

## General Crop Management Practices

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### Crop Rotations

Crop rotations can help control pests, supplement soil nutrients, improve soil tilth, and reduce soil erosion, but producers may have to forgo some income when the rotation includes low-profit crops [NRC, 1989]. Alternatively, producing the highest profit crop on the same land year after year (monoculture) is feasible on many soils with good management of the soil, nutrients, and pests. Besides farm profits, crop rotations may also affect the environment. Environmental effects from crops grown in one year that are erosive or require high levels of chemical input may be mitigated by crops grown in other years in the rotation that are less erosive or use fewer chemicals. For example, soil-conserving crops can be grown in rotation with erosive row crops to keep average soil loss under the tolerance levels. Another way crop rotation affects the environment is when crops grown in a specific sequence have a beneficial effect on the following crop. For example, a legume crop can lower the fertilizer needs for a following crop. Also, the rotation of different crops often breaks the pest reproduction cycle and lowers the need for pesticides.

Federal farm policy changes could encourage greater use of crop rotation. Early Federal Government price support program payments were calculated using a farm base acreage and yield concept that encouraged producers to plant program crops in order to maintain maximum eligibility. The Food, Agriculture, Conservation, and Trade Act of 1990 and the

Federal Agricultural Improvement and Reform Act of 1996 provided options to grow alternative crops and could encourage crop rotation when alternative crops are a profitable option to program crops [USDA, ERS, 1996]. The 1990 Act contained a flex-acre provision that allowed farmers to plant up to 15 percent of their contract acreage to certain alternative crops. The 1996 Act basically eliminated all acreage restrictions and allows farmers to respond to market signals without regard to future program eligibility. With these changes, farmers can select alternative rotations and not lose base acreage and eligibility for Federal support payments.

The information about preceding crops from USDA's Agricultural Resource Management Study was used to estimate acreage in alternative rotations or acreage where the same crop was produced for 3 consecutive years (monoculture) [USDA, ERS, 1996c]. Because some rotation systems last more than 3 years, the 3-year crop sequence available from the survey may not accurately reflect longer term rotation systems. Also, the constructed rotations represent only land where the 1997 planted crop was corn, soybeans, wheat, cotton, or potatoes. Additional area may be in some of the constructed rotations if crops other than those previously listed were planted or produced in 1997, for example, hay, other small grains, or other row crops. Estimates of winter cover crops were also constructed from the survey data. Any fall-planted small grain, hay, or meadow crops were assumed to be cover crops. (See box on Cover Crop Benefits, p. 62.)

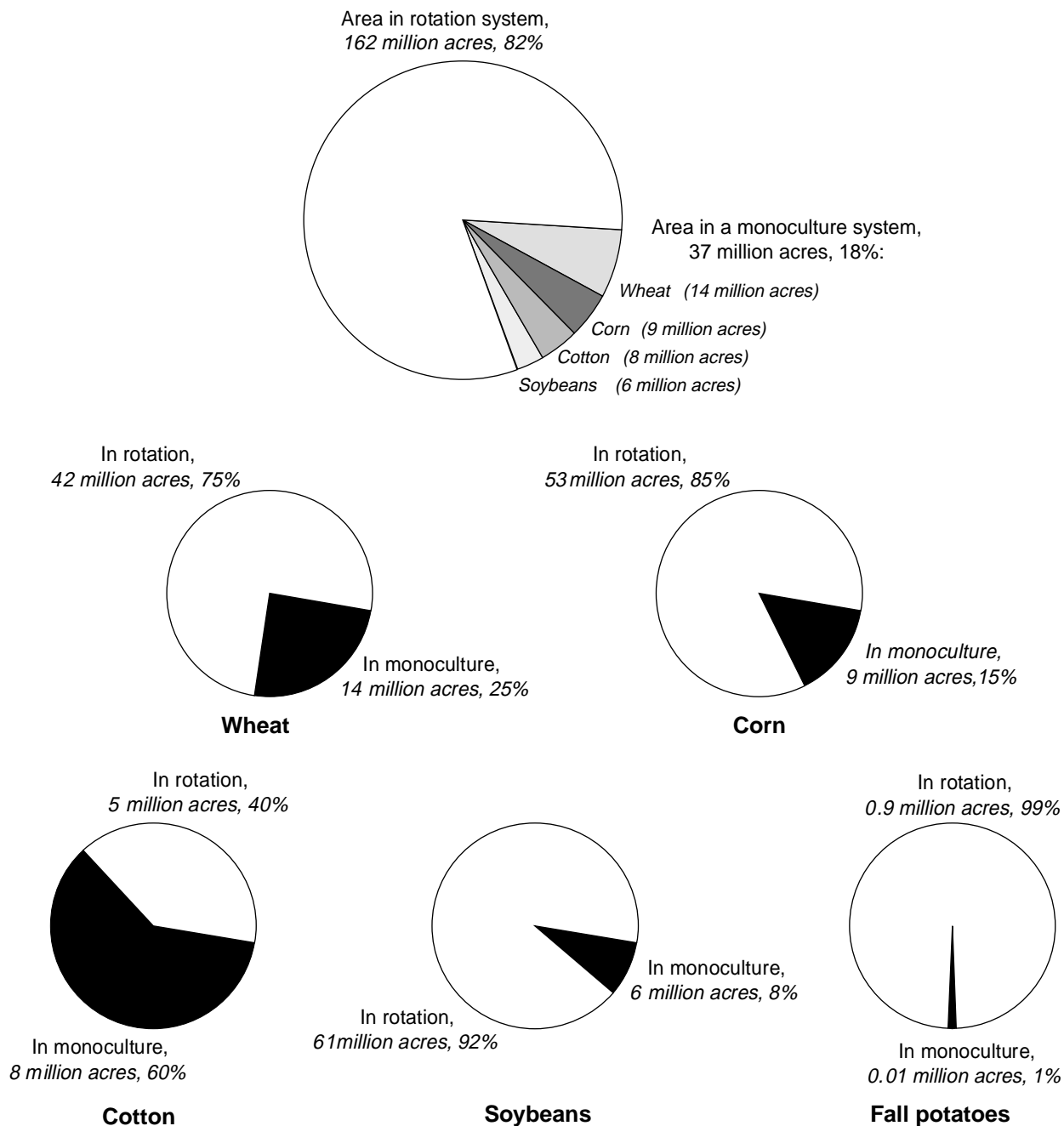
**Most Cotton Grown with Monoculture, but Crop Rotation is Common with Other Field Crops**

One-fifth of the total area planted to corn, soybeans, wheat, cotton, and fall potatoes in 1997 were also planted to the same crop in the preceding 2 years (monoculture practice) (fig. 4A). On the remaining area, a rotation with at least

one other crop or any idle year occurred in one or both of the 2 preceding years. Monoculture production practices were most widely used for cotton. Wheat and corn, however, accounted for the largest acreage of crops using a monoculture system. Monoculture was least used for soybeans and potatoes.

Figure 4A

**Most cotton grown with monoculture, but crop rotation is common with other field crops, 1997 1/**



1/ Represents 198 million acres of total U.S. cropland.

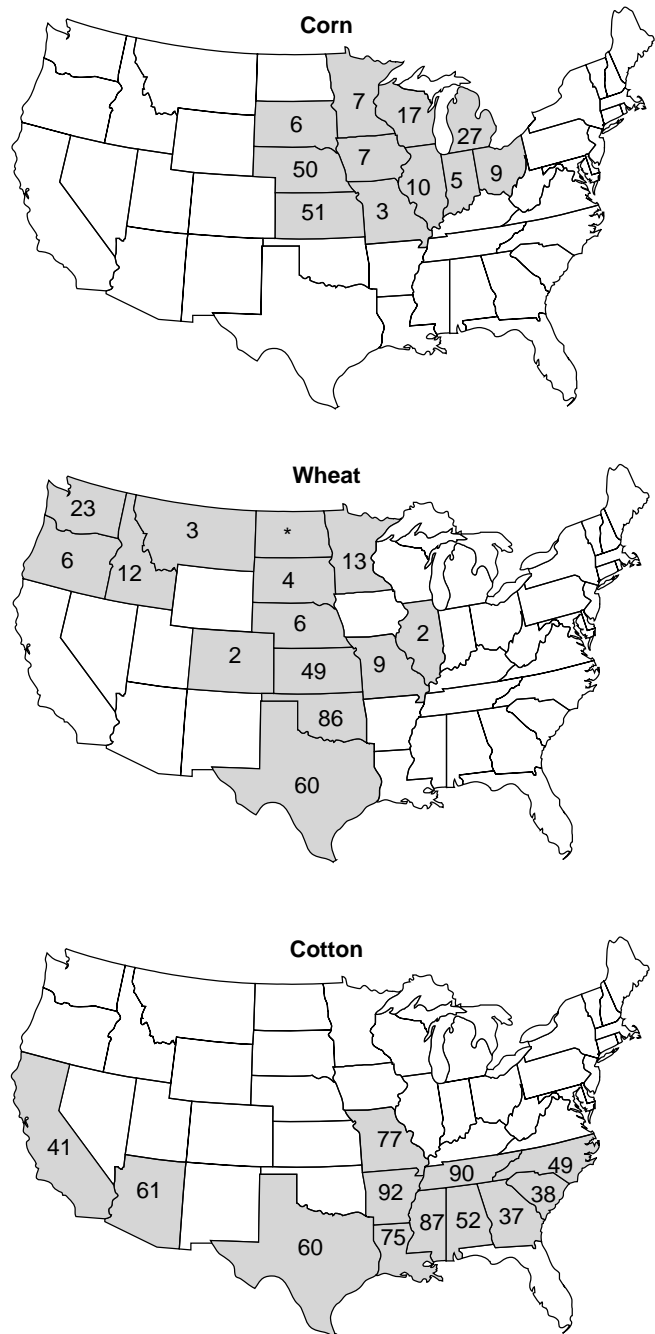
Sources: USDA, NASS and ERS, 1994, 1995c, and 1995d.

**Monoculture Practices**

Monoculture systems for wheat, corn, and cotton were concentrated in a few regions, mostly because of the uniqueness of soil and water resources (fig. 4B). Continuous wheat was more common in Texas and Oklahoma—States which receive sufficient annual rainfall for wheat but frequently too little rainfall to support row crops without supplemental irrigation. Most cotton produced in the Delta Region was grown with a monoculture practice. Cotton production relies heavily on insecticides to control damaging pests in this region. Continuous corn occurred throughout most of the corn-producing region. However, continuous corn was most common in Kansas and Nebraska—States that extensively use groundwater for irrigating corn.

Figure 4B

**Monoculture's share of planted area by crop and State, 1997 1/**



\* = Less than 1 percent.

1/ Monoculture area includes 9 million acres of corn, 8 million acres of cotton, and 14 million acres of wheat.

Sources: USDA, NASS and ERS, 1996c.

## Crop Rotation Benefits

Rotating crops can provide several kinds of economic and environmental benefits [NRC, 1989; Brust and Stinner, 1991; and Heichel, 1987]. Crop rotations are used to increase soil productivity and reduce the need for commercial fertilizers. Legume crops, especially small-seed legumes such as alfalfa, sweet clover, or lespedeza can supply large quantities of nitrogen to the soil over time and significantly reduce commercial nitrogen fertilizer needs for crops that follow [Power, 1987]. Soybeans, dry beans, and other large-seed legume crops provide most of their own nitrogen needs and also reduce commercial fertilizer needs for following crops. In regions with longer growing seasons, winter legume crops are also used to supply nitrogen and other soil nutrients for following crops. The organic matter supplied by previous crops, especially the roots of legumes and sod, supports soil micro-organisms that add other crop nutrients to the soil.

Crop rotation influences the length of time and the degree to which soils are exposed to the erosive forces of wind and water, critical factors affecting soil erosion rates on cropland [USDA, SEA, 1978]. Land planted to corn, soybeans, cotton, and other row crops is more prone to erosion than that planted to small grains, hay or meadow crops, because it lacks vegetative cover, especially during critical erosion periods. Crop rotations that include small grains, hay, or other closely grown crops quickly establish a vegetative cover and root structure that helps protect soils from erosion. When closely grown crops are grown in rotation with row crops, the average erosion rate of the full rotation sequence is reduced. Closely grown crops also provide crop residues that, depending on the residue management system, can help reduce the erosion rate of the following crop. Some soil conservation plans for highly erodible land use conservation crops in rotation with row crops to meet compliance erosion rates.

In semi-arid or other regions where soil moisture is a limiting production factor, rotations are commonly used to conserve soil moisture [Cook, 1986; NRC, 1989]. The practice of fallow is leaving land idle 1 year to accumulate additional moisture for the following crop. Soil management practices designed to increase rainfall infiltration, decrease transpiration, and decrease evaporation of accumulated soil moisture are used. Fallow is most common in wheat production areas in the Plains, Mountain States, and Northwest, but may also be used in other areas having low precipitation or soils with low water-holding capacity. Besides fallow, other crops in a rotation affect soil moisture. Deep-rooted forage crops, such as alfalfa, are often not grown prior to wheat or other crops highly dependent on topsoil moisture. Crops that are harvested early in the summer, such as winter wheat, oats, or rye, allow more soil moisture accumulation after harvest to benefit the following crop.

Crop rotations are effective in controlling many kinds of pests and can reduce the need for intervention with pesticides [NRC, 1989]. Rotations affect pest infestation in many different ways. Perennial grasses and legumes often provide good weed control because they compete with many weed species and when pastured or cut for forage the annual weeds are unable to produce seeds to infest future crops. Fallow tends to encourage weed germination during the idle year when there are many chemical and nonchemical options for their control. Weed infestations are reduced when fall-planted crops such as winter wheat or rye develop a vegetative cover before the spring germination of many weed species. Insect and disease pests, such as corn rootworm, often require the host crop to survive dormant periods. By planting alternate crops, many producers can eliminate or significantly reduce pesticide treatments for corn rootworm. Crop rotation can also be a critical component in reducing species resistant to a pesticide. Planting different crops usually allows the use of pesticides with different control mechanisms, helping to prevent the buildup of resistant pest populations.

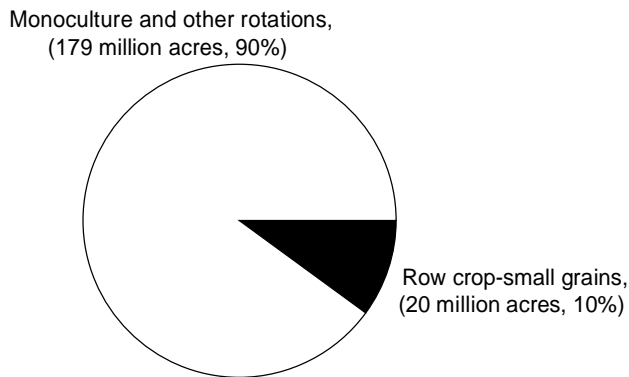
Crop rotations that increase the diversity of commodities produced on a farm may reduce the peak labor requirements or income risk. Peak planting and harvesting dates usually differ between crops. A more even distribution of fieldwork through the year gives operators an opportunity to make more efficient use of the available fixed labor supply. Because adverse weather or low product prices usually do not affect all commodities equally, the more diverse outputs from crop rotation help to stabilize and reduce the risk of low income in years with abnormal weather or low market prices for one or more major products.



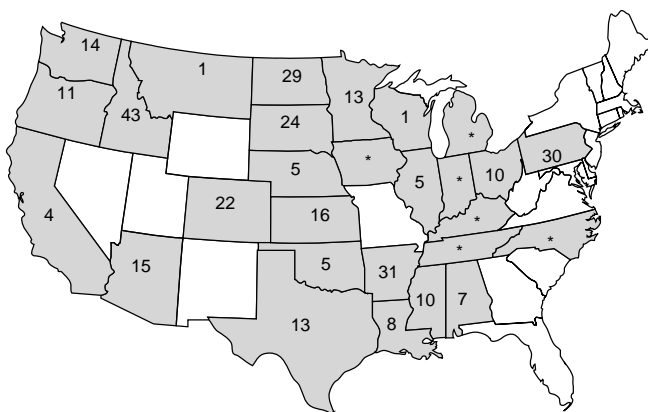
### Row Crops and Small Grains in Rotation

Small grains grown in rotation with row crops offer important environmental and conservation benefits over continuous row crops (including row crops grown with a monoculture system) (fig. 4E). Small grains help reduce average annual soil loss and are also helpful in controlling weeds and reducing herbicide needs. Crop rotations that included a combination of small grains and row crops contained many different specific crop sequences. Some of the more common sequences reported in the surveys were corn-wheat-corn, corn-wheat-soybeans, soybeans-rice, corn-oats-corn, potatoes-wheat-potatoes. Growing small grains and row crops in rotation with each other was most common in the Northern Plains. Some crop rotation was used for nearly all potatoes, and the crop in rotation with potatoes was most often a small grain.

Figure 4E  
**Row crops and small grains in rotation, 1997 1/**



Percent of major field crop area where both row crops and small grains are in rotation



\* Less than 1 percent.  
 1/ Represents 198 million acres of corn, cotton, potatoes, and wheat. The rotation includes any combination of row crops and small grains planted between 1995 and 1997. Double-cropped soybeans or small grains planted as winter cover crops are not included.

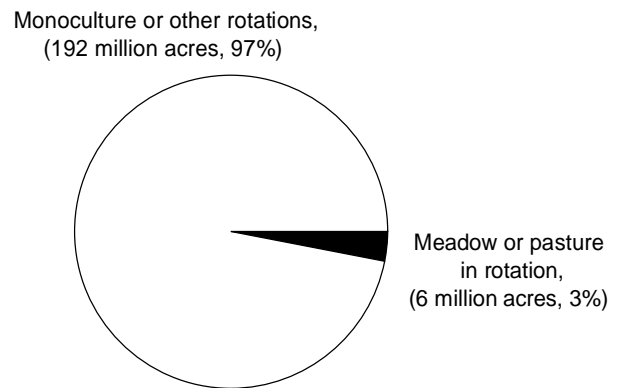
Source: USDA, NASS and ERS, 1996c.

### Rotations with Hay or Pasture Crops

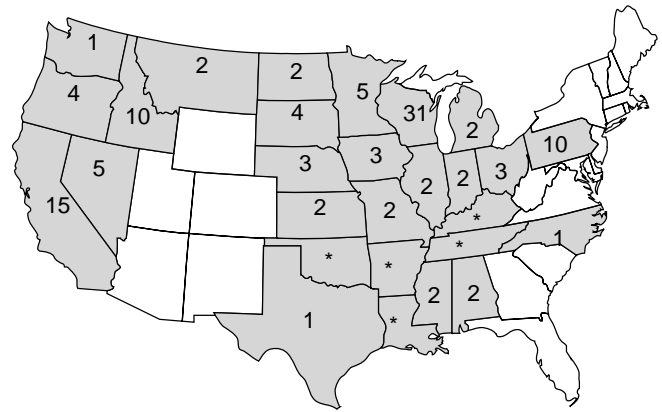
Although not widely used, hay and pasture crops in rotation with row crops or small grains can provide many environmental benefits (fig. 4F). Most hay and pasture crops are perennials and have year-round vegetative cover, which provides protection against soil erosion.

Rotations with hay or pasture crops were most common in Wisconsin, California, and Pennsylvania—States with many livestock operations, especially dairy. Without livestock operations or local markets for forages, meadow crops often have a high opportunity cost. The cost for special machinery, labor, transportation, and storage of hay crops can significantly reduce the advantages of including them in rotation with major field crops.

Figure 4F  
**Rotations with hay or pasture crops, 1997 1/**



Percent of major field crop area where hay or pasture was a previous crop



\* Less than 1 percent.  
 1/ Represents 198 million acres of corn, cotton, potatoes, and wheat. The rotation includes only acreage where alfalfa, other hay, or pasture was grown in either of the two preceding years. Areas in hay or pasture in 1997 are excluded.  
 Source: USDA, NASS and ERS, 1996c.

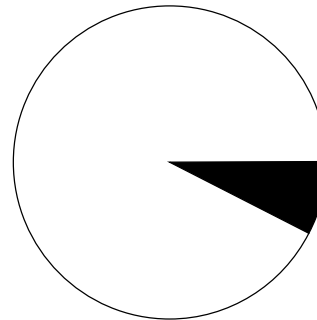
**Double-Cropped Winter Wheat-Soybeans**

In regions with longer growing seasons and sufficient rainfall, soybeans can be planted immediately after winter wheat or barley and allow the production and economic returns for two crops in one growing season (fig. 4G). Where feasible to use, this rotation also offers some environmental benefits. The winter wheat or rye provides the nutrient and soil erosion benefits of a cover crop as well as providing crop residue to reduce soil erosion during the soybean production period. The total annual applications of fertilizer and pesticide ingredients for both crops, however, are usually higher than for a single crop.

Figure 4G

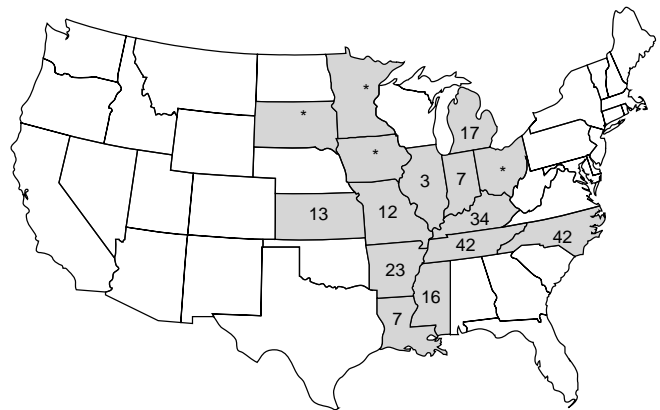
**Double-cropped winter wheat-<sup>1/</sup>soybeans, 1997**

Monoculture and other soybean rotations,  
61 million acres, 93%



Double-cropped soybeans,  
5 million acres, 7%

Share of double-cropped soybean area



\* Less than 1 percent.

<sup>1/</sup> Represents 67 million acres of soybeans planted in 1997. It does not include winter wheat harvested in 1997 when soybeans were planted in the spring of 1996.

Source: USDA, NASS and ERS, 1996c.

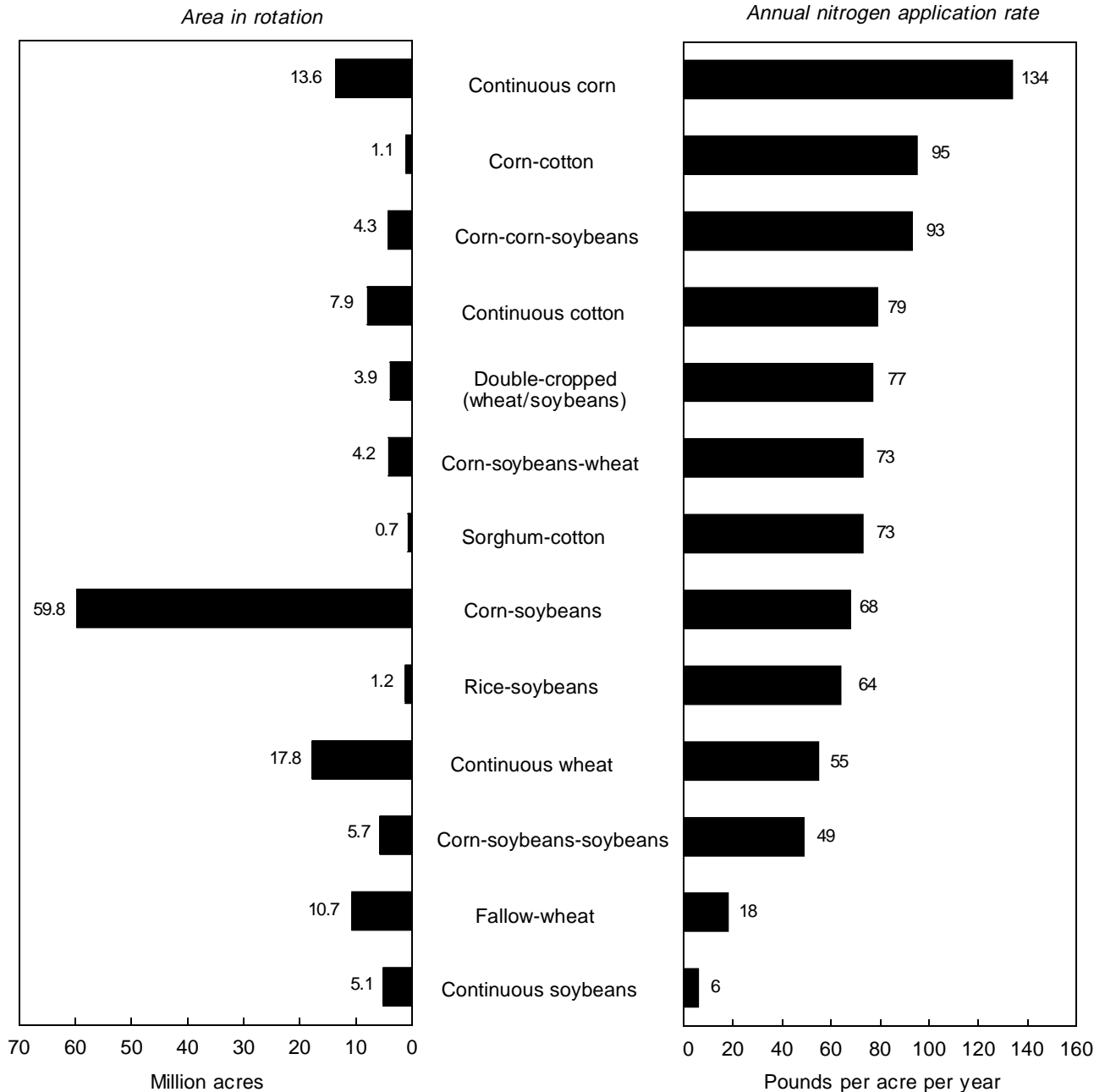
## Average Annual Nitrogen Use with Alternative Crop Rotations

Crop rotations affect the amount of nutrients and pesticides applied to crops in two different ways—one is the offsetting effects of crops with different nutrient needs and pest problems and the other is the effect one crop has on a following crop (fig. 4H). The survey data were used to construct average annual estimates of nitrogen use to illustrate

differences in input levels for several commonly used crop rotations. Estimates of usage rates for individual crops are also reported to illustrate the effect that one crop has on another when grown in a crop rotation. In a corn-soybean rotation, the average annual nitrogen application rate was 68 pounds compared with 134 pounds for corn in a monoculture system.

Figure 4H

### Average annual nitrogen use with alternative crop rotations, 1995



Source: USDA, ERS and NASS, 1995c.

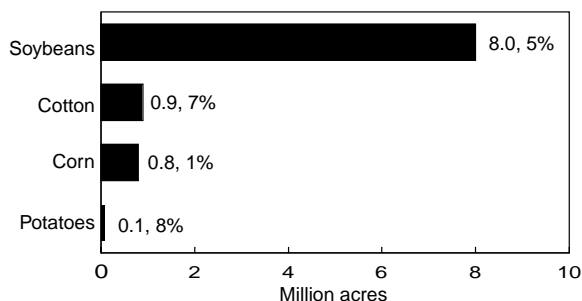


## Crop Area with Winter Cover Crops

Cover crops can be used to protect soil and water resources and improve soil productivity (fig. 4I). However, unless a harvestable grain or forage is produced, they may offer little economic gain to producers. The previous crop information from USDA's Agricultural Resource Management Study provides an estimate of the use of winter cover crops. The use of cover crops with corn, cotton, and soybeans was small compared with the total crop acreage, and its use var-

ied widely between the crops and production regions. The most prominent use of cover crops was with soybeans in Southern States. The cover crop was usually winter wheat or rye and was usually harvested (double-cropping). Cover crops are less common with corn and cotton, partially because they have longer growing seasons and there is less opportunity for the cover crop to mature and be harvested. Because winter wheat is planted in the fall, the total acreage provides cover crop benefits, even when a crop is not planted in the following spring or summer.

Figure 4I  
**Crop area with winter cover crop, 1997 1/**



### Percent of crop area with a cover crop planted



\* Less than 1 percent or none reported.  
 1/ The first value at the end of the bar is the number of acres with a preceding winter cover crop, and the second value is the percentage of crop area with a winter cover crop.  
 Source: USDA, NASS and ERS, 1996c.

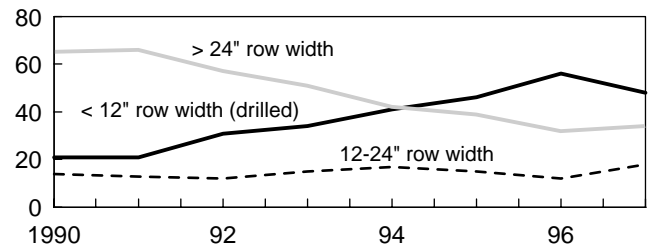
## Drilled and Narrow-Row Soybeans

Reducing row spacing by using either a drill or row-planter is a practice that can help some producers increase profits, but it also can be environmentally beneficial (fig. 4J). Narrower spacing between plants allows the crop to develop a full canopy over the land earlier, which can lead to increased photosynthesis and higher yields. Such planting also results in fewer pods developing at the bottom of plants, reducing harvest loss. An earlier crop canopy and more uniform distribution of roots from drilled or narrow-row soybeans can also reduce soil erosion and decrease the ability for late germinating weeds to compete. Some disadvantages to drilled and narrow-row soybeans are increased reliance on pre-emergence herbicides, elimination of row cultivation options, increased disease potential, and higher seed cost.

Since 1990, the share of soybean acreage drilled or planted in narrow rows has doubled with a corresponding acreage decrease in the area planted in rows 24 inches and wider. Besides the above advantages, the increase in no-till acreage and improved technology of no-till drills have also been factors affecting the adoption. While differences occur in the ingredients and timing of herbicide application between fields planted at different row widths, the overall application rates are nearly equal for all row widths.

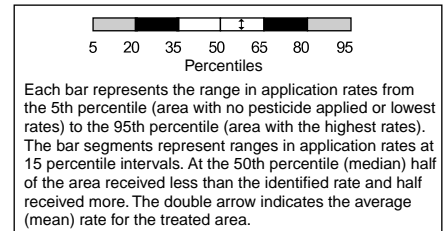
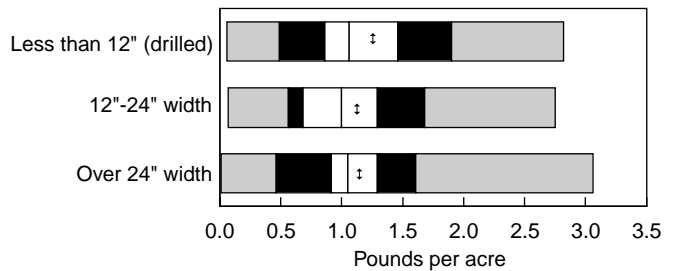
Figure 4J

### Drilled and narrow-row soybeans, 1990-97 1/



1/Represents only soybeans grown in OH, NE, IL, IN, IA, MN, and MO.

### Soybean herbicide use rates by row widths, 1997



Sources: USDA, NASS and ERS, 1996c.

## Cover Crop Benefits

Cover crops are grasses, small grains, legumes, or other crops grown between regular crop production periods for the purpose of protecting and improving soil and water resources. Cover crops prevent soil erosion and nitrogen leaching and help control weeds. They can also improve soil structure and nutrients by returning organic matter to the soil. Cover crops are most frequently planted in the fall following the harvest of a regular crop and then incorporated into the soil or used as a mulch before planting another crop the following spring. Cover crops also are used between crops at other times of the year and in orchards and vineyards to provide permanent vegetation. For some regions and crops, the growing season between regular crops allows the cover crop to mature and be harvested for grain, as with double-cropped soybeans. Cover crops can also be grazed or harvested as forage to provide economic benefits.

Cover crops such as rye, wheat, or other small grains germinate quickly and develop a vegetative cover that protects soils from wind and water erosion. The fast growing vegetation also takes up soil nitrogen thus reducing potential leaching. Compared with conditions without a cover crop, evapo-transpiration from the plants removes excess soil moisture, which can also reduce the potential for nitrate leaching. Besides returning nitrogen back to the soil when their residue is incorporated, these crops also add other organic matter to improve soil productivity. Legume cover crops such as clover or vetch can add nitrogen to the soil and may be planted to precede nitrogen-demanding crops such as potatoes, cotton, or corn. These legume crops are also used in orchards and vineyards to help supply nitrogen needs. Another advantage to cover crops is that the vegetative cover established over the winter helps to prevent spring germination of weeds.

## Organic Production Practices

Organic production practices were implemented on 0.2 percent of the 435 million acres of U.S. cropland and on over 1 percent of U.S. fruit and vegetable acreage in 1994, according to USDA's Agricultural Marketing Service (AMS) [Dunn, 1995] (figs. 4K1, 4K2, and 4K3). Fifty-nine percent of all organic acreage was devoted to cropland (669,000 acres). The majority of organic acres was for food crops, and fruits and vegetables represented 6 and 7 percent of the acreage, respectively. Other food crops included grain, dry beans, coffee, and other produce such as nuts, mushrooms, aloe vera, and herbs. The number of certified organic farmers grew by over 70 percent between 1991 and 1995 to approximately 5,000, according to USDA and private-sector reports [Fernandez-Cornejo, 1998].

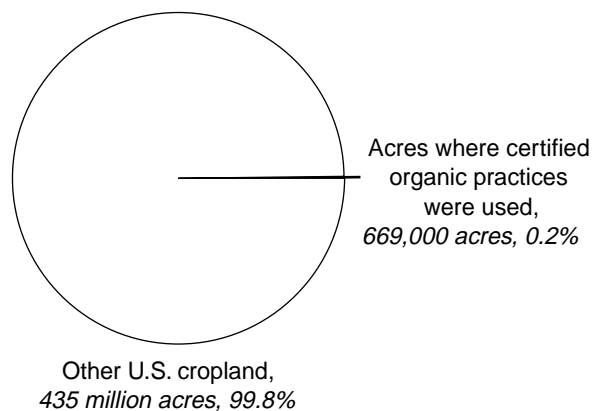
Though organic acreage is small, there is interest in organic production practices as an alternative technology to reduce chemical use and to maintain soil productivity. There is no national standard for certifying that a product is "organic," although USDA is in the process of developing uniform standards for all organic production. These standards will provide a national definition of "organic" that will better inform customers about organic products and may encourage organic production. Over 43 States have private and/or State organic certification programs that handle organic certification of production, but the standards differ between States. According to AMS, 73 percent of these organizations handle fruit and vegetable production.

USDA's Vegetable and Fruit Chemical Usage Surveys included questions about organic production and practices. In general, questions covered pest and nutrient management, operator characteristics, bearing or planted and harvested acreage, and other characteristics.

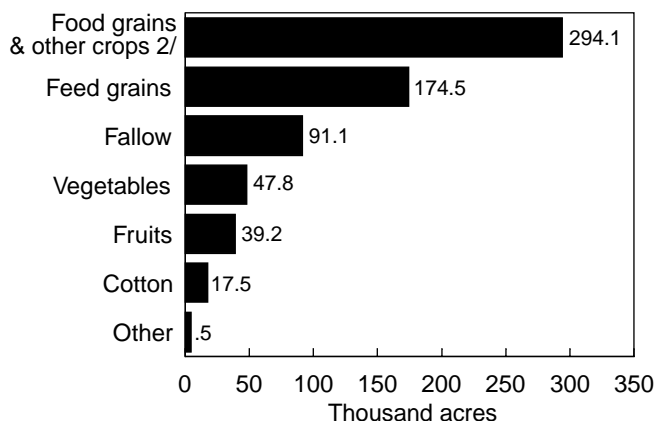
The sample of organic vegetable growers in 1994 (close to one-fifth of all certified organic growers of vegetables) showed that most of the growers used crop rotation and resistant varieties for disease and insect control [Fernandez-Cornejo, 1998]. Fruit growers were sampled in 1995 (15 percent of all certified organic fruit growers), and the analysis showed that most growers scouted their fields and used mechanical tillage for weed control. These growers also often planted legume crops and applied manure to provide nutrients to their cropland.

Figure 4K1

### Certified organic acreage, 1994 1/



### Crop acreage using certified organic production practices



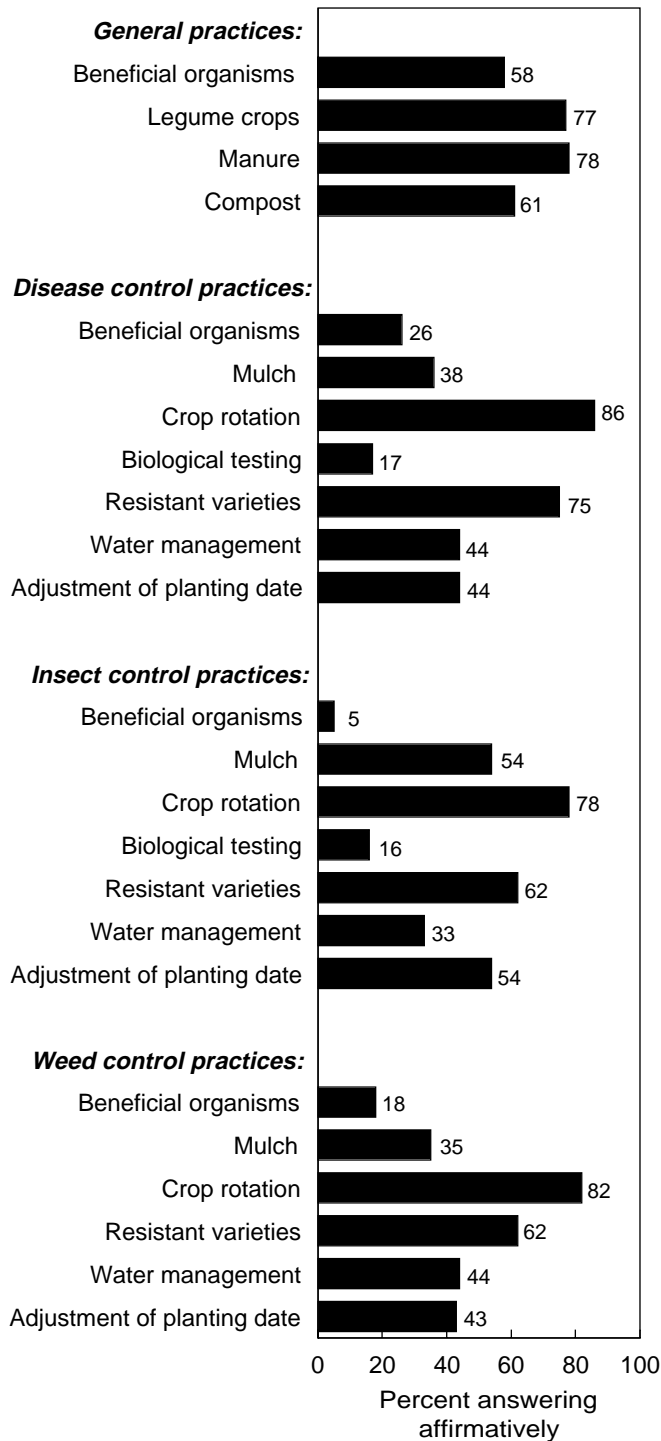
1/ Reflects private and State organic certification programs. Cropland total includes cropland harvested, pastured, idle, and other.

2/ Includes food grains, dry beans, coffee, and other produce such as nuts, mushrooms, aloe vera, and herbs.

Sources: Dunn, 1995.

Figure 4K2

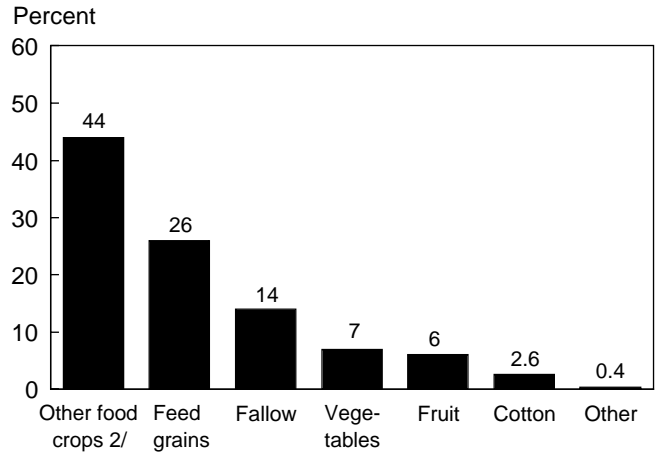
**Pest management practices used by organic farmers to produce vegetables, 1994**



Sources: USDA, NASS and ERS, 1994

Figure 4K3

**Proportion of organic cropland, by crop, 1994 1/**



1/ Crop area is reported as a percentage of the total organic cropland acres (668,690).  
 2/ Other food crops include grains, dry beans, coffee, and other produce such as nuts, mushrooms, aloe vera, and herbs.

Source: Dunn, 1995.