Pests and Pest Management

In general, the term "pest" can be simply defined as any organism detrimental to humans (Glass, p. 43). From the agricultural viewpoint, pests "are organisms that diminish the value of resources in which man is interested" (NRC, 1975, p. 27) as they "interfere with the production and utilization of crops and livestock" used for food and fiber. The term "pest" applies to all noxious and damaging organisms, including insects, mites, nematodes, plant pathogens, weeds, and vertebrates (OTA, 1979, Vol. I, p. 14).

From an economic viewpoint, an agricultural pest is an "animal or plant whose population density exceeds some unacceptable threshold level, resulting in economic damage" (Horn, 1988). There are approximately 600 species of insects and 1800 species of weeds considered pests in agriculture (USDA, 1997c, p. 181), but only a few of those are considered significant to U.S. agriculture. According to the ARMS 1996 survey, weeds are by far the most important pests in U.S. agriculture in terms of the share of pesticide treatments used to control them. For corn, 83 percent of all pesticide acre-treatments (number of acres treated times the number of pesticide treatments) were aimed at controlling weeds; for soybeans, it was nearly 100 percent, and for wheat around 90 percent (table 1). Only for potatoes and cotton, among major crops, do other pest classes surpass weeds in control efforts. Pathogens account for 56 percent of all potato pesticide acre-treatments, while insects account for 45 percent of all cotton pesticide acre-treatments. More detailed survey results on primary target pests by State and crop are shown in Appendix I.

Pest management involves a set of techniques to reduce pest populations or prevent their detrimental effect (Glass, p. 43). Technically, the term "pest management" has had various interpretations by researchers, but the underlying philosophy is that "pests should be managed, not eradicated" (Cate and Hinkle) and that pests are inevitable components of an agricultural system (Zalom et al., 1992). Pest management techniques can be broadly classified into chemical, cultural, and biological.

Chemical controls usually involve the immediate and temporary decimation of localized pest populations using chemical pesticides. The term "chemical pesticide" includes a large number of different products used to repel, debilitate, or kill pests. Thousands of formulations (commercial forms in which the pesticide is sold) are used, with different mixtures of active ingredients and inert materials. Hundreds of chemical products are used as active ingredients, and each has a different spectrum of pest control, a different potency, and a different impact on human health and the environment (Fernandez-Cornejo and Jans, 1995). From 1991-96 several of the major active ingredients experienced large changes in usage, and the most heavily used active ingredients were in the herbicide class (table 2). Appendix III provides detailed information on chemical pesticides used for major field crops by State and active ingredient.

Most pesticides in U.S. agriculture are applied on very few crops and, consequently, any effort in overall pesticide reduction is likely to focus on these crops. In 1995, four crops — corn, soybeans, cotton, and wheat — accounted for more than 85 percent of the herbicides used, and two crops (corn and cotton) accounted for nearly 65 percent of the insecticides used (table 3).[2] Potatoes and other vegetables used 75 percent of the fungicides and other pesticides.

[2]Per acre pesticide expenditures vary widely, increasing with the value of the crop. For example, wheat farmers annually spent less than $6 per acre on pesticides in 1991 while corn or soybean growers spent about $22 per acre, cotton farmers spent $48 per acre, and peanut growers spent $88 per acre. Per acre pesticide expenditures by producers of high-value commodities such as fruits and vegetables were much higher—more than $800 per acre for tomatoes and approaching $1,600 per acre for strawberries (Fernandez-Cornejo, Jans, and Smith).

Table 1— Pesticide treatments distributed by primary target pests, field crops, 1996

Weeds are the biggest pest in terms of share of pesticide treatments for most field crops

Item	Corn	Soybeans	Cotton	Fall potatoes	Winter wheat	Spring wheat	Durum wheat
				Percent of acre-treatments			
Insects and other arthropods	16	0	45	20	12	2	1
Aphids	*	0	2	4	7	1	0
Beetles, weevils or wireworms							
Corn rootworm - adult	3	0	0	0	0	0	0
Corn rootworm - larvae	7	0	*	0	0	0	0
Other[1]	1	**	20	14	**	0	0
Cutworms or armyworms	2	*	2	0	2	0	0
Moths or caterpillars:							
Pink bollworm	**	0	4	0	0	0	0
Tobacco budworm	0	**	3	0	0	0	0
Other[2]	3	**	4	1	0	0	0
True bugs[3]	*	*	4	1	2	0	0
Whitefly, mealybugs or leaf hoppers	0	0	1	**	0	0	0
Grasshoppers or crickets	**	**	**	0	*	0	**
Mites	*	0	2	*	1	0	0
Flies or maggots	0	0	**	0	0	1	1
Thrips	**	0	3	**	**	0	0
Pathogens[4]	0	0	2	56	1	2	1
Nematodes	0	0	1	2	0	0	0
Fungus diseases	0	**	1	49	1	2	1
Virus diseases	0	0	**	5	*	0	0
Weeds	83	100	38	16	87	97	99
Annual grasses:							
Foxtail	21	19	*	*	1	7	5
Other annual grasses	17	22	7	1	7	14	15
Perennial grasses:							
Shattercane	1	1	**	0	1	0	0
Johnsongrass	2	4	4	0	1	0	0
Quack grass	1	1	**	*	**	1	*
Other perennial grasses	4	6	4	1	2	8	1
Perennial broadleafs	9	8	4	3	20	13	21
Annual broadleafs	28	40	19	11	55	54	57
Others[5]	*	**	18	10	*	0	0

1 Includes other beetles, weevils, or wireworms.

2 Includes other moths or caterpillars such as loopers, leafminer, leaf perforator, leafworm, corn borer, webworm, and leafrollers.

3 True bugs include fleahoppers, lygus bugs, stink bugs, chinch bugs, and tarnish plant bugs.

4 Survey excludes treated seed and seed treatments for seedling diseases.

5 Treatments of desiccants, defoilants, and growth regulators.

* Less than 0.5 percent. ** Less than 0.1 percent.

Source: National Agricultural Statistics Service and Economic Research Service, 1996 Agricultural Resource Management Study.

Table 2—Major pesticides used, by active ingredient, field crops, 1991-96[1]

Because weeds are the biggest pest, herbicides are used in the largest amounts

Name	Class	Family	Pesticide use	
			1991	1996
			Million pounds	
Atrazine	Herbicide	Triazine	44.4	53.6
Metolachlor	Herbicide	Acetamide	42.5	46.1
Cyanazine	Herbicide	Triazine	24.1	22.9
Acetochlor	Herbicide	Acetamide	0.0	29.9
Trifuralin	Herbicide	Dinitroaniline	18.4	16.3
Pendimethalin	Herbicide	Dinitroaniline	10.6	18.6
2,4-D	Herbicide	Phenoxy	6.8	13.9
Alachlor	Herbicide	Acetamide	46.0	15.2
Glyphosate	Herbicide	Phosphinic acid	3.0	12.9
Chlorpyriphos	Insecticide	Organophosphate	7.1	6.5
EPTC	Herbicide	Carbamate	15.2	6.3
Dicamba	Herbicide	Benzoic	3.8	6.3
Terbufos	Insecticide	Organophosphate	5.3	4.5
Methyl-parathion	Insecticide	Organophosphate	2.4	4.1

[1] Major field crops included in 1991: corn (10 States), soybeans (8 States), cotton (6 States), winter wheat (11 States), spring and durum wheat (4 States), and fall potatoes (11 States) (USDA, 1997c, p. 120, 122). Included in 1996: corn (16 States), soybeans (12 States), cotton (7 States), winter wheat (10 States), spring and durum wheat (4 States), and fall potatoes (5 States) (1997c, p. 120) (USDA, 1997d, p. 1). These States represent about 80 percent of these crops' acreage.
Source: USDA, 1997c, p. 120, 122; USDA, 1997d.

Table 3—-Pesticide use for major U.S. crops, 1995 (million pounds of active ingredient)

The largest amounts of herbicides are used for corn and soybean production, while more insecticides and fungicides are used for cotton and potatoes respectively

Crop	Herbicides		Insecticides		Fungicides and other	
	Million lbs.	*Percent*	*Million lbs.*	*Percent*	*Million lbs.*	*Percent*
Field crops						
Corn	186.3	51.9	15.0	20.6	0.0	0.0
Cotton	32.9	9.2	30.0	41.2	20.7	11.3
Soybeans	68.1	19.0	0.5	0.7	0.0	0.0
Wheat	20.1	5.6	0.9	1.2	0.5	0.3
Potatoes	2.9	0.8	3.1	4.3	80.9	44.5
Other field crops[1]	34.9	9.7	3.3	4.5	9.6	5.3
Other crops						
Vegetables (excluding potatoes)	6.1	1.1	5.6	7.7	55.1	30.3
Fruits	7.4	1.5	14.5	19.9	15.0	8.3
Total	358.7	100.0*	72.9	100.0*	181.8	100.0*

*Percentages may not add up to 100 due to rounding.
[1] Sorghum, peanuts, and rice.
Source: USDA, 1997c, p. 119.

Several techniques have been developed to improve the efficiency of chemical pesticides. ***Scouting*** involves monitoring pest populations by regular and systematic sampling of the fields to determine the presence and severity of pest infestation levels, and to determine when an economic threshold (see below) is reached (Vandeman et al.). Scouting may also involve monitoring beneficial organisms, which help control pests without harming the crops. The scout may use several techniques, including visual rating of pest severity and the use of traps or collecting devices to concentrate pest samples (VCES, p. 19).[3]

An ***economic threshold*** refers to the pest population density below which pests are tolerated. When the threshold is reached or exceeded "control measures should be taken to prevent an increasing population from reaching the economic injury level," (EIL) defined as the lowest pest population density that will cause net economic losses (Stern et al.) The EIL is the pest population density at which the cost of incremental damage just equals the cost of controlling that damage (Headley, 1972a). Economic thresholds are difficult to determine and are not constant because they depend on individual farmer's pest problems, stage of crop growth, and economic expectations (NCR, 1989, pp. 176-77).[4] Moreover, economic thresholds have not been used as extensively for managing pathogens as they have for insects due to the lack of monitoring techniques.[5] Information on threshold levels for weeds is far from complete, but there is an increasing level of research being carried out on major weeds species or complexes of two or more species (El-Zik and Frisbie, p. 37).

Farmers can also use a number of ***cultural practices*** to make the environment less favorable to pests. The most common of these include crop rotation, tillage, plant density, timing of harvest, and water management (USDA, 1997c). Other techniques considered in this category include the use of trap crops, field sanitation to destroy or utilize crop refuse, mulching, and the use of pest-free seeds and seeding methods (USDA, 1997c).

Biological methods include controls such as predators (e.g., wasps, lacewings, lady beetles), parasites, pathogens (including bacteria, fungi, and virus), competitors, and antagonistic microorganisms (Hokkanen, p. 185), all of which are believed to pose little health and environmental effects (NRC, 1995). Other biological techniques involve the use of biological pesticides, or biopesticides, including bacteria, viruses, and fungi. Among biopesticides, the most successful so far is the soil bacterium *Bacillus thuringiensis* (Bt).[6]

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[3]Monitoring methods also include soil testing for pests (nematodes, for example), the use of pheromone odors and visual stimuli to attract target pests to traps, and the recording of environmental data (e.g., temperature and rainfall) associated with the development of some pests.

[4]For these reasons, the majority of the economic thresholds found in extension publications, as well as in verbal recommendations, are not based on calculated economic injury levels but rather are based on the practitioner's experience and are often called subjective or nominal thresholds (Pedigo).

[5]However, empirical thresholds based on observations and experience have been used successfully in many disease-managing programs (El-Zik and Frisbie, p. 37). In addition, computer models and other forecast methods based on weather conditions and other environmental factors are used to predict whether or not disease is likely to occur in an important manner.

[6]Another important technique sometimes considered among biological techniques includes the use of pest-resistant plant varieties and rootstock. Host plant resistance to pests enables the plant to avoid, tolerate, or recover from the effects of pests that would cause a greater damage to other genotypes of the same species under similar conditions (El-Zik and Frisbie, p. 46).