4.2 Crop Rotations

Most corn and soybeans are grown in rotation with other row crops, while most cotton is grown successively in the same fields. The most common wheat rotation includes fallow or idle land. Soil conserving crops in rotation with corn are more commonly used on highly erodible land (HEL) than on non-HEL.

Expanding markets, new production technologies, and economic competition in recent decades have resulted in crop specialization, increased purchase of off-farm inputs, and production practices that often have adverse environmental consequences. Monoculture (successively growing the same crop on the same land), continuous row crops, and other intensive cropland uses have increased with the availability of commercial fertilizers to supply nutrient needs and of chemicals to control pests. Crop rotations that include hay, grass sod, and other soil-conserving crops were abandoned by many producers as the demand for hay and forages declined.

The choice between monoculture and rotating different crops on the same land depends on a broad range of economic and physical factors. The choice of rotation frequently affects the use of fertilizer and pesticides. The Cropping Practices Survey, which collects a 3-year cropping history, indicates the use of crop rotations and how they affect input use in the production of corn, cotton, soybeans, and wheat (see box, "Crop Rotation Definitions").

Environmental Benefits of Crop Rotations

Planned crop rotations can increase yields, improve soil structure, reduce soil loss, conserve soil moisture, reduce fertilizer and pesticide needs, and provide other environmental and economic benefits. However, crop rotations may reduce profits when the acreage and frequency of highly profitable crops are replaced with crops earning lower returns.

Many crop rotations reduce soil loss and are an option for meeting conservation compliance on highly erodible land. The growth of hay, small grain crops, or grass sod in rotation with conventionally tilled row crops reduces the soil's exposure to wind and water and decreases total soil loss. These rotations, however, are a desirable option to farmers only when profitable markets exist or the conservation crops can be utilized by onfarm livestock enterprises.

Alternating wheat and fallow is a common practice for conserving soil moisture in regions with low rainfall. Applying tillage practices to minimize evaporation or transpiration from idle land in one

Crop Rotation Definitions

The following definitions were applied to the 3-year crop sequence data reported in the Cropping Practices Survey to represent a crop rotation for each sample field. The data were limited to the current year's crop plus the crops planted the previous 2 years on the sample field.

Monoculture or continuous same crop--A crop sequence where the same crop is planted for 3 consecutive years. Small grains (wheat, oats, barley, flax, rye, etc.) or other close-grown crops may be planted in the fall as a cover crop. The rotation excludes double-cropped soybeans with winter wheat.

Continuous row crops--A crop sequence, excluding continuous same crop, where only row crops (corn, sorghum, soybeans, cotton, peanuts, vegetables, etc.) are planted for 3 consecutive years. Small grains or close-grown crops may be planted in the fall as a cover crop.

Mix of row crops and small grains--A crop sequence where some combination of row crops and small grains are planted over the 3-year period. The rotation excludes double-cropped soybeans with winter wheat.

Hay, pasture, or other use in rotation--A crop sequence that includes hay, pasture, or other use in one or more previous years. The rotation excludes any of the above rotations and any area that was idle or fallow in one of the previous years.

Idle or fallow in rotation--A crop sequence that includes idle, diverted, or fallowed land in 1 or more of the previous years.

Double-cropped soybeans--A crop sequence, limited to soybean acreage, where winter wheat was planted the previous fall.

season increases the amount of stored soil moisture available for the crop in the following season.

The ability of legume crops to fix atmospheric nitrogen and supply soil nitrogen needs for subsequent crops is well documented. The plowdown of established alfalfa or other legumes can provide carryover nitrogen for a crop that requires high levels of nitrogen, such as corn. Research has shown that soybeans can be managed to fix 90 percent of their nitrogen needs and provide a soil nitrogen credit of 20 pounds or more per acre for a subsequent crop (Heichel, 1987). However, soybeans grown in rotation with corn where soils are already rich in nitrogen have not been shown to fix significant amounts of nitrogen.

Crop rotations affect pest populations and can reduce the need for pesticides. Different crops often break pest cycles and prevent pest and disease organisms from building to damaging levels. Treatment for corn rootworm, the most common insecticide treatment on corn, normally only requires alternating another crop to sufficiently reduce root-worm survival rates to levels that do not require insecticide treatment. Hay and grass sod grown in rotation with corn, however, may increase the need for other corn insecticides to treat other pests.

Besides providing erosion control, small grains, hay, and grass sod are competitive with broadleaf weeds and may help control weed populations in subsequent crops. These crops are usually harvested or can be cut before weeds reach maturity and produce seed for germination the following season. Weeds on prior idle acres or fallow land may be controlled by either cutting or tilling to reduce weed infestations the following year. Sometimes, herbicides are used to kill existing vegetation on idle land (chemical fallow) in lieu of mechanical methods.

Rotations also can reduce financial risk and provide a more sustainable production system. Since adverse weather or low market prices are less likely to affect all crops simultaneously, the diversity of products resulting from crop rotation can reduce risk.

Crop Rotations Nationally

About 83 percent of the 1993 corn and soybean acreage was reported in either monoculture or in row crop rotations (fig. 4.2.1, table 4.2.1). Continuous corn or continuous soybeans (monoculture) was reported on 25 percent of corn acreage and 6 percent of soybean acreage. Other continuous row crop rotations, often alternating corn and soybeans, occurred on 58 percent of the 1993 corn and 76 percent of the 1993 soybeans. Only 6 percent of the total corn and soybean acreage was reported planted to any small grain, forage crop, or pasture. Acreage idled under the feedgrain price support program is sometimes rotated or returned to production as Acreage Reduction Program (ARP) requirements change. About 7 percent of the corn and soybean acreage was idle for at least 1 of the 2 preceding years.

Farmers in many semiarid wheat production areas fallow fields to conserve moisture and nutrients for a subsequent wheat crop. Nearly 45 percent of the wheat acreage in the survey was on land that was fallow or idle the preceding year. Continuous wheat (monoculture) was reported on about 30 percent of the 1993 wheat acreage. In more humid areas or under irrigated conditions, row crops can be grown in rotation with wheat. About 20 percent of the wheat acreage was on land planted to a row crop in 1 or both of the 2 preceding years. Most of this acreage was in Minnesota, Missouri, Ohio, and Illinois (app. tables 4.1.1-4.1.5).

Most cotton was grown in a monoculture system (fig. 4.2.1). In the six surveyed States, 60 percent of the cotton was on land planted to cotton for at least 3 successive years. Row crops other than continuous cotton accounted for an additional 29 percent of the acreage. Of the remaining cotton acreage, 6.5 percent was idle, 1.7 percent had small grains, and 2.5 percent had hay, pasture, or other crops in rotation.

Crop Rotations on Highly Erodible Land

Although the most commonly chosen practice in plans prepared to meet the conservation compliance requirements for highly erodible lands (HEL) in the 1990 and 1985 Farm Acts is crop residue management, some plans also include crop rotations. The Cropping Practices Survey does not identify all soil conservation practices in use nor whether the conservation plans have been fully implemented. It does, however, report the use of conservation crops in the rotation.

Crop rotations that include soil-conserving crops are not widely used on HEL planted to corn, soybeans, and cotton. Most of these crops are in continuous row crops including monoculture (table 4.2.2). However, rotations including idle, small grains, hay, or pasture, which offer some protection against soil erosion, are more prevalent on highly erodible corn land (22 percent of corn planted) than on corn land that is not highly erodible (15 percent) (fig. 4.2.2). Soil-conserving crops in

Table 4.2.1—Fertilizer and pesticide use by crop rotation in major producing States, 1993[1]

Crop/item	Three-year crop sequence[2]							
		Continuous						
	Monoculture	Row crops	Small grains	Combination row crop and small grain	Hay, pasture, or other crops	Idle or fallow	Double-cropped soybeans	Total
Corn:								
Planted acres (1,000 ac.)	14,269	33,164	n/a	2,871	2,612	4,434	n/a	57,350
Percent of planted acres treated with:								
Nitrogen	97.5	97.9	n/a	89.2	95.4	92.0	n/a	96.8
Phosphate	79.0	84.1	n/a	75.7	86.5	82.7	n/a	82.4
Potash	62.3	75.6	n/a	44.4	81.8	73.4	n/a	70.8
Any pesticides	98.8	98.6	n/a	91.7	94.6	96.2	n/a	98.0
Herbicides	98.2	98.4	n/a	91.3	93.2	95.9	n/a	97.6
Insecticides	61.1	17.2	n/a	8.4	26.0	17.9	n/a	28.2
Average application rates (lbs./acre of active ingredient)								
Nitrogen	129	129	n/a	81	83	112	n/a	123
Phosphate	45	62	n/a	45	49	54	n/a	56
Potash	65	87	n/a	52	57	80	n/a	79
Herbicides	2.64	3.03	n/a	2.00	2.37	2.84	n/a	2.84
Insecticides	.89	.83	n/a	1.00	.96	.87	n/a	.87
Soybeans:								
Planted acres (1,000 ac.)	2,473	32,483	n/a	2,094	516	2,398	2,536	42,500
Percent of planted acres treated with:								
Nitrogen	14.2	10.8	n/a	21.9	20.6	19.0	16.2	12.5
Phosphate	22.8	16.6	n/a	38.8	22.3	32.1	26.9	19.6
Potash	34.0	21.8	n/a	38.3	31.1	42.9	29.4	25.1
Any pesticides	95.9	98.4	n/a	94.5	95.8	97.2	91.9	97.6
Herbicides	95.5	98.4	n/a	93.9	95.8	97.2	91.5	97.5
Insecticides	0.5	nr	n/a	0.5	nr	nr	1.1	0.2
Average application rates (lbs./acre of active ingredient)								
Nitrogen	24	16	n/a	21	10	21	47	20
Phosphate	44	47	n/a	42	41	47	54	46
Potash	78	83	n/a	64	108	88	69	81
Herbicides	1.12	1.09	n/a	1.27	0.98	1.41	1.15	1.12
Insecticides	.17	.50	n/a	.17	nr	nr	.65	.45
Cotton:								
Planted acres (1,000 ac.)	6,258	2,994	n/a	175	255	678	n/a	10,360
Percent of planted acres treated with:								
Nitrogen	85.5	83.9	n/a	72.4	95.8	80.5	n/a	84.7
Phosphate	54.1	58.8	n/a	49.2	76.2	34.6	n/a	54.6
Potash	43.1	27.4	n/a	43.8	36.6	14.7	n/a	36.5
Any pesticides	98.6	99.3	n/a	100.0	100.0	95.5	n/a	98.7
Herbicides	91.7	94.0	n/a	100.0	90.6	83.9	n/a	92.0
Insecticides	65.0	63.1	n/a	62.9	65.0	71.1	n/a	64.8
Average application rate (lbs./acre of active ingredient)								
Nitrogen	96	73	n/a	94	129	87	n/a	90
Phosphate	47	45	n/a	42	49	58	n/a	47
Potash	63	51	n/a	42	36	35	n/a	58
Herbicides	2.31	1.64	n/a	1.53	1.43	1.25	n/a	2.01
Insecticides	2.31	1.43	n/a	1.20	2.80	1.50	n/a	2.00
All wheat:								
Planted acres (1,000 ac.)	16,861	n/a	2,275	11,311	628	25,036	n/a	56,110
Percent of planted acres treated with:								
Nitrogen	92.7	n/a	98.0	93.2	100	77.7	n/a	86.4
Phosphate	55.7	n/a	85.2	80.8	96.1	49.4	n/a	59.6
Potash	10.0	n/a	28.3	44.9	28.8	8.6	n/a	17.3
Any pesticides	49.9	n/a	96.2	64.0	94.9	64.1	n/a	61.5
Herbicides	48.9	n/a	96.2	62.5	94.9	63.4	n/a	60.5
Insecticides	2.7	n/a	nr	1.0	nr	1.4	n/a	1.6
Average application rates (lbs./acre of active ingredient)								
Nitrogen	65	n/a	78	82	62	52	n/a	64
Phosphate	34	n/a	30	44	25	28	n/a	34
Potash	22	n/a	12	48	13	24	n/a	35
Herbicides	.31	n/a	.46	.44	.32	.45	n/a	.41
Insecticides	.35	n/a	nr	.29	nr	.24	n/a	.30

nr = None reported. n/a = Not applicable. [1] For States included, see box "Cropping Practices Survey," p. 129. [2] See box "Crop Rotation Definitions," p. 145. Source: USDA, ERS, Cropping Practices Survey data.

soybean rotations occur at about the same frequency in both highly erodible and non-highly erodible land. In contrast, soil-conserving crops in cotton rotations occurred less frequently on HEL.

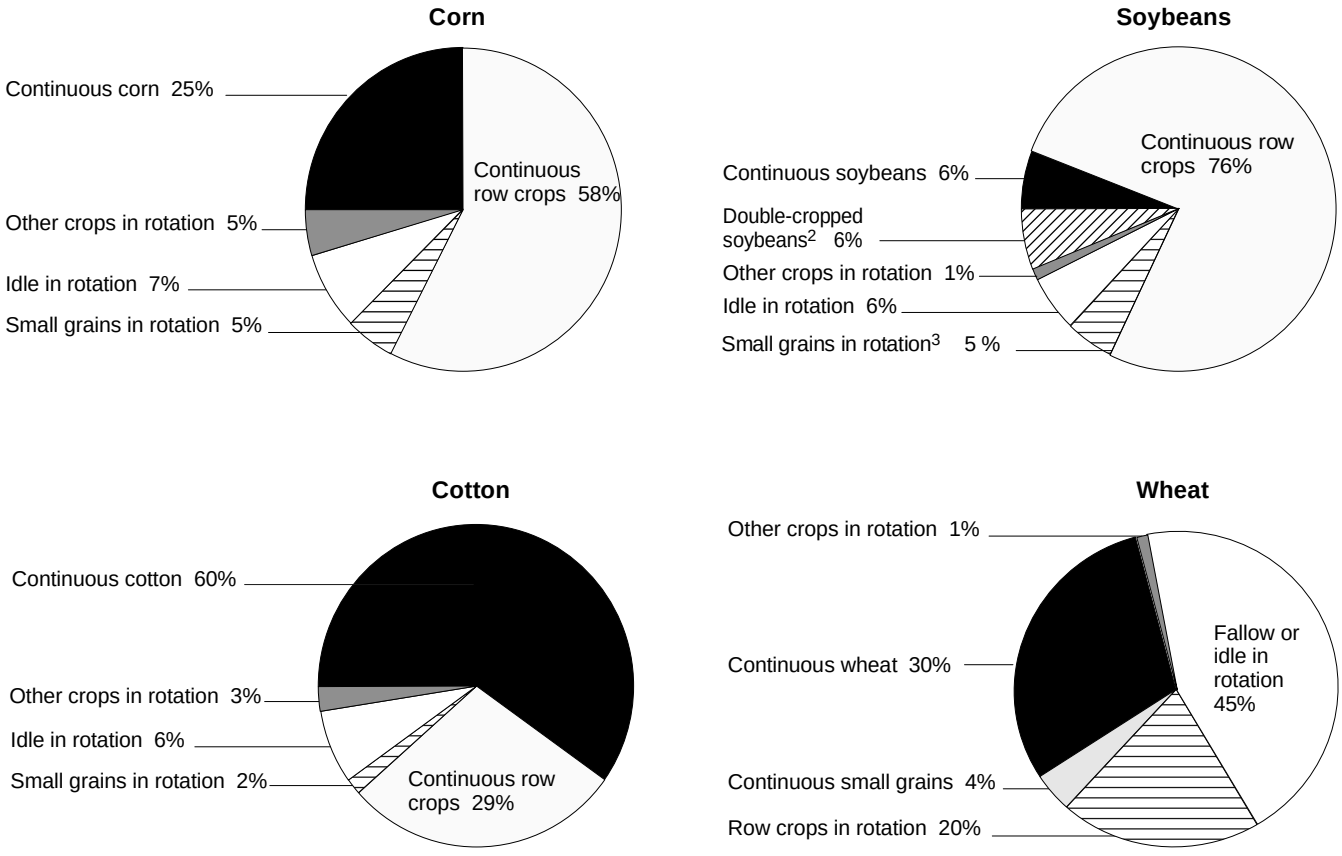
Pesticide and Fertilizer Use Under Different Crop Rotations

Crop rotation is often key to a sustainable agricultural production system and can reduce the need for fertilizer and pesticides. Fertilizer applications are often adjusted for prior nitrogen-fixing crops. Fewer pesticides may be needed when rotations break pest cycles or reduce infestation levels.

The use of herbicides in 1993 varied little between different corn rotations, but continuous corn more frequently used insecticides, especially to control corn rootworm (fig. 4.2.3 and table 4.2.1). Rootworm larvae populations most frequently reach damaging infestations when corn follows corn. Alternating another crop with corn usually eliminates the need for insecticide treatment for corn rootworm. Over 60 percent of the continuous corn acres were treated with an insecticide, compared with 8-26 percent of corn in rotation with other crops. This difference can mostly be attributed to the need to control corn rootworms.

Both herbicide and insecticide use were higher in 1993 on continuous cotton than cotton in rotation (fig. 4.2.4). While there was little difference in the proportion of acres treated, the annual per-acre treatments were greater on continuous cotton. The yearly quantity of pesticide applied per acre to continuous cotton was about 50 percent higher than

Figure 4.2.1
Crop rotations, 1993[1]

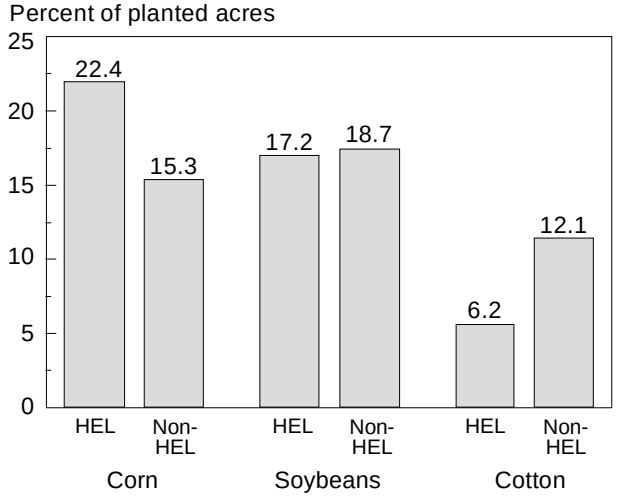


[1] Crop rotations are based on 1991, 1992, and 1993 crops only.
[2] Soybeans when preceded by winter wheat.
[3] Excludes winter wheat double cropped with soybeans.

Source: USDA, ERS, 1993 Cropping Practices Survey.

to cotton in rotation with other row crops. On average, about one additional herbicide and one additional insecticide ingredient were used with continuous cotton. Continuous cotton received an average of 7.1 pesticide treatments and 6.8 different pesticide ingredients compared with 5.1 treatments and 5 ingredients for other rotations.

Figure 4.2.2
Row crop acreage in rotation with soil conservation crops,[1] highly erodible and non-highly erodible land, 1993



[1]Other than continuous row crops.
Source: USDA, ERS, 1993 Cropping Practices Survey.

Relative to cotton and corn, soybeans and wheat used fewer pesticides in 1993 (table 4.2.1). Nearly all soybeans were treated with a herbicide, and there was little difference in herbicide use between rotations (fig. 4.2.5). Soybeans were rarely treated with an insecticide. Nearly 40 percent of wheat received no pesticides, and on the treated acres, the average number of products and application rates were much lower than for either cotton or corn.

Unlike continuous cropping of corn and cotton, continuous wheat received pesticides less frequently than wheat in rotation (fig. 4.2.6). Only about half of the acres in continuous wheat were treated with a herbicide in 1993 and the average amount of all herbicides applied was 0.31 pound per acre. About two-thirds of all wheat fallowed or in rotation with other crops was treated with herbicides and the average application rate was about one-third higher than for continuous wheat.

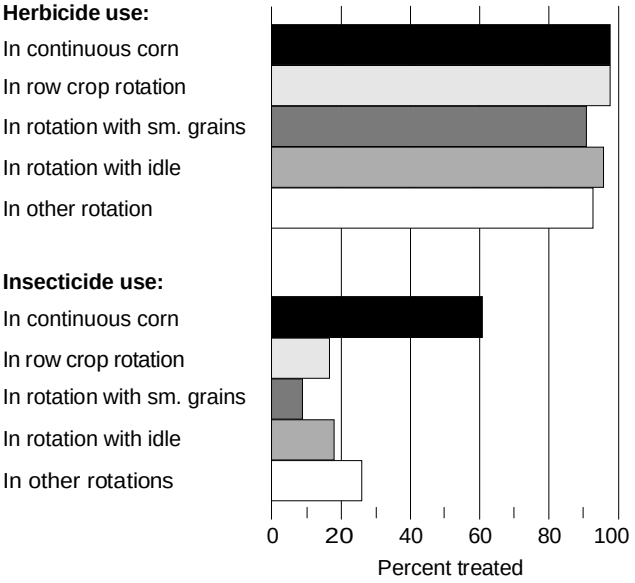
Table 4.2.2—Erodibility distribution of crop acreage by crop rotations, 1993

Category	Corn	Soybeans	Cotton	Winter wheat[1]	Spring wheat	Durum wheat	Total
Planted acres (1,000)[2]	57,350	42,500	10,360	37,210	16,950	1,950	166,320
Erodibility:			*Percent of planted acres*				
Highly erodible land	20	18	23	34	21	12	23
Land not highly erodible	75	79	68	62	77	86	73
Land not designated	5	3	9	4	2	2	4
Three-year crop sequence on HEL:			*Percent of HEL planted acres*				
Continuous same crop	26	4	63	24	13	n/a	22
Continuous row crops	52	80	31	n/a	n/a	n/a	34
Continuous small grains	n/a	n/a	n/a	id	6	14	id
Row crop and small grains[3]	3	7	2	13	7	nr	7
Idle or fallow in rotation	10	8	2	62	68	86	33
Hay or other crops in rotation	9	1	2	id	nr	4	4
Three-year crop sequence on non-HEL:			*Percent of non-HEL planted acres*				
Continuous same crop	24	6	60	46	14	14	24
Continuous row crops	60	76	28	n/a	n/a	n/a	44
Continuous small grains	n/a	n/a	n/a	id	14	12	4
Row crop and small grains[3]	5	12	2	14	44	13	11
Idle or fallow in rotation	7	5	8	40	26	57	15
Hay or other crops in rotation	3	1	2	id	2	4	2

n/a = not applicable. id = insufficient data. nr = none reported.
[1] Harvested acres for winter wheat only. [2] Preliminary. For the States included, see box "Cropping Practices Survey," p. 129.
[3] Includes double-cropped soybeans.
Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.3

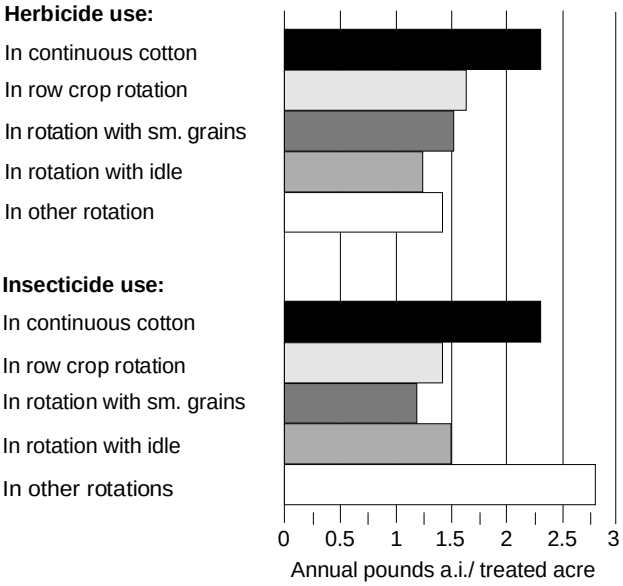
Corn acres treated with pesticides, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.4

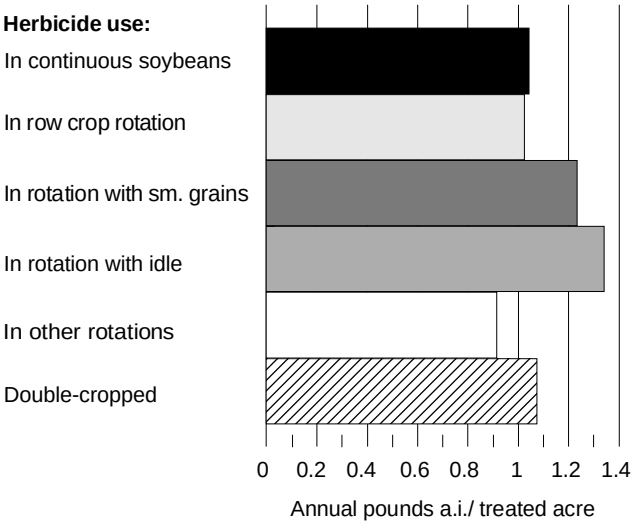
Cotton pesticide application, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.5

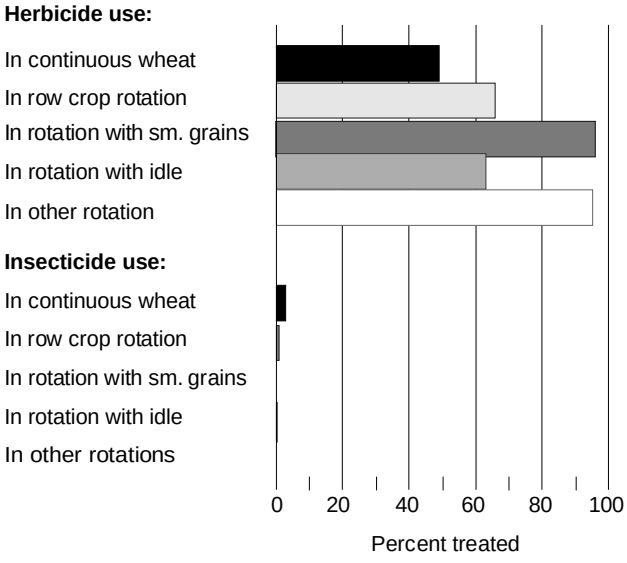
Soybean herbicide application, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.6

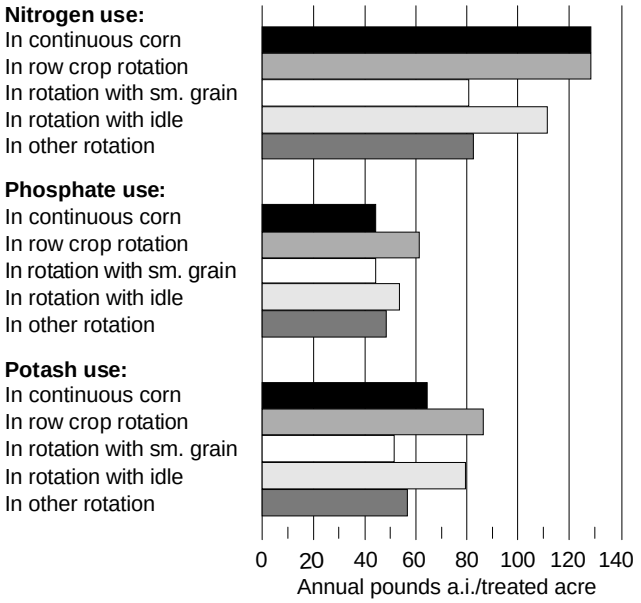
Wheat acres treated with pesticides, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.7

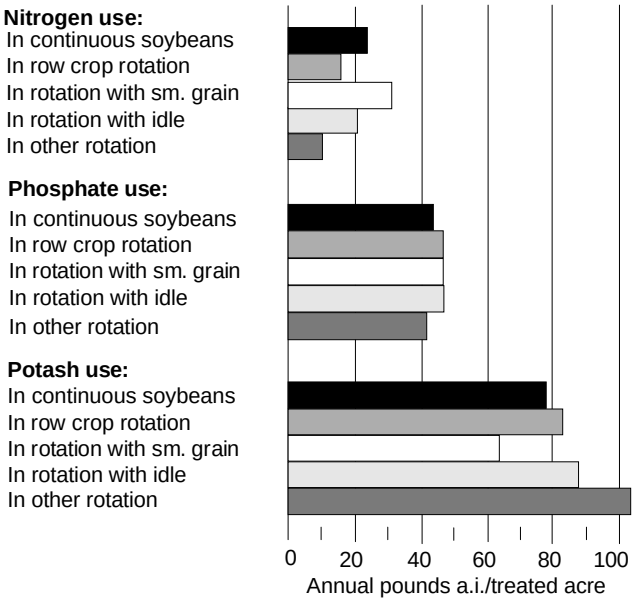
Corn nutrient application, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.8

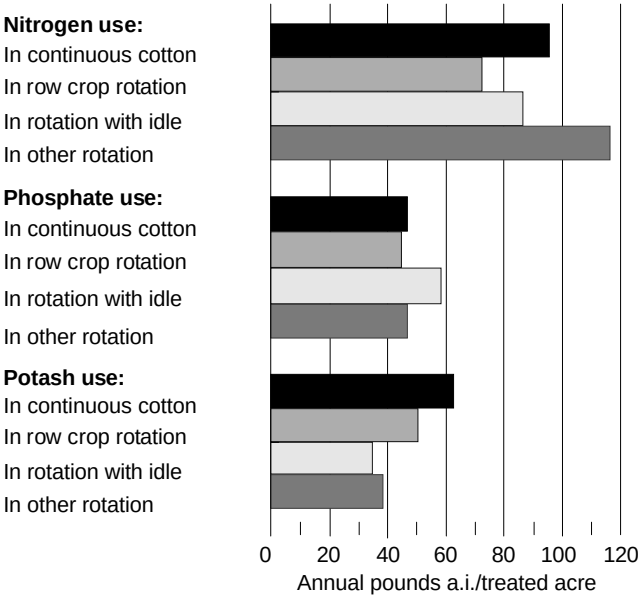
Soybean nutrient application, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.9

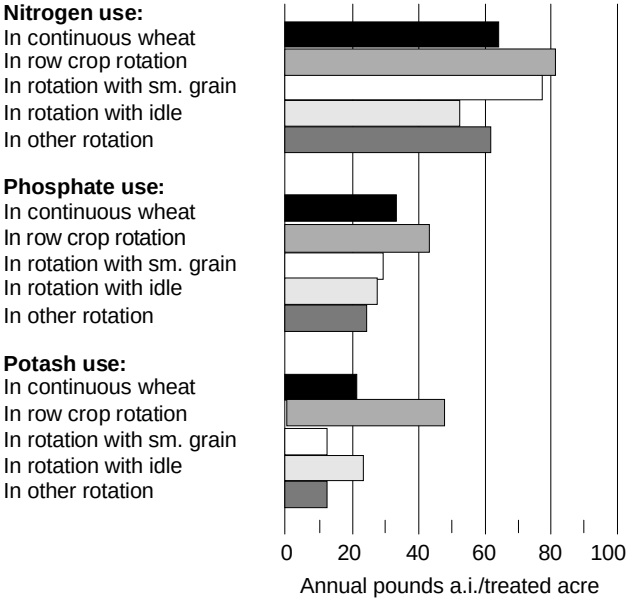
Cotton nutrient application, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Figure 4.2.10

Wheat nutrient application, by crop rotation, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

The 1993 Cropping Practices Survey reported about 5 percent of corn acreage, 3 percent of cotton acreage, and 1 percent of wheat and soybean acreage had hay or pasture in the preceding 2 years, which could provide some nitrogen carryover (figs 4.2.7-4.2.10). Where the previous crop was hay or pasture (other rotation), lower nitrogen applications were reported for corn; 85 pounds per acre in rotation with hay or pasture compared with 129 pounds when the land was in continuous row crops.

For wheat in 1993, a wheat-fallow rotation used the least amount of nitrogen. When wheat was preceded by fallow or idle, nitrogen was applied to 77 percent of the acreage at a rate of 52 pounds per acre, compared with 93 percent and 65 pounds for continuous wheat. Wheat-fallow rotations were primarily reported in the Plains and Mountain States, which have vastly different climatic and soil conditions than other wheat regions. However, in Kansas, which has about equal acreage in wheat-fallow and continuous wheat, more nitrogen was used with continuous wheat.

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Contributor: Leonard Bull.

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