0.00%	$2,105.00	$2,105.00	0.00%	$1,794.00	$1,794.00	0.00%	$1,342.00	$1,342.00	0.00%
Total, variable cash expenses	$1,947.60	$1,970.05	1.15%	$2,296.00	$2,335.00	1.70%	$2,080.00	$2,060.00	-0.96%	$1,482.00	$1,516.00	2.29%
Variable Cash expenses ($/cwt):												
Chemicals	$0.69	$0.78	13.42%	$0.56	$0.68	20.42%	$2.38	$2.66	11.61%	$0.41	$0.51	24.29%
Other variable cash expenses	$6.14	$6.25	1.78%	$6.19	$6.19	0.00%	$14.95	$17.94	20.00%	$3.95	$3.95	0.00%
Total, variable cash expenses	$6.83	$7.04	2.96%	$6.75	$6.87	1.70%	$17.33	$20.60	18.85%	$4.36	$4.46	2.29%

[a] Peach regions included represent 49% of the acreage and 75% of the production during the 1993-1997 period.

[b] US yields and costs are derived by weighting the analyzed regions' planted acreage by their respective yield.

Appendix Table A12. Yields and Costs for Producing Potatoes With and Without Organophosphates and Carbamates

	United States[a]			Idaho			Columbia Basin			Central States			Northeast		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (lbs/planted acre)[b]	37744	36473	-3.37%	33000	33000	0.00%	57000	54150	-5.00%	35000	33250	-5.00%	28500	27075	-5.00%
Variable Cash expenses ($/acre)															
Chemicals	$240.95	$278.22	15.47%	$132.60	$176.49	33.10%	$487.91	$485.34	-0.53%	$219.64	$283.34	29.00%	$238.69	$247.53	3.70%
Other variable cash expenses	$775.02	$770.61	-0.57%	$655.96	$655.96	0.00%	$1,119.48	$1,106.73	-1.14%	$668.16	$667.35	-0.12%	$882.52	$867.72	-1.68%
Total, variable cash expenses	$1,015.97	$1,048.83	3.23%	$788.56	$832.45	5.57%	$1,607.39	$1,592.07	-0.95%	$887.80	$950.69	7.08%	$1,121.21	$1,115.25	-0.53%
Variable Cash expenses ($/cwt):															
Chemicals	$0.64	$0.76	19.49%	$0.40	$0.53	33.10%	$0.86	$0.90	4.71%	$0.63	$0.85	35.79%	$0.84	$0.91	9.16%
Other variable cash expenses	$2.05	$2.11	2.90%	$1.99	$1.99	0.00%	$1.96	$2.04	4.06%	$1.91	$2.01	5.14%	$3.10	$3.20	3.50%
Total, variable cash expenses	$2.69	$2.88	6.83%	$2.39	$2.52	5.57%	$2.82	$2.94	4.26%	$2.54	$2.86	12.72%	$3.93	$4.12	4.70%

[a] Potato regions included represent 77% of the acreage planted to potatoes and 80% of the production during the 1993-1997 period.

[b] US yields and costs are derived by weighting the analyzed regions' planted acreage by their respective yield.

Appendix Table A13. Yields and Costs for Producing Fresh Tomatoes With and Without Organophosphates and Carbamates

	United States[a]			Florida Fresh			California Fresh		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwt/acre)[b]	0.00	0.00	??	0.00	0.00	??	0.00	0.00	??
Variable Cash expenses ($/acre):									
Chemicals	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
Other variable cash expenses	??	??	ERR	??	??	ERR	??	??	ERR
Total, variable cash expenses	$0.00	$0.00	??	$0.00	$0.00	??	$0.00	$0.00	??
Variable Cash expenses ($/cwt):									
Chemicals	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
Other variable cash expenses	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
Total, variable cash expenses	$0.00	$0.00	??	$0.00	$0.00	??	$0.00	$0.00	??

[a] Fresh tomato regions included represent 63% of the fresh tomato acreage and 74% of the fresh production during the 1993-1997 period.

[b] US yields and costs are derived by weighting the analyzed regions' planted acreage by their respective yield.

Copies of this publication have been deposited with the Texas State Library in compliance with the State Depository Law.