Chapter 4.3

Pest Management Practices

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Crop producers use pesticides and other practices to manage pests. The quantity of pesticides used on crops was less in 2002 than in 1997. The development and marketing of new pesticides and the adoption of genetically modified seed have resulted in changes to insecticide and herbicide compounds used, while new pest problems can increase pesticide use.

Introduction

Crop producers use pesticides and other practices to manage insects, diseases, and weeds and to prevent crop yield or quality losses. Factors that influence pest management decisions include the extent of pest problems, cost and effectiveness of available practices, regulations on what pesticides can be used and how, and the prices of commodities and inputs. The recent entry of Asian soybean rust into the United States could increase fungicide use.

Pesticide Use

Pesticide use can be measured by expenditures, quantity, and area of use. The measure for which estimates have been available for the longest time is million pounds of active ingredient (a.i.). However, this measure does not capture changes in the use of pesticide compounds applied at different rates (where the area treated is unchanged). Nor is total quantity a good measure of total pesticide toxicity, which varies by pesticide compound, or of risk, which can be mitigated by application practices.

One measure of pesticide area is acre-treatments, which is the product of acreage treated and treatments per acre. We use this measure when discussing market shares of insecticides and herbicides, because some pesticides are applied at low rates per acre and account for small portions of total quantity applied, but large portions of total treatments.

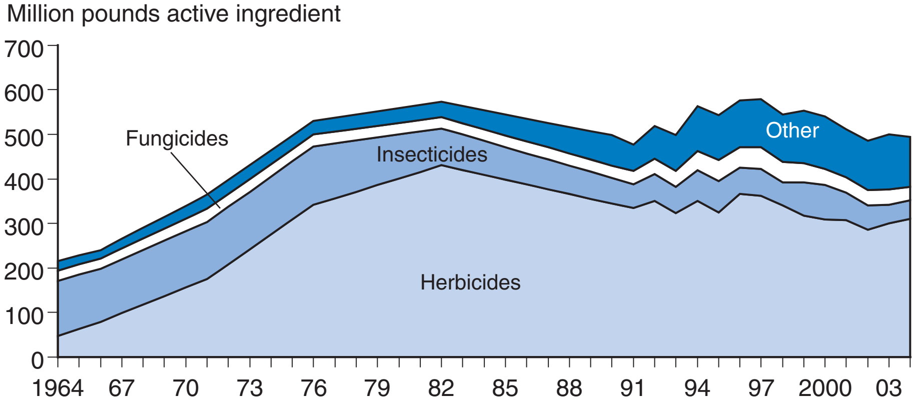
Agricultural pesticide expenditures reached an estimated all-time high of $9 billion in 1997-98 and totaled $8.3–8.5 billion in 2002-2004. Herbicides accounted for two-thirds of those expenditures, while insecticides accounted for about one-fifth in 2000 and 2001 (Kiely et al., 2004). Crop pesticide use peaked at an estimated 579 million pounds a.i. in 1997; in 2004, it was 495 million pounds a.i. (fig. 4.3.1, table 4.3.1).

In recent decades, the development of new pesticides, increased use of practices such as genetically modified seed, and the regulatory process encouraged shifts in pesticide compounds used. Many, but not all, compounds increasing in total use are applied at lower rates per acre than those declining in total use,

Contents

Figure 4.3.1

Pesticide use on major crops, 1964-2004[1]



[1] Linear interpolation of use estimates between survey years from 1964 to 1990.

Source: Padgitt et al., 2000, U.S. Census Bureau and unpublished ERS data.

Table 4.3.1

Quantity of pesticides applied, total and to selected crops, 1964-2004

Type of pesticide and commodity	1964	1971	1982	1991	1997	2004
	Quantity of pesticides applied (million pounds active ingredient)					
Total	215.0	364.4	572.4	477.5	579.3	494.5
Herbicides	48.2	175.7	430.3	335.2	362.6	311.0
Insecticides	123.3	127.7	82.7	52.8	60.2	40.7
Fungicides	22.2	29.3	25.2	29.4	48.5	29.8
Other	21.4	31.7	34.2	60.1	108.0	112.9
Corn	41.2	127.0	273.7	233.2	227.3	174.6
Cotton	95.3	111.9	49.5	50.3	68.4	56.7
Wheat	10.1	13.6	23.5	13.8	25.5	22.3
Soybeans	9.2	42.2	147.4	70.4	83.5	87.8
Potatoes	6.1	15.5	24.6	35.6	59.4	62.1
Other vegetables	20.8	20.7	21.7	40.3	73.3	65.1
Citrus fruit	8.1	14.1	16.5	13.7	15.0	7.2
Apples	19.9	12.7	10.0	9.1	10.6	8.5
Other deciduous fruit	4.4	6.6	5.5	11.1	16.4	10.3

Sources: Padgitt et al., 2000; U.S. Census Bureau; and unpublished ERS data.

resulting in lower pesticide quantity. Rather than discuss hundreds of pesticide compounds, we show use of major insecticide and herbicide families measured by shares of total quantity applied and acre-treatments on five major crops: corn, cotton, potatoes, soybeans, and wheat.

Among insecticides, the organophosphate share of acre-treatments and quantity applied was greater in 2000 than 1996, while pyrethroid and carbamate shares were less (table 4.3.2). Corn and cotton are the major insecticide markets among the five crops. The higher organophosphate share was largely due to higher malathion use on cotton for boll weevil eradication, which has since declined. During 1996-2000, organophosphate and pyrethroid use on corn varied year to year, with no obvious trend. (See "Crop Production Practices" in the ARMS Data Tool on the ERS website.)

Table 4.3.2

Shares of insecticide use by family, 1964-2000[1]

Insecticide family	1964	1971	1982	1991	1996	2000
			Percent			
Quantity						
Carbamates[2]	7	10	15	11	12	7
Organochlorines[3]	73	51	9	2	3	*
Organophosphates[4]	20	39	71	80	80	86
Pyrethroids[5]	0	0	4	3	4	2
Others	0	0	*	5	2	5
Acre-treatments[6]						
Carbamates	NA	NA	14	11	10	8
Organochlorines	NA	NA	5	2	1	*
Organophosphates	NA	NA	60	57	54	60
Pyrethroids	NA	NA	21	27	29	20
Others	NA	NA	*	3	6	12

NA = Not available.

* = Less than 1 percent.

[1] Estimated for corn, cotton, potatoes, soybeans, and wheat; excludes oils, sulfur, and other inorganics. Since potatoes were not surveyed in 2000, the 2000 estimate includes potato use in 1999.

[2] Examples include aldicarb, carbaryl, carbofuran, formetanate, methomyl, and oxamyl.

[3] Examples include dicofol, endosulfan, methoxychlor, and many materials no longer registered: aldrin, chlordane, deldrin, DDT, and toxaphene.

[4] Examples include azinphos-methyl, chlorpyrifos, fonodos, malathion, methyl parathion, mevinphos, parathion, phorate, and terbufos.

[5] Examples include permethrin, cypermethrin, tralomethrin, deltamethrin, cyhalothrin, cyfluthrin, and esfenvalerate.

[6] Sum of acreage treated with a pesticide multiplied by average number of applications per acre.

Source: Eichers et al., 1968; Andrelenas, 1974; unpublished ERS data.

According to NASS, malathion was used on 11 percent of cotton acres (with 6 treatments per acre) in 1997 and 1998, 40 percent (7 treatments per acre) in 1999, but only 11 percent (5 treatments per acre) in 2003. The U.S. Environmental Protection Agency (USEPA), under a regulatory review of organophosphates (discussed below), determined that malathion use for boll weevil eradication was not a significant dietary and drinking water health risk (USEPA, 2000). The adoption of cotton seed genetically modified to produce the *Bacillus thuringiensis* toxin may reduce organophosphate, pyrethroid, and carbamate insecticide use for lepidopteran insects, such as bollworms and tobacco budworms (see Chapter 3.3, "Biotechnology and Agriculture").

Among herbicides, shares of acre-treatments and quantity for phosphinic acids—primarily glyphosate (trade name: Roundup) but also glufosinate-ammonium and sulfosate—were much higher in 2000 than in 1996 (table 4.3.3). At the same time, shares of amides, anilines, phenoxys, and triazines, widely used since the 1960s and 1970s, were lower in 2000. Shares of sulfonyl ureas and other new families increased before 1996, but there was little change between 1996 and 2000.

Table 4.3.3

Shares of herbicide use by family, 1964-2000[1]

Herbicide family	1964	1971	1982	1991	1996	2000
			Percent			
Quantity						
Amides[2]	0	24	31	35	33	28
Anilines[3]	2	8	11	12	13	9
Carbamates[4]	10	5	17	9	4	*
Phenoxys[5]	43	12	4	4	7	4
Triazines[6]	23	32	26	29	27	22
Phosphinic acids[7]	0	0	1	2	5	23
Sulfonyl ureas[8]	0	0	*	*	*	*
Other new families[9]	0	0	3	3	8	8
Others	22	16	6	6	4	4
Acre-treatments[10]						
Amides	NA	NA	20	16	12	11
Anilines	NA	NA	15	13	10	6
Carbamates	NA	NA	6	2	1	*
Phenoxys	NA	NA	13	10	12	7
Triazines	NA	NA	26	24	18	14
Phosphinic acids	NA	NA	1	2	6	20
Sulfonyl ureas	NA	NA	*	9	13	13
Other new families[9]	NA	NA	7	15	22	22
Others	NA	NA	12	9	10	6

NA = Not available.

* = Less than 1 percent.

[1] Estimated for corn, cotton, potatoes, soybeans, and wheat. Since potatoes were not surveyed in 2000, the 2000 estimate includes potato use in 1999.

[2] Alachlor, acetochlor, metolachlor, propachlor.

[3] Oryzalin, pendimethalin, ethalfluralin, trifluralin.

[4] Butylate, EPTC, pebulate.

[5] 2,4-D, 2,4-DB, MCPA, MCPB.

[6] Atrazine, cyanazine, propazine, simazine, metribuzin, ametryne.

[7] Glyphosate, glufosinate-ammonium, sulfosate.

[8] Chlorsulfuron, halosulfuron, metsulfuron, nicosulfuron, primisulfuron.

[9] Includes bipyridyls (paraquat), benzothiadiazoles (bentazon), benoxazoles (fenaxaprop), imidizolinones (imazaquin, imazethapyr), diphenyl ethers (acifluorfen, diclofop, lactofen, oxyfluorfen), oximes (clethodim, clomazone, sethoxydim), pyridines (clorpyralid, fluazifop), pyridazinones (norfluorazon), and others that first appeared in pesticide use surveys since 1976.

[10] Sum of acreage treated with a pesticide multiplied by average number of applications per acre.

Source: Eichers et al., 1968; Andrelenas, 1974; unpublished ERS data.

Phosphinic acid shares were higher in 2000 than in 1996 on all major crops, but especially cotton and soybeans, where adoption of genetically modified seed tolerant to these herbicides has been widespread (see Chapter 3.3, "Biotechnology and Agriculture"). Phosphinic acids were the most used herbicides on cotton and soybeans in 2000; their share of herbicide acre-treatments increased from 4 percent in 1996 to 30 percent in 2000 on cotton and from 10 to 42 percent on soybeans, while shares of other major herbicide families were stable or declined. The higher application rates with phosphinic acids contributed to the higher soybean herbicide quantity in 2002 relative to previous years (table 4.3.1). The phosphinic acid share of herbicide acre-treatments increased from 2 percent in 1996 to 6 percent in 2000 on corn, 7 to 13 percent on winter wheat, 3 to 7 percent on durum wheat, and 4 to 10 percent on other spring wheat. However, shares of sulfonyl ureas and other new herbicide families on corn and wheat were higher in 2000 than in 1996. (see “Crop Production Practices” in the ARMS Data Tool on the ERS website.)

Since some producers used phosphinic acids and other newer post-emergence herbicides (applied after weed emergence) instead of older pre-emergence herbicides, the shares of corn, cotton, soybean, and spring wheat acres receiving post-emergence applications were higher and acres receiving pre-emergence applications lower in 2000 than in 1996. While producers treat many acres with both pre- and post-emergence herbicides, the shares of acres receiving post-emergence applications only were higher in 2000 than 1996, with the share of soybean acreage almost doubling from 28 percent in 1996 to 50 percent in 2000. (See “Crop Production Practices” in the ARMS Data Tool on the ERS website.)

Pesticide Prices

The USDA/NASS agricultural chemical price index was relatively stable from 1996 through 2003, while the herbicide price index declined by 4 percent, the insecticide price index increased by 17 percent, and the fungicide/other index was stable (table 4.3.4). Prices of individual pesticides may behave differently, responding to different factors. The price for glyphosate fell by 22 percent from 1996 to 2003, which may reflect marketing strategy as well as its patent’s expiring in September 2000. The lower price may have encouraged producers to use glyphosate and genetically modified herbicide-tolerant seed. The price for methyl bromide increased by 147 percent from 1996 to 2003, because EPA required supply reductions to implement the Montreal Protocol phaseout, beginning in 1999. Higher prices encouraged producers to use other pesticides, and focused methyl bromide use on crops and acres with higher returns.

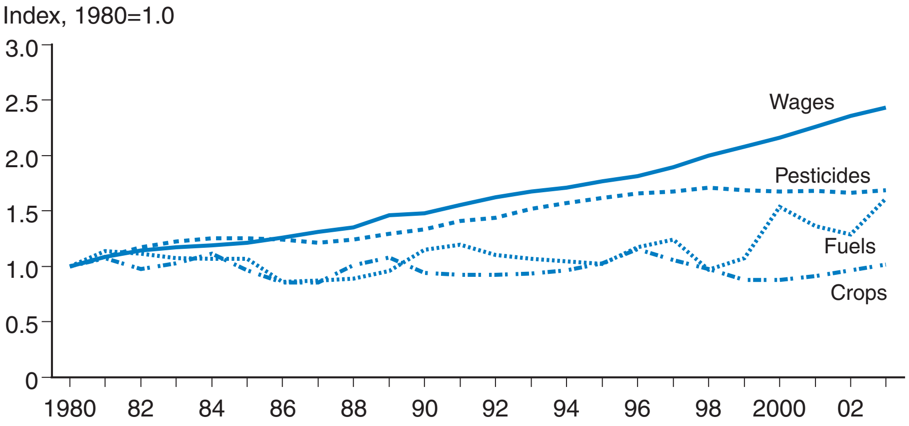
Based on USDA/NASS indices, pesticide prices have risen more slowly than wages, fuel prices, and crop prices since the late 1990s, which departs from the post-1980 trend of pesticide prices rising faster than crop and fuel prices (fig. 4.3.2, table 4.3.4). Pesticide prices have risen more slowly than crop prices since 2000 and fuel prices since 1998. Recent trends could encourage producers to substitute pesticides for fuel- and labor-intensive practices, but the slowdown in pesticide prices could also reflect declining demand.

Pest Management Practices

Growers use biological and cultural practices and information to improve the cost effectiveness of pest management, often coordinating their use through Integrated Pest Management (IPM). Use of practices varies by crop because of different pests and production requirements. Cotton growers use many practices, especially insecticide applications, more

Figure 4.3.2

Price indices: crops, wages, fuels, and pesticides, 1980-2003



Source: NASS/USDA.

Table 4.3.4

Price indices and selected pesticide prices, 1996-2003

Index or price	1996	1997	1998	1999	2000	2001	2002	2003
				(1990-92 = 100)				
Price indices								
Agricultural chemicals	119	121	122	121	120	121	119	121
Herbicides	117	117	118	114	111	112	111	112
Insecticides	125	130	136	141	145	144	140	146
Fungicides and others	117	119	119	120	120	120	121	117
Fuels	102	106	84	93	134	119	112	140
Wage rates	117	123	129	135	140	146	153	157
Crops	127	115	107	97	96	99	105	111
				($/lb. a.i.)				
Selected pesticide prices								
Glyphosate	13.93	14.18	14.08	11.38	10.83	11.13	10.88	10.88
Methyl bromide	3.02	3.31	3.23	3.15	3.58	4.97	5.42	7.45

Source: NASS/USDA.

intensively than do growers of other crops because of the crop's high value and its vulnerability to pests (especially insects) (See "Crop Production Practices" in the ARMS Data Tool on the ERS website.)

Corn, cotton, soybean, and wheat growers reported tilling, chopping, mowing, or cleaning equipment for pest control on more than 30 percent of acres in 2000, but cotton growers reported the highest proportions. Cultivation for weed control was higher in 1996 than in 2000 on cotton (89 percent of acres versus 65 percent) and soybeans (30 percent versus 17 percent). This may reflect increased use of genetically modified herbicide-tolerant seed and post-emergence herbicides. The share of corn acres cultivated for weed control was higher in 2000 (38 percent) than in 1996 (32 percent).

Among other practices, growers reported adjusting planting or harvest dates to manage pests on about 20 percent of cotton and wheat acres in 2000–more than on corn or soybeans. Growers reported alternating pesticides to prevent pest resistance on 30 percent or more of corn, cotton, soybean, and spring wheat acres in 1996 and 2000, but only about 10 percent of winter wheat acres. (Pesticides are generally applied to 50 percent or less of winter wheat, but to 90 percent or more of the other crop acres.) Cotton growers reported protecting beneficial organisms on the highest proportion of acres, approximately 50 percent in 1996 and 2000.

Cotton growers reported more scouting for insects and reliance on independent consultants or scouts than did growers of other crops in 1996 and 2000 (See Chapter 4.7, "Information Technology Management"). Corn, cotton, soybean, and wheat growers reported scouting for weeds, insects, and diseases on 50 percent of acres or more. With the exception of scouting for insects on cotton, operators, partners, or family members scouted the most acreage for insects and weeds, more so than farm supply/chemical dealers and independent consultants and scouts. Independent consultants or scouts had the largest role on cotton, scouting for insects on about 50 percent of cotton acres and weeds on 20-25 percent. On corn, they scouted about 10 percent of acres for insects and 12 percent for weeds.

Farm supply or chemical dealers were identified by growers as primary pest management information sources on corn, soybean, and wheat acreage, ranging from 40 percent on wheat to over 60 percent on corn and soybeans in 1996 and 2000. Cotton growers relied more on independent crop consultants or pest control advisors (30 percent of acres in 2000), Extension (17 percent), and commercial scouting (10 percent) than did growers of other crops, with farm supply or chemical dealers (26 percent) the second most identified source. Winter wheat producers reported no pest management information source for 22 percent of acres in 2000, which may reflect their less intensive use of pesticides.

Policy and Regulatory Issues

Asian Soybean Rust

Asian soybean rust is caused by a windborne, highly prolific, and virulent fungal pathogen (*Phakopsora pachyrhizi*) that can infect over 95 species of cultivated and wild plants, including soybeans and kudzu. The pathogen has caused yield losses and higher production costs in Asia, Australia, Africa, India, and South America. Responding to its introduction in South America, USDA's Animal and Plant Health Inspection Service established a rust surveillance, information, and education program in 2002 to help domestic producers respond effectively. Asian soybean rust was first identified in the United States in late 2004.

Historically, producers treat less than 1 percent of U.S. soybean acres with fungicides (excluding seed treatments). To prevent production losses from soybean rust, U.S. producers might increase fungicide use by 2.5-10.5 million pounds a.i. per year, with 20 to over 90 percent of soybean acres treated, depending upon the severity and extent of outbreak. This would increase production costs (Livingston et al., 2004). Total fungicide use on crops could increase 7 to 30 percent over the 34 million pounds a.i. estimated in 2002. Fungicides registered for soybean rust include azoxystrobin, chlorothalonil, and pyraclostrobin. In addition, EPA granted Federal Insecticide Fungicide and Rodenticide Act emergency exemptions for propiconazole, tebuconazole, myclobutanil, tetraconazole, and the combination of trifloxystrobin plus propiconazole. Some have been used successfully in other countries.

Scientists estimate that soybean rust could reduce yields of untreated soybeans by 10 to 60 percent. Based on evidence that fungicide use would limit average losses to about 4 percent, Livingston et al. (2004) estimated U.S. producer and consumer losses from soybean rust could vary between $240 million and $2 billion per year over 5 years, depending upon the extent and severity of an outbreak.

Food Quality Protection Act

The potential dietary, drinking water, worker, human health, and environmental hazards of pesticide use often are not completely reflected in producers' costs and returns. So the Federal Insecticide, Fungicide and Rodenticide Act of 1947 (FIFRA) regulates which pesticides can be used on crops and how they can be used, through EPA's pesticide registration process. The Federal Food, Drug, and Cosmetic Act of 1938 (FFDCA) regulates pesticide residues in food.

The Food Quality Protection Act of 1996 (FQPA) amended FIFRA and FFDCA to set new standards for and to modify the regulation of pesticide residues in food. Under FQPA, EPA must consider dietary exposure from all food uses and drinking water, nonoccupational exposure such as homeowner use, and the susceptibility of infants and children in setting pesticide residue tolerances, as well as the cumulative effects of substances if there is a common mechanism of toxicity. FQPA required a reassessment of all existing pesticide residue tolerances by 2006, with priority to pesticides that pose the greatest risk to public health. EPA is coordinating the tolerance reassessment with the reregistration of pesticides to comply with new standards mandated in amendments to FIFRA in 1988.

The reassessment resulted in revocations or modifications of some residue tolerances and cancellations or restrictions of some use registrations. Among the highest priorities are pesticides in the carbamate, organochlorine, and organophosphate families, or pesticides classified as carcinogens. EPA met FQPA-mandated interim goals, and by the end of fiscal year 2004 had reassessed about 73 percent of the 9,721 mandated tolerances, including about 67 percent of 1,691 organophosphate, 57 percent of 545 carbamate, 71 percent of 2,008 carcinogen, and all 253 organochlorine tolerances (USEPA, 2005a). Many reassessed organophosphate tolerances required no modification, but EPA restricted or cancelled use of azinphos methyl, chlorpyrifos, and methyl parathion on some crops due to dietary risk. EPA cancelled use of chlopyrifos by homeowners and in schools, parks, and other settings, as well as outdoor residential use of diazinon to reduce risks to children. EPA is conducting a cumulative assessment of organophosphate tolerances that could lead to further actions.

Methyl Bromide Phaseout

Methyl bromide is used for soil fumigation before planting many fruit and vegetable crops, post-harvest storage and facility fumigation, and government-required quarantine treatments. It was identified as an ozone-depleting substance under the Montreal Protocol, implemented in the United States through the Clean Air Act. Its use was incrementally phased out in developed countries from 25 percent of the 1991 use baseline beginning January 1, 1999, to 100 percent on January 1, 2005. Its use will be phased out by 2015 in developing countries. The Protocol's Quarantine and Preshipment (QPS) and Critical Use Exemptions allow some methyl bromide use in developed countries after the phaseout. QPS treatments are permitted to meet some government phytosanitary and quarantine requirements for imports and exports, and some standards of Federal, State, and local governments.

The Parties to the Montreal Protocol can grant critical-use exemptions for specific uses in a country if no technically and economically feasible alternative with acceptable health and environmental effects is available, and if a significant market disruption would occur without methyl bromide, but the country must take steps to develop alternatives and minimize methyl bromide use and emissions (Osteen, 2003). Countries requesting exemptions submit annual nominations, and the approval process has been contentious. The United States requested more methyl bromide for 2005 and 2006 than permitted under the 2003 reduction goal—30 percent of its 1991 baseline of 56.3 million pounds. The Parties approved quantities for the U.S. in 2005 totaling 37 percent of its baseline; however, permitted production and imports would satisfy only 30 percent, with the remainder coming from existing U.S. stockpiles (USEPA, 2005b). For 2006, the U.S. requested exemptions totaling 37 percent of the baseline, and the Parties approved quantities totaling 32 percent. For 2007, the United States requested 29 percent of the baseline.

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