VERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE · COOPERATIVE EXTENSION SERVICE CIRCULAR 972

Should you fall-plow or spring-plow?

CONTENTS

This circular was prepared by H. P. Bateman, Assistant Professor of Agricultural Engineering, and T. D. Hinesly, Assistant Professor of Agronomy.

Urbana, Illinois October, 1967

Cooperative Extension Work, University of Illinois, College of Agriculture, and the U.S. Department of Agriculture cooperating. JOHN B. CLAAR, *Director*. Acts approved by Congress May 8 and June 30, 1914.

should you fall-plow or spring-plow?

SHOULD YOU plow your land in the fall or should you wait until spring? The answer depends on your soil type, the slope of your land, your available labor, power, and time, and the weather conditions.

Reasons Given for Fall-Plowing

In recent years an estimated 8 million acres of land in Illinois has been fall-plowed. Some reasons most often given for the increased amount of fall-plowing are:

- It provides for better distribution of labor.
- It helps to replenish available plant nutrients and water in the soil.
- It improves soil tilth.
- It lessens insect and disease hazards.
- It destroys weeds and volunteer corn.

Distribution of labor. With the use of larger machines and with field-shelling of corn, soybeans and corn are being harvested earlier thus leaving more time for fall-plowing. Some of the extra fall time is used to apply and plow under the major portion of the fertilizer required for the succeeding crop. Getting two time-consuming jobs out of the way during the fall leaves more time in the spring for other urgent work.

Replenishment of available plant nutrients and water. Fall-plowing intensifies the biological and chemical processes involved in the conversion of plant nutrients from an unavailable to an available form. However, the amount of additional plant nutrients made available by weathering due to fall-plowing is insignificant in comparison with the nutrients added as fertilizer. On the other hand, applying fertilizer and plowing too early in the fall may result in increased plant nutrient losses by leaching. Nitrogen, in particular, may be lost when the plowing is done while the soil temperature is above 50° F.

In warm moist soils, applied nitrogen in the form of anhydrous ammonia or ammonium salts is rapidly converted to the nitrate form of nitrogen. Nitrate nitrogen is highly mobile in soils and may be lost from the soils in drainage water, especially on sandy soils. But on most soils the greatest loss of nitrate nitrogen is by the process of denitrification. This is the loss of gaseous nitrogen from the soil which occurs when certain bacteria in soils make use of the oxygen present in nitrate nitrogen to carry on their respirational processes. Severe losses of nitrate nitrogen by denitrification often occur when the soil is saturated or nearly saturated with water. When the rate of oxygen renewal in the soil atmosphere is restricted by high soil moisture contents, the denitrifying bacteria use the alternative source of oxygen contained in nitrate nitrogen, reducing the nitrate nitrogen to a gaseous nitrogen oxide.

Therefore, the best way to prevent large losses of nitrogen by denitrification and leaching is to keep it in the ammonium form as long as possible. Ammonium nitrogen is firmly held in the soil and is not readily lost by leaching or by denitrification.

One way to prevent nitrogen losses is to delay fall applications until soil temperatures are below 50°. At temperatures below 50°, nitrifying bacteria are not very active, and most of the applied ammonia or ammonium-salt fertilizer will be retained in the soil in the ammonium ion form.

The first stage of nitrogen release from decomposing plant residues is the ammonia nitrogen form. To prevent the ammonia nitrogen from being rapidly converted to the nitrate form, a leguminous crop should not be plowed too early in the fall. Like fall applications of nitrogen fertilizer, leguminous crops should not be turned under until soil temperatures are low enough to inhibit the nitrifying bacteria. Furthermore, if the legume is plowed under the same year in which it is seeded, early fall-plowing may prevent the fixing of the maximum amount of nitrogen.

In 1953 an Iowa study in which time of plowing was a variable found that the catch crop did increase yields, but time of plowing did not appear to be a major factor in determining yields.[1] Although the Iowa study was designed primarily to study the effects of leguminous nitrogen and organic matter on crop yields in a corn-oats and corn-oats-sweet clover catch rotation, it is one of the few published reports of experimental results comparing fall- with spring-plowing.

Corn following a spring-plowed alfalfa meadow in 1959 and 1961

[1] DeBoodt, M. F., Englehorn, A. F., and Kirkham, Don. Fall- vs. spring-plowing and soil physical condition in a rotation experiment. Agronomy Journal 45:257-261. 1953.

Table 1. — Average Corn Yields (4 Replications) Following Alfalfa for Spring-Plowing and Fall-Plowing at Urbana

Date of planting	Time of plowing	
	Fall	Spring
	bushels per acre	
May 7, 1963	120	126
May 11, 1964	119	120
May 11, 1965	129	143
Three-year average yields	123	130

in Minnesota suffered a 40-percent reduction in yield as compared with yields from second-year and continuous corn.[2] The study concluded that alfalfa depleted a greater supply of the available soil moisture as a result of transpirational water losses during the fall and early spring growth periods. However, at Urbana average corn yields over a 3-year period were greater for spring-plowing a standover alfalfa meadow preceding corn on Drummer silty clay loam and associated soils than for fall-plowing it. Average yields for corn following alfalfa at Urbana for three consecutive years are given in Table 1. The alfalfa meadow was plowed either about November 15 or between April 12 and April 20 each year during the 3-year comparison study.

Since other studies have shown that very little additional nitrogen fixation is gained by the extra spring growth of a standover alfalfa crop, it is not likely that the increase of 7 bushels per acre for spring-plowing over fall-plowing, averaged over all years, is due entirely to a difference in nitrogen availability. At Urbana, additional nitrogen was applied in a complete starter fertilizer in the amounts of 30, 55, and 21 pounds per acre in 1963, 1964, and 1965 respectively.

Although the average yields shown in Table 1 are greater for spring-plowing, only in 1965 were the yields for spring-plowing significantly better than those obtained on fall-plowed land.

It appears that time of plowing-under a catch or meadow crop could be the most important factor in determining yields during years of short moisture supply on some soil types. Delaying the plowing of a legume hay or cover crop could decrease the moisture supply available to the succeeding crop in years when rainfall is not sufficient to completely recharge the available water-holding capacity of the soil after plowing. On the other hand, wet soil conditions may be improved for better pulverization by late spring-plowing a meadow crop on those soils that are poorly drained and frequently wet in the spring.

[2] Anonymous. Alfalfa and corn are high-moisture-use crops. Crops and Soils 17(2):19. 1964.

Because of the amount of spring rainfall generally received in Illinois, crops growing on those soils where fall-plowing is common seldom suffer a moisture deficiency attributable to late spring-plowing of soils where forage is growing. On some soils that are better drained, and especially on some moderately and steeper-sloping soils, spring-plowing a meadow crop may occasionally reduce the moisture supply available to the succeeding crop. But the meadow crop is usually grown in rotation on sloping soils as part of the cropping system to keep soil losses by erosion within practical limits. Therefore, the occasional reduction in yields from a moisture deficit does not justify increasing the number of years in meadow to lower soil loss by water erosion resulting from fall-plowing.

Soil tilth. If spring-plowed soils are to have good tilth, they must be plowed at the optimum moisture content for good pulverization. On poorly drained soils that have a high clay content, moisture conditions are often unfavorable for plowing in the spring. Spring-plowing clay and clay loam soils too wet often causes a "puddled" condition and excessive compaction resulting in a poor seedbed that requires several disking operations to sufficiently pulverize the soil. Such soils — at least those with a fairly high organic-matter content — are easily tilled the next spring after fall-plowing. Exposing plowed soil to the fluctuating winter weather conditions enhances granulation and disintegration of large clods by alternate freezing and thawing.

Plowed surfaces of soils have lower winter temperatures than unplowed surfaces because the conduction of heat from the deeper soil regions is not as rapid in the loose plowed soil. The alternating freezing and thawing processes are especially important in structurally rejuvinating soil surfaces that are often severly compacted during harvesting operations. On the other hand, compaction below the plowed layer may not be as effectively alleviated by winter freezing where fall-plowing is practiced because plowed soils do not freeze as deep as unplowed soils.

Most of the soils that are fall-plowed are wet, dark soils, called humic gleys. In Illinois there are approximately 6.5 million acres of cultivated humic gley soils. About 1 million acres of these soils have sandy loam-textured surfaces and should not be fall-plowed because they are subject to severe wind erosion. The remaining 5.5 million acres of humic gley soils have for the most part a surface texture classed as silty clay loam. These level soils, high in both clay and organic-matter content, are easy to prepare for a seedbed with a minimum of tillage after fall-plowing.

Very little of the relatively level, moderately dark- and light-colored soils in south-central Illinois are fall-plowed even though they often remain too wet for normal tillage operations until late spring. Since these soils have both a low organic-matter and surface-clay content, intensifying the freezing and thawing processes by fall-plowing often makes an already poor tilth problem worse. Fall-plowing these soils may be especially detrimental to tilth where continuous row cropping is practiced.

Insect and disease hazards. Fall-plowing has long been credited as a practice that aids in preventing the serious buildup of plant insect and disease hazards. However, evidence documenting the effectiveness of fall-plowing as a method of controlling plant insects and diseases is not available. The fact that most small-grain seedings are made on unplowed corn and soybean stubble indicates that most farmers rely on insecticides and resistant varieties as control measures for insects and plant diseases.

Weeds and volunteer corn. Fall-plowing may aid in destroying some weeds having perennial underground parts, but probably has little effect on annual weeds which must start from seed each year.

Since most volunteer corn comes from whole ears and since pickers are being made that glean fields cleaner, volunteer corn is not the serious problem it was in the past. Where corn is harvested early and field losses are small, fall-plowing plays only a minor role in reducing the amount of volunteer corn.

Early Planting

If some of the reasons given for fall-plowing were significant in crop production, one would expect that yields would surely be affected by time of plowing. However, this was not true for corn when a four-year comparison was made of spring- and fall-plowing a Drummer silty clay loam soil at Urbana (Table 2). All comparisons are for corn

Table 2. — Four-Year (1963-1966) Average Corn Populations and Yields for Fall-Plowing and Spring-Plowing at Urbana

Date of planting	Time of plowing	Stalks with ears per acre	Barren stalks per acre	Total stalks per acre	Yield in bushels per acre
May 3-7	Fall	19,100	1,700	20,800	129
	Spring	18,500	1,600	20,100	129
May 11-20	Fall	16,100	1,600	17,700	119
	Spring	16,400	2,100	18,500	119
May 25-June 9	Fall	14,900	3,400	18,300	101
	Spring	15,100	2,700	17,800	96

following corn on Drummer silty clay loam soil, a humic gley soil that is difficult to pulverize. See Table 3 (page 12) for the degree of pulverization at seed level for the two times of plowing.

The main thing to note from the data in Table 2 is that yields vary with date of planting, but not with time of plowing except for the late May or early June planting date. Germination also appears to decrease and the number of barren stalks to increase as planting is delayed.

Fall-Plowing and Soil Erosion

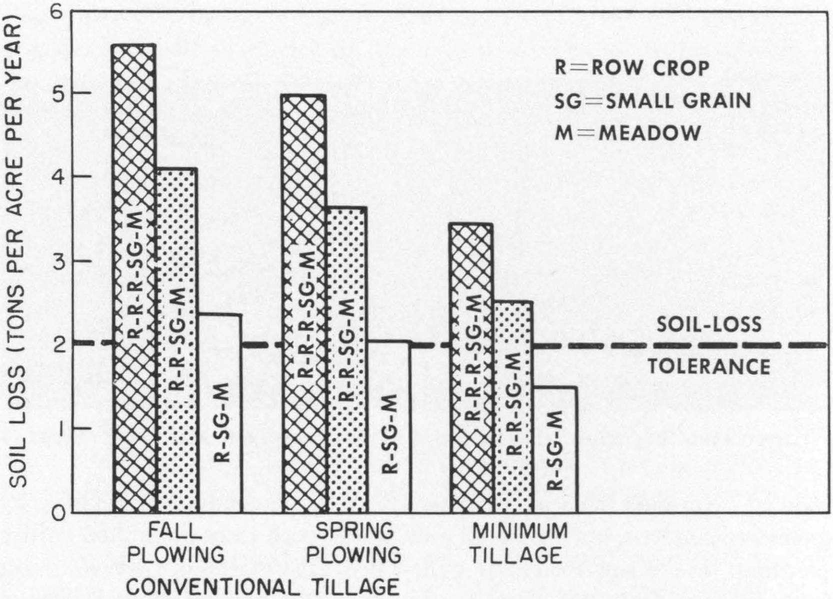
As early as 1946 Illinois farmers were cautioned against fall-plowing soils on slopes greater than 2 percent in northeastern Illinois. It was pointed out that the soils in northeastern Illinois developed from a thin blanket of loess resting on glacial tills of various kinds. For these soils the loss of topsoil is a serious matter. Once the subsoil has been exposed by erosion, these soils cannot be restored to even moderate production.

Shallow soils already bordering on an inadequate moisture storage capacity and underlain by strata of clay, bedrock, chert, shale, etc., that limit crop rooting depth, or by strata of gravel or sand having exceptionally low water-holding capacities, cannot be restored to their former productivity by the application of additional fertilizer after severe erosion.

Water erosion. Fall-plowing is risky on long slopes greater than 2 to 3 percent. Leaving the soil bare of residue and vegetation exposes the surface to the beating action of falling raindrops. Raindrops detach small particles and aggregates of soil from larger aggregates and clods. Some of the fine material detached by rain clogs the surface and reduces the rate of water infiltration into the soil. As infiltration decreases, water run-off increases and the detached material is transported off the field by the flowing water.

We are fortunate in Illinois that a large proportion of our soils are silt loams which are easy to prepare as a seedbed and have excellent fertility and water-holding capacities. However, these soils are very susceptible to erosion by water. Silt loam soil particles are not as easily detached by falling raindrops as sands and not as easily transported by flowing water as clays. But because of a balance between the ease with which silt-size particles are detached by rain and transported by flowing water, they are more likely to suffer from water erosion than either sandy or clay-textured soils.

Figure 1 shows the kind of water erosion damage that often occurs when silt loam soils with greater than 2 to 3 percent slopes are fall-



Soil-loss predictions from Clarence silt loam soil with various rotations and times of plowing. (Fig. 2)

In light of the predicted soil losses shown in Figure 2, fall-plowing Clarence silt loam will necessitate the addition of another year of meadow to even the least intensive rotation if soil losses by rainfall erosion are to be kept within the 2-ton permissible limit for the assumed percent and length of slope. Spring-plowing, with a rotation of one row-crop year in three, is needed to control erosion on this soil type. If a minimum tillage system where plowing is performed either with or immediately ahead of the planting operation is used, soil losses will be well within the safe limits for a row crop-small grain-meadow rotation. On slopes somewhat shorter than the 400 feet assumed here, using a minimum tillage system may allow the growing of two years of row-crop in a rotation with small grains and meadow.

On those deep silt loam and finer-textured soils that have a high resistance to rainfall erosion and are farmed less intensively than three row-crop years in five, fall-plowing slopes up to 3 percent may not cause soil losses exceeding the 5-tons per-acre per-year maximum permissible loss. But soils on slopes greater than 4 percent cannot be fall-plowed regardless of rotation without jeopardizing long-term yield capabilities.

Wind erosion. Although under the humid climatic conditions of

Illinois water erosion is the most serious menace to soils, in some years on some plowed soils wind erosion may also be a problem not only in the spring but also during the fall and winter.

Research has shown that dry soil particles of fine to medium sand grain size are readily set in motion by wind with speeds of 13 to 15 miles per hour one foot above a smooth soil surface.[4] Greater wind speeds are required to dislodge and set in motion particles of greater or smaller size. Particles smaller than these have greater cohesion and do not protrude high enough above the slow moving layer of air at the soil surface to be moved by turbulent winds. Particles larger than medium sand grain are not as readily moved by wind because the surface area per unit weight of particle presented to the force of the wind decreases as particle size increases.

Because of a higher rate of air flow at the upper surface than at the lower surface of a wind-erodible particle, it is made to roll and spin until the pressure difference between its top and bottom is great enough to overcome the force of gravity. Once the air pressure or force per unit area on the particle exceeds the force of gravity, erodible particles up to 0.02 inch in diameter may rise or jump a vertical distance of one foot or more. As they move across the soil surface in a series of short bounces they kick up dust particles, which would otherwise be resistant to wind erosion, into the turbulent air which may carry the small particles in suspension for several miles before they settle out.

Particles of soil having diameters greater than the most erodible sizes, about half the size of a wheat kernel, may be caused to slide, roll, and skip along the soil surface by bombarding impact of the bounding particles. Aggregated particles too large to be moved by wind may be broken down to erodible sizes by the abrasive action of eroding particles.

Since a particle or aggregate size of about half the size of a wheat kernel is the dividing point between the larger erodible and nonerodible soil grains, a rough index of soil erodibility can be determined by dry-sieving. If a soil contains at least two-thirds by weight of particles or aggregates too large to be moved by wind, it is fairly resistant to wind erosion.

The winter processes of rapid freezing, thawing, wetting, and drying of plowed soils aid in the pulverization of large clods and also often set the stage for severe wind erosion during the spring. These same processes often loosen large quantities of small water-stable aggregates that are of the proper size for wind erosion.

---

[4] Anonymous. A universal equation for measuring wind erosion. USDA, ARS. Special report 22-69. 1961.

Wind erosion in early April in central Illinois. The field on the west side of the highway (left side of the picture) was fall-plowed after the corn harvest. (Fig. 3)

Table 3 shows average dry-sieving data obtained from Drummer silty clay loam soil samples collected at seed level in the row after each of the three corn-planting dates given in Table 2.

Notice in Table 3 that there are over 50 percent more aggregates less that 0.03 inch in size in the fall-plowed sample than in the spring-plowed sample. Since some of the aggregates included in the 0.03- to 0.07-inch range are also included in the erodible fraction, one may conclude that fall-plowed Drummer silty clay loam is susceptible to wind erosion during spring dry periods. Like nearly all of the wet dark soils that are usually fall-plowed, the high humus and clay content of Drummer silty clay loam favors the development of a coarse state of aggregation which is not readily eroded by wind except under exposure

Table 3. — Percentages of Various Aggregate Sizes Obtained by Dry-Sieving Drummer Silty Clay Loam

Time of plowing	Aggregate size in inches					
	Less than 0.03	0.03-0.07	0.07-0.25	0.25-0.5	0.5-1.0	1.0-3.0
	percent of total dry-sample weight					
Fall	37	17	20	11	10	5
Spring	24	14	24	18	14	6

to extreme conditions of freezing and thawing. Thus a finer-pulverized seedbed is often achieved by fall-plowing at the expense of making the soil more susceptible to wind erosion.

Most wind erosion in Illinois occurs during the latter part of March and in April. Daily average wind speeds during this period may be only 8 or 9 miles per hour one foot above the soil surface, but wind erosion can take place since daily maximum wind speeds sometimes exceed 20 miles per hour.

The results of wind erosion like those shown in Figure 3 are not an uncommon sight where expansive areas of dark-colored prairie soils are fall-plowed.

The sharp contrast, shown in Figure 4, between the amounts of eroded soil in the highway drainage ditch adjacent to a fall-plowed and an unplowed field graphically illustrates the value of leaving plant residues on the soil surface to protect it from wind erosion.

Wind erosion begins with soil particles about the size of fine and medium sand grains on the windward side of the fall-plowed fields. The intensity of erosion increases progressively with distance across the plowed field. As erodible particles are moved by the wind across the field, more erodible-size particles like those shown in Figure 5 are produced by abrasion and the wearing away of nonerodible-size clods.

Once wind erosion begins, it can continue at wind velocities very much lower than the velocity required to initiate soil movement. The process usually ceases only as particles of an erodible size are trapped by mulches of residues on unplowed soils, in cover crops, or in ditches, ridges or some other rough soil surface. Rains may temporarily stop wind erosion, but most of the erodible particles are water stable and movement begins again as soon as the soil surface becomes dry.

The lower part of this photograph shows the same field pictured in Figure 3. The upper portion shows another field that was also in corn the preceding year but was not fall-plowed. (Fig. 4)

Well-sorted erodible particles such as these accumulate as they fall into the relatively still air at the bottom of the drainage ditch shown in Figure 3 on page 12. (Fig. 5)

It is somewhat of a paradox that those soils that are usually fall-plowed to obtain a better seedbed are among those most subject to wind erosion. This is because they suffer less crusting by rainfall and produce the greastest number of water-stable particles of erodible size. These soils also occur in areas of the state with the greatest density of drainage districts. Thus, from the farmer's point of view, the most costly direct result of wind erosion is probably the increased assessment by the drainage district for cleaning drainage ditches. Like the highway ditch in Figures 3 and 4, drainage ditches and grass waterways often become the depository for wind-eroded material. However, another direct cost is the loss of fertility because the most fertile soil material is moved off the field by wind erosion.

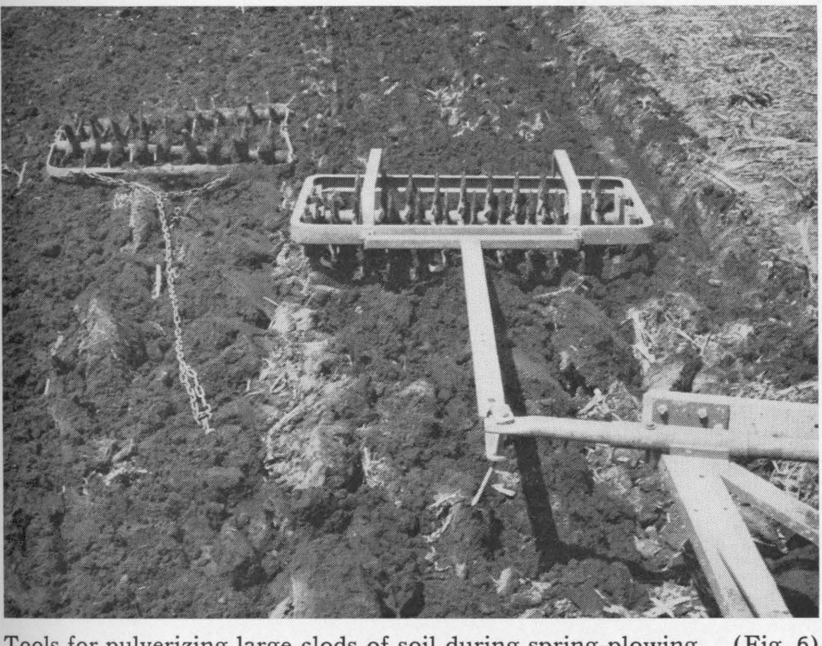
Some Considerations Before and Alternatives to Fall-Plowing

Data collected for 13 years by the Illinois Cooperative Crop Reporting Service show that during the first six weeks after April 1 Illinois farmers have an average of 20 to 25 days that are favorable for field work. The number of favorable days is least in the southeastern area of the state and greatest in the northwestern area.

The obvious solution to many of our soil-management problems is to leave the previous crop residues on the soil surface as long as possible. One of the major benefits of minimum-tillage systems is that the residues protect the soil against the weather until planting time. Furthermore, minimum-tillage systems require less labor than conventional tillage systems for corn or soybeans. Therefore, if you farm sloping land or land that suffers from severe wind erosion, you can conserve your soil and still get your planting done by the middle of May by adopting a minimum-tillage system. If you do fall-plow your level land, one disking or cultivation to kill weeds just before planting is all the tillage you will need for making a good seedbed.

Some land is fall-plowed because it is difficult to obtain adequate pulverization for seedbed after the clods produced by spring-plowing have dried. On many soils this problem can be reduced by pulling a tiller or mulcher tool, like those shown in Figure 6, behind the plow. Clods that are difficult to pulverize after drying are often easy to work at the moisture content that is optimum for plowing. These machines pulverize or cover large clods so they do not become extremely dry and difficult to pulverize.

Those wet dark soils that are so seldom at an optimum moisture



Tools for pulverizing large clods of soil during spring-plowing. (Fig. 6)

content for spring-plowing should be left rough after fall-plowing until immediately ahead of planting. This is especially true if wind erosion has been a serious problem. Since wind erosion increases with width of field, only those areas that cannot be spring-plowed should be plowed during the fall. For large areas subject to wind erosion that must be fall-plowed, leaving unplowed strips at about 50-yard intervals to trap the erodible particles or aggregates is an effective method of preventing excessive soil losses from the field. The unplowed strips should be of some convenient width for plowing-out just ahead of planting the next spring. To provide adequate capacity for trapping eroding particles and to prevent them from jumping the unplowed strips, a width of at least 15 to 20 feet is usually needed.

Many farmers in recent years have adopted the practice of fall-plowing as a means of applying fertilizer, thus deleting this time-consuming operation during the spring season. If this is your main objective and you are fall-plowing sloping soils or soils that have poor tilth, a chisel plow can be used for incorporating fertilizer and increasing the surface water storage on and infiltration into sloping soils while leaving some of the residues on the soil surface to help control erosion.

Most of the major implement companies now make field cultivator-planter combinations. Most of the fertilizer may be applied in the fall or early spring with the chisel plow and the field cultivator-planter may be used for the planting operation. When there is a high amount of corn left in the field, turning under ears of corn with a moldboard plow will do a better job of controlling volunteer corn than chisel plows. But if volunteer corn in soybeans is a persistent problem, an effort should be made to leave less corn in the field.

The Decision

When all factors are taken into account, it appears that the best time to plow depends on the objective to be achieved. If you want a better distibution of labor, you may accomplish this at the risk of losing some fertility and the expense of soil erosion by water and wind.

Soil type and slope are the keys to whether to plow in the fall or the spring. Your county extension adviser or soil conservationist can help you with soil reports and maps that give the exact soil type and the slope of the land on your farm. Make your decision after consulting these reports and maps and after considering your available labor and the objectives you wish to achieve.

12M—10-67—94635