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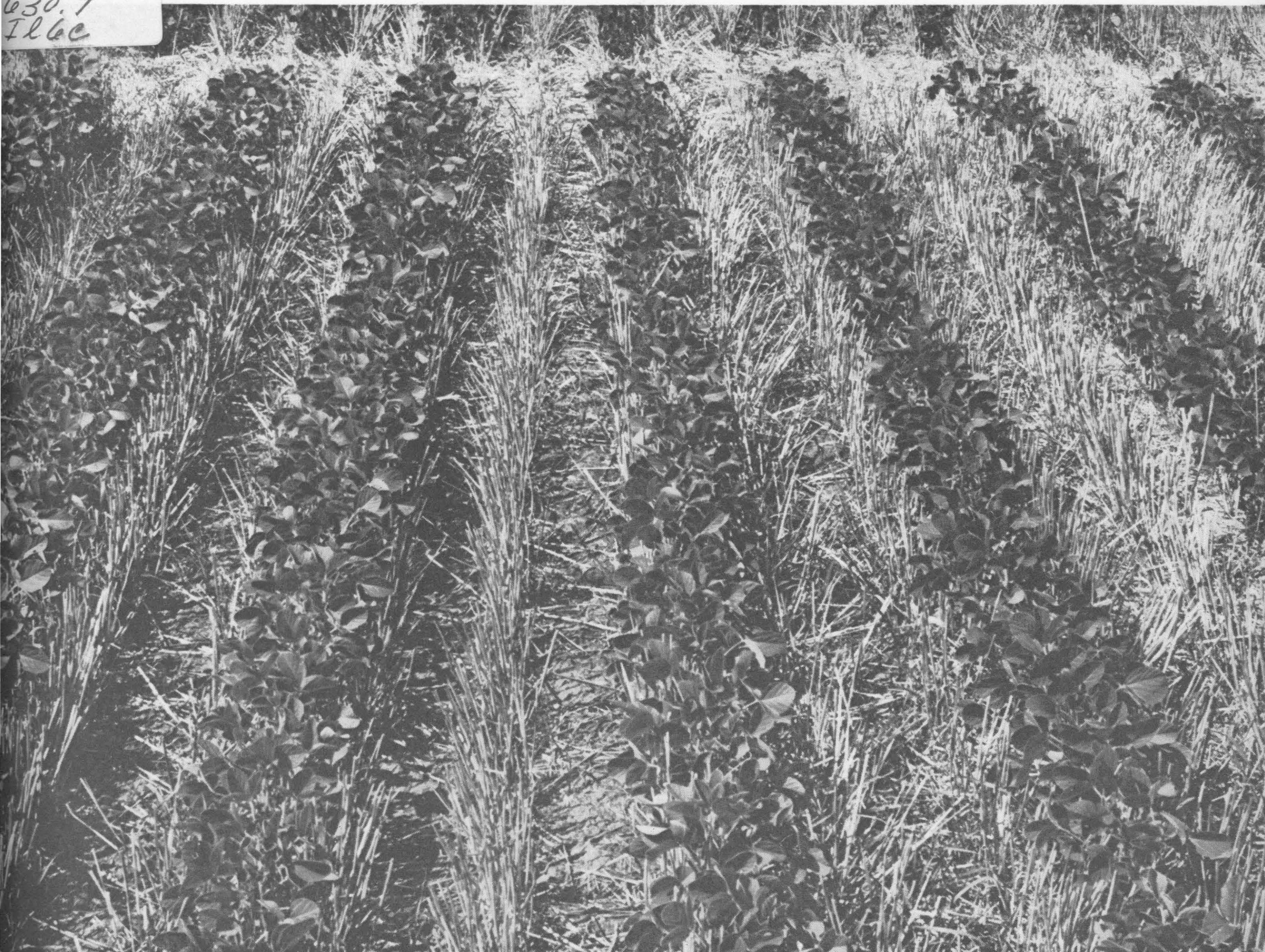

ILLINOIS AGRONOMY HANDBOOK 1974

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CORN

Planting Date

Plant early if possible. Yields will be higher on the average. In addition the plants will be smaller, ears lower, and more uniform in height.

Start anytime after April 1 in southern Illinois, April 10 to 15 in central Illinois, and April 20 to 25 in northern Illinois. In central and northern Illinois the corn planted in April may yield no more than that planted during the first few days of May. However, starting in April improves your chance of finishing in early May.

The temperature of the soil may be used to help you decide whether to start planting in April — don't worry about soil temperature after May 1.

Here are two useful guides, though they may not be correct all the time.

1. Plant when the temperature at *7:00 a.m. reaches 50° F. at the 2-inch level.* This will assure a temperature favorable for growth during most of a 24-hour period if there is an appreciable amount of sunshine.

2. Plant when the temperature at *1:00 p.m. reaches 55°F. at the 4-inch level.* The 4-inch level is suggested for the 1:00 p.m. measurement because this level is not affected as much as the 2-inch level by a single day of bright sunshine. After May in central Illinois and May 10 in northern counties, *plant if the soil is dry enough even though temperature is below* the suggested guidelines. Perhaps a simple way to say it is: early in the season plant according to soil temperature; later on plant by the calendar.

Incidentally, soil temperature data put out by the weather bureau are taken under sod where the midday temperature at 2 to 4 inches is often 8 to 12 degrees lower than under bare ground.

Extra Early Corn Planting When Soil and Weather Conditions Permit

It is a reasonable goal to plant 25 percent of your corn acreage two weeks before and 10 percent three weeks before the normal planting date for your area when a good seedbed can be prepared and soil temperature is favorable. The ideal would, of course, be to select the optimum date based upon long-term research tests and to plant the entire acreage on that date. Unfortunately, that is not how the real world operates. Here then are six reasons for extra early planting.

1. When you intentionally delay planting after soil conditions are right you have lost control of your date of planting in that year. Wet weather may set in and keep you out of the field far beyond the optimum date. Or the opposite may occur — the seedbed may dry so seed will not germinate. Early planted fields would have sprouted and become established before the seedbed dried out. That happened in the case of soybeans in some areas in 1972.

2. The optimum date to plant is slightly earlier than *is indicated by published date-of-planting studies* because there was no plant population variable included in the research studies. Since extra early planting allows a few additional thousands of plants per acre, farmers can capitalize on this and often harvest a greater yield advantage for earlier planting than is indicated in the research trials.

3. The average yield reduction from planting ten days too early is less than from planting ten days too late.

4. Having some extra early planted corn spreads the risk of unfavorable weather at the critical silking time which interferes with kernel set.

5. The earlier that corn is ready for harvesting in the fall, the better the chances of field drying and of avoiding field losses from bad weather and excessive stalk breakage.

6. There is often a slight price advantage for early harvested corn in the fall.

The hazards of early planting include: a) poor stand because of a cold, wet soil; b) weed problems in case the soil is too wet for timely cultivation; and c) frost injury. Frost effect is undoubtedly grossly exaggerated in the minds of most farmers. The weed problem can be largely offset by the proper choice of preemergence herbicide. The hazard of poor stand from cold, wet soil is real, but is far less of a danger than 30 years ago because of modern seed treatment. Furthermore, in the unlikely event of very poor growing conditions, an inadequate stand can be corrected by replanting for the cost of seed plus the planting operation itself.

We are not aware of any case of loss of stand by frost as the result of too early planting in Illinois during the past 15 years. Substantial acreages of corn were frosted in 1963, 1965, and 1972. The dates of frost ranged from May 30 to June 21. Corn planted at normal dates was as vulnerable as the extra early planted fields. Loss of stand occurred only when there was an extended period of poor growing weather after the frost.

The reason why frost effect is usually small is that it kills only a few leaves on the young corn plants. These leaves, though the upper ones at the time of frost, would have soon become the lower leaves on fully grown plants and were destined to soon become ineffective because of being shaded by leaves further up the stalk when the plant reached full height. Most of them in fact break off before the plant is full grown. The growing point of corn is seldom killed by freezing because it is below ground level until the plant is about knee high.

Researchers at the Michigan Agricultural Experiment Station planted corn about April 15 for at least 14 consecutive years. The corn was often frosted once and sometimes twice with little effect on yield.

Degree Days and Corn Development

Temperature records can be used to predict the maturity development of corn. The greater the amount of solar energy received, the more rapid the development of corn toward maturity. Corn hybrids of differing maturities require differing amounts of solar energy to reach maturity.

The "degree day" is used to describe and record the solar energy received.

The Illinois Cooperative Crop Reporting Service and the Weather Bureau calculate and report the accumulation of growing degree days for the state during the period April 1 to November 1.

The formula used is:

$$\frac{\text{Maximum daily temperature} + \text{Minimum daily temperature}}{2} - 50 = \text{growing degree days}$$

Since corn grows little, if at all, at temperatures lower than 50° F., this temperature is substituted for the actual minimum whenever the daily minimum drops below 50° F. Eighty-six degrees is substituted for the maximum whenever the daily maximum exceeds 86° F. Therefore, 50° F. is the lower cutoff temperature and 86° F. the upper cutoff temperature. The estimated growing degree days and departure from average for 1972 are:

	Section of state				
April 1-Oct. 1	NW	NE	W	C	E
Degree Days	2,932	2,782	3,223	3,191	3,127
Departure from normal	−165	−295	−134	−86	−70
April 1-Oct. 1	WSW	ESE	SW	SE	
Degree Days	3,377	3,429	3,797	3,581	
Departure from normal	−302	−160	−189	−274	

Planting Rate

The optimum planting rate might be defined as the one that will result in the maximum population that can be supported with normal rainfall and distribution without excessive barren plants or pollination problems. This population will be slightly more than optimum in years with less than normal rainfall and probably less than optimum in years of higher but not excessive rainfall.

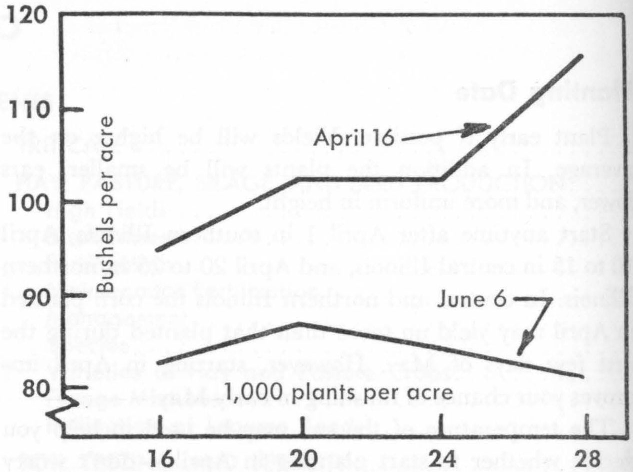
Many facts must be known before determining the optimum population for a particular field. These include:

1. **The crowding tolerance of the variety.** Varieties differ in their ability to tolerate high populations (Table 1).

2. **The fertility level, especially nitrogen.** Increase the amount of nitrogen applied as population increases (Table 2).

3. **Row width used.** Population can usually be increased 2,000 to 4,000 plants per acre when rows are narrowed from 40 inches to 30 or 20 inches without any serious increase in barrenness or pollination problems. The result is an increase in yield (Table 3).

4. **Planting date.** Varieties that tolerate high plant populations may be planted at a higher population when planted early than when planted late (Fig. 1). There are several reasons for this. First, the early planted corn is shorter. Second, the early planted corn is more likely to pollinate during a period with favorable rainfall and temperature. Third, less of the subsoil moisture reserve has been used up. Moisture stress during the pollinating period is aggravated by high population.



Planting date and population, Dixon Springs, 1968. (Fig. 1)

In summary, a specific recommendation on planting rate is impossible unless such facts as the soil type, fertility level, date of planting, and so on, are known. If you are changing varieties or making a major change in some other practice, increase the population by 2,000 to 4,000 plants per acre over that which you normally use. Do this in two or three places in the field and check the effect of the increase in the fall.

Table 1. — Effect of Crowding on Corn, Urbana, Illinois, 1966

Variety	Plants per acre planted in 30-inch rows		
	16,000	24,000	32,000
	Bushels per acre		
A.	127	140	153
B.	126	98	62

Table 2. — Effect of Nitrogen and Plant Population on Corn Yields, Northern Illinois Experiment Field

Nitrogen	Plants per acre		
	16,000	22,000	28,000
Pounds per acre		*Bushels per acre*	
0	88	83	76
240	139	148	158

Table 3. — Effect of Row Width on Corn Yield, Urbana, Illinois, 1964-66

Plants per acre	Row width	
	40 inches	30 inches
	Bushels per acre	
16,000	127	132
24,000	133	144
32,000	126	138

Research in Progress

High-lysine corn made its commercial debut in 1969. Lysine is one of the amino acids essential to animal life. Ruminants need not be concerned whether the protein they eat contains this amino acid because the microflora in their rumen can synthesize lysine from lysine-deficient protein. Non-ruminants cannot do this, so swine, poultry, and humans must have a source of protein that contains sufficient lysine to meet their needs.

Normal dent corn is deficient in lysine. The discovery in 1964 that the level of this essential amino acid was controlled genetically and could be increased by incorporating a gene named Opaque 2 was exciting news to the corn geneticist and the animal nutritionist.

The potential value of this discovery to the swine farmer was obvious when feeding trials demonstrated that growing swine needed very little additional protein when fed high-lysine corn.

Agronomic research work with high-lysine corn indicates that it is slightly lower in yield and higher in moisture than its normal counterpart. It also has a softer kernel which sometimes contributes to stand loss under adverse weather conditions.

Current research with more sophisticated hybrids indicates that the differentials in yield may be overcome. Continued work will probably solve the other problems in the future.

Swine growers should explore the possibility of growing high-lysine corn.

Liguleless or upright-leaved corn development and research indicates these types are more tolerant of high populations. One form of the upright leaf angle is controlled by a gene known as liguleless. Upright leaves in the upper part of the corn plant allow more light to penetrate deeper into the leaf canopy, providing more solar energy for leaves in the lower half of the plant at the earshoot level.

Illinois researchers have shown that as the corn leaf becomes more upright the amount of photosynthesis done by a given area of a leaf is slightly less. However, the upright leaves allow more light to penetrate into the canopy and enable the lower leaves to conduct photosynthesis at a greater rate than under heavily shaded conditions. Better distribution of light energy over the plant should return a higher yield.

High-oil corn. In the summer of 1896, Dr. C. G. Hopkins started breeding corn for high oil content. With the exception of three years during World War II, this has been a continuing research at the University of Illinois. The oil content of the material that has been under continuous selection has been increased to 17.5 percent as compared with 4 to 5 percent which is normal for dent corn.

Until recently efforts to develop varieties that were materially higher in oil than normal dent corn resulted in disappointing yield performance. Recent research results, which involve new gene pools of high-oil material unrelated to the original Illinois High Oil, indicate that varieties which contain 7 to 8 percent oil may be produced with little or no sacrifice in yield.

Commercial high-oil varieties are available. The question of yield as compared with normal corn will be determined in the field. However, there will probably be little difference.

Since oil is higher in energy per pound than starch, a ration containing high-oil corn should have some advantage over one containing normal corn. Feeding trials involving high-oil corn generally confirmed this assumption.

The corn-milling industry interest in high-oil corn as a source of edible oil is increasing. Corn oil has a high ratio of polyunsaturated fatty acids to saturated fatty acids and it is used in salad oils, margarine and cooking oils.

Waxy maize. Waxy maize is a type of corn that contains 100 percent amylopectin starch instead of 75 percent which is normal for dent corn. Amylopectin starch is used in numerous food and industrial products.

Our chief source of supply of amylopectin starch prior to World War II was tapioca which was imported from eastern Asia. The Japanese occupation of what was then known as the Dutch East Indies essentially cut off our supply of tapioca and an emergency program to develop and produce waxy maize was undertaken by the government.

After the war, waxy maize continued to be an important supply of amylopectin starch. Several corn milling companies annually contracted for its production in the central Corn Belt.

The results of recent feeding trials at the University of Illinois indicate that the value of waxy maize as a livestock feed may have been overlooked.

These trials, which involved lambs and yearling steers, showed that animals fed waxy maize gained faster and more efficiently than those fed normal corn.

The waxy characteristic is controlled by a recessive gene. This makes isolation from normal corn important because kernels pollinated by pollen from normal corn will develop into normal dent corn.

An isolation of 40 rods from normal corn is often required when waxy maize is being produced for milling purposes. Waxy maize being grown for feeding purposes should also be isolated. Regardless of the use intended, it should not follow normal corn because of the danger of volunteer plants appearing in the field.

High-amylose corn. High-amylose corn is corn in which the amylose starch content has been increased more than 50 percent. Normal corn contains 25 percent amylose starch and 75 percent amylopectin starch.

The amylose starch content is controlled by a recessive gene. Therefore isolation of production fields is important, as is selecting production fields that were not in normal corn the previous year.

Fertilizing Corn

Corn is the first or second most important crop on most Illinois farms, hence much of the fertility program is aimed at its efficient production. Corn responds well to the three major nutrients, is moderately tolerant of variations in pH, and should be watched for possible micronutrient problems on very high pH, sandy, and organic soils. There is no simple recipe for efficiently fertilizing corn. The best available information is presented here and on pages 38 to 48.

Nitrogen

Harvested crops remove more nitrogen than any other nutrient from Illinois soils. Erosion if allowed to occur reduces nitrogen because the surface soil is richest in nitrogen and it erodes first. Further losses of nitrogen occur through volatilization (following denitrification) and leaching, especially on sandy soils. About 40 percent of the original content of nitrogen and organic matter have been lost from typical Illinois soils since farming began.

To replenish the nitrogen supply, forage legumes which take nitrogen from the air and add it to the soil fit well into livestock farming systems. Legume acreage has declined to near 5 percent of the cropland. Nitrogen fertilizer is therefore needed for efficient production and to preserve soil productivity. In order to minimize the contribution of nitrates to surface and ground water, fertilizer nitrogen should not be applied at unnecessarily high rates or at improper times. These topics are discussed in the following sections.

The response to fertilizer nitrogen depends not only upon soil type and the cropping system but also on the kind of job a farmer does in growing corn. Farmers who make better choices of planting date, hybrid, population, and weed-control practices may profitably apply far more nitrogen than their neighbors for the same kind of soil and cropping system. Nitrogen suggestions for four situations are given in the following paragraphs.

Situation 1. Corn after corn in a continuous corn or corn-soybeans grain-farming system: 125 to 200 pounds of nitrogen per acre.

Rates of 160 to 180 pounds of nitrogen have generally given the most profitable yield responses in experiments at the Illinois research fields and centers in recent years. A lower rate (125 to 160 pounds) is suggested for fields where soil physical properties often limit yields to 100 bushels or less (sands and poorly drained, slowly and very slowly permeable soils). Rates higher than 160 to 180 pounds per acre are likely to be most profitable only for highly productive soils (150 bushels or more per acre in favorable years) on which excellent supporting practices are used and where the application is split between preplant and sidedress.

High rates of nitrogen increase the nitrogen content of residues returned to the soil, thus increasing the nitrogen the soil can supply for the next corn crop and reducing the fertilizer needed.

If you plan to apply more than 150 pounds, consider a split application: 100 to 125 pounds in the late fall or in the spring before planting, and an additional amount as a sidedressing if warranted after evaluation of the situation when the corn is 12 to 18 inches tall. (a.) Estimate how well your fall or early spring application has been preserved. (b.) If you planted early, and have 20,000 or more plants per acre, weeds under control, and a good supply of subsoil moisture, then sidedress with 75 to 100 pounds of nitrogen. (c.) If the crop outlook is not favorable, you may dispense with sidedressing unless you feel that nitrogen loss from your previous application was large.

Situation 2. Corn following soybeans, a small grain (no catch crop), or one year of corn in a farming system that includes a legume hay crop or catch crop once in 5 to 6 years: use 100 to 150 pounds of nitrogen per acre on dark-colored prairie soils and 125 to 150 pounds on light-colored timber soils.

Apply the lower rate in either case where soil physical properties limit average yields to only 85 to 100 bushels with good management. The higher rate is suggested for superior management on soils with 5-year average yields in the 110- to 140-bushel range. These soils will produce 150 to 180 bushels in the best years without uneconomically heavy rates of fertilizers.

Situation 3. Corn following a good legume sod or 10 tons of manure per acre: use 75 to 125 pounds of nitrogen per acre.

Dark prairie soils with a good legume sod or 10 tons of manure will usually supply enough nitrogen for 100 bushels of corn per acre. Farmers who aim for 150 to 180 bushels will need to apply 100 to 125 pounds of nitrogen per acre.

For light-colored timber soils and the claypan soils in south central Illinois, 75 to 100 pounds of nitrogen are suggested. The top rate is less than for dark soils because yield potentials are less.

Situation 4. Corn following both a good legume sod and animal manure. No extra fertilizer nitrogen is likely to be profitable.

Adjust rate for date of planting. Research at the Northern Illinois Research Center for several years showed that as planting was delayed, corn responded less to nitrogen fertilizer. Based upon that research, Illinois agronomists suggest that for each week of delay in planting after the optimum date for the area, the nitrogen rate may be reduced 20 pounds per acre down to 80 to 90 pounds per acre as the minimum for a corn-soybean cropping system for very late planting. Suggested reference dates are April 10 to 15 in southern Illinois, April 20 to May 1 in central Illinois, and May 1 to 10 in northern Illinois. This adjustment is, of course, possible only if the nitrogen is sidedressed.

Because of the importance of planting date, farmers are encouraged not to delay planting in order to apply nitrogen fertilizer: plant, then sidedress.

Which nitrogen fertilizer? Each nitrogen fertilizer has certain advantages and disadvantages over all others. For many uses on a wide variety of soils, all nitrogen fertilizers are likely to produce about the same yield increases.

One exception is that fertilizers containing a considerable part of the nitrogen in nitrate form are not suitable for fall application on any soil or early spring application on sandy soils because of the likelihood of leaching. Nor are they suitable for soils that are often very wet in April and May because of possible loss by dentrification. Anhydrous ammonia may have a slight advantage for fall application because the high NH_3 concentration delays nitrification and keeps more nitrogen in the ammonium form, so it cannot be lost by leaching or denitrification.

Time of Nitrogen Application

Choosing the best time to apply nitrogen fertilizer requires an understanding of how nitrogen behaves in the soil. Key points to consider are the change from ammonium (NH_4^+) to nitrate (NO_3^-) and the movements and transformations of the nitrate.

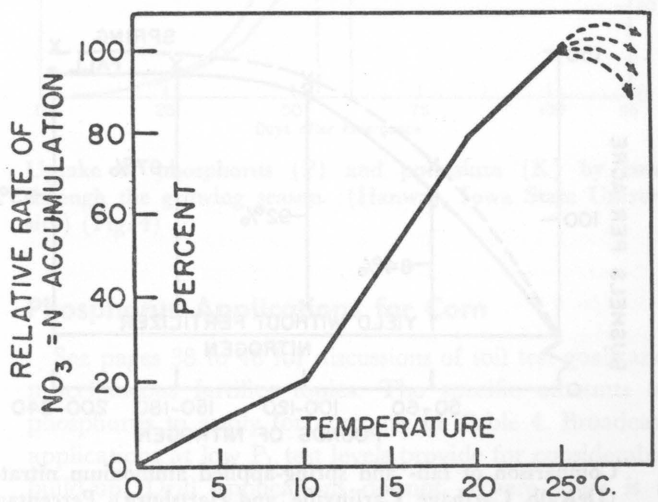
Nearly all of the nitrogen applied in Illinois is in the ammonium form or converts to ammonium (anhydrous ammonia and urea, for example) soon after application. Ammonium nitrogen is held by the soil clay and organic matter and cannot move very far until after it nitrifies (changes from ammonium to nitrate).

Whether ammonium from fertilizer, manure, or the decay of residues nitrifies in the fall depends mainly on soil temperature (Fig. 2). Agronomists generally suggest that fall application of fertilizer nitrogen be delayed until the soil temperature at 4 inches deep is 50° F. or less. The choice of 50° F. is explained on page 6. *Average dates* on which these temperatures are reached are not satisfactory guides to use because of great variability from year to year. Local dealers and farmers can make good use of soil thermometers to guide fall nitrogen applications.

In Illinois most of the nitrogen applied in late fall or very early spring *will be converted to nitrate by corn-planting time.* Though the rate of nitrification is slow (Fig. 2), the period of time is long during which the soil temperature is between 32° F. and 40° to 45° F.

Nitrogen is lost by denitrification or leaching. *Only nitrogen in the nitrate form can be lost by either route.*

Denitrification. Denitrification is believed to be the main pathway of nitrate and nitrite nitrogen loss, except on sandy soils where leaching is more important. Denitrification involves only nitrogen that has already been



Influence of soil temperature on the relative rate of NO_3 accumulation in soils. (Fig. 2)

converted from the ammonium form to either nitrate (NO_3^-) or nitrite (NO_2^-).

The amount of denitrification depends mainly on: (1) how long water stands on the soil surface or how long the surface is *completely saturated;* (2) the temperature of the soil and water; and (3) the pH of the soil.

When water stands on the soil or when the surface is completely saturated in fall or early spring, nitrogen loss is likely to be small because (a) much nitrogen is still in the ammonium rather than nitrate form and (b) the soil is cool and the denitrifying organisms are not very active.

Many fields in east central Illinois and to a lesser extent in other areas have low spots where surface water collects at some time during the spring or summer. The flat claypan soils also are likely to be saturated though not flooded. Sidedressing would avoid the risk of spring loss on these soils, but would not affect midseason loss. Unfortunately, these are the soils on which sidedressing is difficult in wet years.

The higher the pH the more rapid the denitrification loss, being almost twice as rapid as pH 6.8 at at 6.0.

Denitrification is difficult to measure in the field, but several laboratory studies show that it can happen very fast. At temperatures that are common in midsummer, most nitrate nitrogen can be lost within 3 to 5 days at pH 6.0 or above.

Leaching. In silt loams and clay loams, one inch of rainfall moves down about 5 to 6 inches though some of the water moves farther in large pores through the profile and carries nitrates with it.

In sandy soils each inch of rainfall moves nitrates down about one foot. If the total rainfall at one time was more than 6 inches, little nitrate will be left within rooting depth on sands.

Between rains there is some upward movement of nitrates in moisture that moves toward the surface as the surface soil dries out. The result is that the penetration of nitrates cannot be predicted from the cumulative total of rainfall.

When trying to estimate the depth of leaching of nitrates in periods of very intensive rainfall, two points need to be considered. First, the rate at which water can enter the surface of silty and clayey soils may be less than the rate of rainfall, so that much of the water runs off the surface either into low spots or into creeks and ditches. Second, the soil may already be saturated.

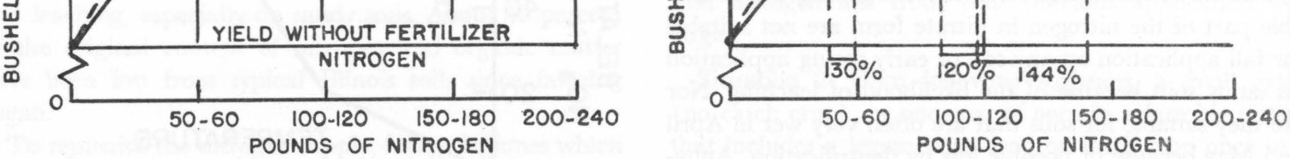
In either of the above cases the nitrates will not move down 5 to 6 inches as suggested in the first sentence of this section.

Corn roots usually penetrate 5 to 6 feet in Illinois soils. Thus nitrates that leach 3 to 4 feet are well within normal rooting depth unless they reach tile lines and are drained from the field.

Fall, spring, or sidedressed nitrogen? In recent years farmers in central and northern Illinois have been encouraged to apply nitrogen in the late fall in non-nitrate form, except on sandy, organic, or very poorly drained soils, any time after the soil temperature at 4 inches was below 50° F.

The 50° F. level for fall application was believed to be a realistic guideline for farmers. Applying nitrogen earlier involves risking too much loss. Later application involves risking wet or frozen fields, which would prevent application and fall plowing.

The results from 18 experiments in central and northern Illinois in four recent years (Fig. 3) show that fall-applied ammonium nitrate (one-half ammonium, one-half nitrate) was less effective than spring-applied nitrogen. There are two ways to compare efficiency. For example, in Figure 3, left, 120 pounds of nitrogen applied



Comparison of fall- and spring-applied ammonium nitrate, 18 experiments in central and northern Illinois, 1966-1969 (DeKalb, Carthage, Carlinville, and Hartsburg). Percentages in figure at left indicate the percentage of increased yield from fall as compared with spring application. Percentages in figure at right indicate the relative amounts of fertilizer you need to apply in the fall to obtain yields equal to those with spring applications. (Fig. 3)

in the fall produced 92 percent as much increase as the same amount applied in the spring. But looked at another way, it required 120 pounds to produce as much increase in the fall as was produced by 100 pounds in the spring (Fig. 3, right). At higher nitrogen rates the comparison becomes less favorable for fall application because the yield leveled off 6 to 8 bushels below that from spring application.

Unfortunately, no results are available to compare fall, spring, and sidedressed applications of a nitrogen source that is entirely in the ammonium form. The effectiveness of fall-applied nitrogen would likely have been greater if an all-ammonium form had been used. The failure of the highest rate to offset the lower efficiency from fall-applied ammonium nitrate remains an important mystery. Five-year comparisons of spring and sidedressed nitrogen at DeKalb in northern Illinois show that spring and sidedressed applications were equal. In dry years spring application was better. In wet years, sidedressing was better.

In consideration of the date at which nitrates are formed and the conditions that prevail thereafter, *the difference between late-fall and early-spring applications of ammonium sources in susceptibility to denitrification and leaching loss is probably small.* Both are, however, more susceptible to loss than is nitrogen applied at planting time or as a sidedressing.

Anhydrous ammonia nitrifies more slowly than other ammonium forms and, therefore, is slightly preferred for fall applications. It is well suited to early spring application, provided the soil is dry enough for good dispersion of ammonia and closure of the applicator silt.

The cost of nitrogen is now so low that even moderate loss is a relatively small factor in deciding when to apply nitrogen. Of more concern is the fact that increasing the rate has often not offset the lower efficiency of fall application (Fig. 3). Also of concern is the fate of the nitrogen that is not used by the crop. Research is urgently needed to quantify the pathways of nitrogen losses under field conditions. The portion that returns to the air through denitrification creates no problem. But the portion that leaches into ground water contributes to unwanted nitrates in streams and lakes and possibly groundwater (see page 44).

Secondary and Micronutrients

No deficiencies of secondary nutrients (calcium, magnesium, sulfur) have been identified on corn in Illinois where soil is pH 5.5 or above.

Illinois agronomists have not found any deficiencies of the micronutrients zinc, iron, manganese, copper, and boron. A few farmers and fertilizer dealers have reported suspected cases of deficiencies of one or more of these micronutrients, but none has been verified by research trials in Illinois.

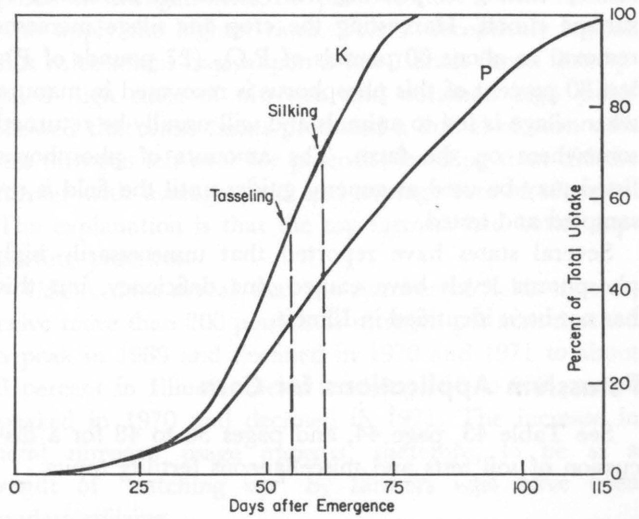
The Department of Agronomy at the University of Illinois is continuing to run spectrographic analyses of plants from several research fields to learn the nutrient status of corn and soybeans in Illinois as described on page 41.

Phosphorus and Potassium Uptake

Phosphorus continues to be taken up by corn until the grain is fully developed. Most of the potassium has been taken up soon after silking (Fig. 4). This indicates the need for different interpretations of phosphorus and potassium tests, based on characteristics of the soil profile.

Soil factors that influence the depth and extensiveness of rooting and the amount of available phosphorus in the *lower subsoil* and substratum are important in interpreting the phosphorus test (page 39). Phosphorus in these lower horizons is especially important in drouth periods when roots cannot feed effectively near the suface.

In contrast with the situation for phosphorus, soil conditions in the *plow layer* and *upper subsoil* are more critical in interpreting the potassium test (page 43). Before the root system has reached maximum depth the plant has satisfied its need for potassium.



Uptake of phosphorus (P) and potassium (K) by corn through the growing season. (Hanway, Iowa State University) (Fig. 4)

Phosphorus Applications for Corn

See pages 38 to 48 for discussions of soil test goals and miscellaneous fertility topics. The specific amounts of phosphorus to apply for corn are in Table 4. Broadcast applications at low P_1 test levels provide for considerable build-up. Drill applications do not. Where there is a range in the amount suggested under the heading "Broadcast," the larger figure will give a quick increase in P_1 test, the smaller figure will give only a small increase.

Table 4. — Available Phosphorus to Apply for Corn and Soybeans, Based on P_1 Soil Tests

P_1 test: Soil region (see page 35) Low	Medium	High	Percent of possible yield	Pounds of P_2O_5 or P to add per acre based on the P_1 test: P_2O_5 Broadcast	P_2O_5 Through planter or drill	P Broadcast	P Through planter or drill
20	10	7	69	or (a) 90 to 150 +	20 to 40[b]	or (a) 39 to 65 +	9 to 17
25	15	10	83	(b)	40 to 60[b]	(b)	17 to 26
30	20	15	90	60 to 120 or	30 to 40[b]	26 to 52 or	13 to 17
38	30	20	97	60 or	20 to 30[b]	26 or	9 to 13
45[a]	40[a]	30[a]	98+	Phosphorus may be applied to maintain the soil test. Little or no response likely in the year of application.			

[a] See also tentative goals for the P_1 test on page 40.
[b] The highest drill rates are all that can profitably be placed in the band, but they will have little effect on the soil test in following years and hence do not substitute for larger amounts broadcast for rapid buildup.

Annual phosphorus removal by corn is about 36 pounds of P_2O_5 (16 pounds of P) in 100 bushels of grain. Fifty to 70 pounds of P_2O_5 will be needed just to maintain the P_1 test level. You may apply it each year, but proportionately larger amounts at two- to three-year intervals are equally good. Mixing the phosphorus fertilizer into the soil by disking or plowing will reduce the likelihood of surface runoff. Harvesting the crop for silage increases removal to about 60 pounds of P_2O_5 (27 pounds of P), but 80 percent of this phosphorus is recovered in manure when silage is fed to animals and will usually be returned somewhere on the farm. The amounts of phosphorus listed may be used as general guides until the field is resampled and tested.

Several states have reported that unnecessarily high phosphorus levels have caused zinc deficiency, but this has not been identified in Illinois.

Potassium Applications for Corn

See Table 43, page 44, and pages 38 to 48 for a discussion of soil tests and miscellaneous fertility topics.

Buildup and Maintenance

You may choose to build up your soils to the desired test levels (pages 41 to 43) in just a few years, or more gradually over a five- to ten-year period. If you choose the slower buildup, row fertilization will be helpful to obtain optimum yields.

There are several reasons why raising the soil tests for P and K with fertilizer is much slower than most people expect. First, the soil tests are in terms of the elements whereas fertilizer analyses are in the oxides P_2O_5 (43.6 percent P) and K_2O (83 percent K). Second, a crop often removes an amount equal to one-half to three-fourths of the amount applied. Third, phosphorus in fertilizers soon changes to forms that are only partly extracted by soil tests; some of the potassium moves back between the clay sheets and is not picked up by the test.

You may make buildup applications at any convenient point in the cropping system and at any time of year, except on bare, sloping, frozen fields.

After the desired soil-test levels have been reached, there is no reason to believe that continued annual broadcast applications are necessary. Larger applications every two or three years are more economical.

Some farmers are substituting chisels or field cultivators for moldboard plows, especially following soybeans. Chiseling and cultivating will mix the nutrients only 3 to 4 inches deep. On soils that test medium to high throughout the plow layer, it is doubtful that one could measure the difference in yield between having the most recently applied fertilizer 3 inches deep or 9 to 10 inches deep. Plowing at least once in 4 or 5 years will provide for deeper placement of P, K, and limestone.

In tests conducted on the Agronomy South Farm and at DeKalb, the use of chisel-plow and zero-tillage systems has not resulted in a loss of efficiency of phosphorus and potassium fertilizers even on soils with low soil test levels. See page 44 for more information on tillage effects on fertilizer use.

Row fertilization. Experimental results from row fertilization in central Illinois and farther south indicate that yield responses are rare on soils that have been built up to a high fertility level. But farmers in central and northern Illinois who plant very early may experience the cool, wet soil conditions typical of the usual planting dates in states farther north where row application is more popular and more effective.

Corn seedlings need a high concentration of available phosphorus. You can supply it either by raising the soil test of the whole plow layer to a high level or by adding a small amount near the seed where the soil test is medium or above (see also "Pop-up" fertilizers below). Phosphorus is the most important component of so-called "starter" fertilizers. Nitrogen in the fertilizer band enhances the uptake of phosphorus, so suggested ratios of N to P_2O_5 are from 1:2 to 1:4. Fifty percent water solubility of the phosphorus is adequate for the amounts applied in typical situations of soil test level and pH. On alkaline soils, higher water solubility is preferred.

Pop-up. Pop-up fertilizer will make corn look very good early in the season and may aid in early cultivation for weed control. But there is not likely to be a substantial difference in yield produced in most years by a so-called pop-up application or by fertilizer that is placed in a band to the side and below the seed. With these two placements there will seldom be a difference of more than a few days in the time the root systems intercept the fertilizer band.

"Pop-up" fertilization means placing 40 to 50 pounds of fertilizer in contact with the seed. Research in many states over a long period of time has shown that, for starter effect only, you should place fertilizer as close to the seed as safety permits. The old split-boot applicator gave more starter effect than the modern side placement equipment that places fertilizer 1½ inches to the side and 1½ inches below seed level.

Many farmers have built up the general fertility level to the point where they are interested in a small amount of fertilizer mainly for an early growth effect.

Farmer interest in pop-up fertilization in Illinois results from the fact that fewer stops are required at planting time because the application rate is cut in half.

Use a fertilizer with all three major nutrients in a ratio of about 1-4-2 of $N\text{-}P_2O_5\text{-}K_2O$ (1-1.7-1.7 of N-P-K). The maximum safe amount of $N + K_2O$ for pop-up placement is about 10 to 12 pounds in 40-inch rows and correspondingly more in 30- and 20-inch rows. It is, in fact, necessary to apply more in narrow rows in order to have an equal amount per foot of corn row.

The term "pop-up" is a misnomer. The corn does not emerge sooner than without it, and it may come up one or two days later. It may, however, grow more rapidly during the first one to two weeks after emergence. Some people think that with pop-up applications the fertilizer is mixed with the seed. This is incorrect. The tube from the fertilizer hopper is repositioned to discharge the fertilizer in contact with the seed.

Plant Nutrients Decision of Illinois Pollution Control Board

After a lengthy hearing process beginning in August, 1971, and ending with the closing of the record in March, 1972, the Illinois Pollution Control Board found there was not a factual basis for imposing restrictions on the application of fertilizers at this time. The hearings disclosed an upward trend in the nitrate content of some streams, especially in east central Illinois where nitrates often exceed the water quality standard for public drinking and food processing water. But the specific steps that would be required to bring the streams into compliance with the standard are not known. Neither is it known whether the standard, 10 mg./l. of nitrate nitrogen, is necessary to protect public health or the environment. A further complication is that the nitrate content of streams is built up by small contributions from hundreds or even thousands of sources in the larger rivers.

No one proposed credible methods to produce needed food that would result in less nitrate reaching ground and surface waters than with present methods. Severe restrictions on nitrogen rates would not only reduce food and raise its cost, but would also require more acres to be farmed. Bringing additional acres into production is undesirable because many acres would be steep thus leading to erosion and flooding. With increased population more and more acres would eventually be taken out of recreational acres and wildlife habitat.

Some have suggested that if restrictions were to be imposed on nitrogen rates, the place to start is with farmers who apply the highest rates. This is deceptively logical. But calculations based upon a few Illinois farms that applied high rates of nitrogen and obtained high yields showed that these farms produced a bushel of corn with less nitrogen left over for potential leaching than did the farmer with average yield and average rate of nitrogen. The explanation is that the top farmers had better supporting practices.

USDA data reveal that the number of fields that receive more than 200 pounds of nitrogen per acre reached a peak in 1969 and declined in 1970 and 1971 to about 3 percent in Illinois. Fields receiving 150 to 200 pounds peaked in 1970 and declined in 1971. The increase in total nitrogen usage appears, therefore, to be as a result of "catching up" by farmers who have been underfertilizing.

In the absence of a suitable basis for deciding whether regulations are needed, the Board asked the Institute for Environmental Quality, the research entity provided in the Illinois Environmental Protection Act, to develop an implementation plan for achieving the water quality standard for nitrates in public drinking and food processing water, or in case the benefits do not justify the cost, to propose a revision in the standard.

No regulation was adopted on the application of phosphorus fertilizer. In other Pollution Control Board hearings it was established that limiting phosphorus inputs to protect water quality is required in Lake Michigan and other still waters and in the Fox River, but not in flow-ing waters generally. There was no showing that fertilizer applied in Illinois contributed significant phosphorus to those waters where the problem is serious. The Board registered its concern for prudent use of phosphorus fertilizer to conserve the known reserves.

The decision of the Board in dealing with a difficult, highly technical, and emotionally charged issue shows that the public hearing process can be used to reach reasonable decisions. Claims and counterclaims can likely be dealt with more effectively in open hearings where witnesses are under oath and subject to cross-examination than by attempting to rebut unproven charges by well intentioned but poorly informed sources through the news media. An important prerequisite to a reasonable decision is a willingness by those who have the facts to come forward to present and defend them in open hearings.

Plant Variety Protection Act

A Plant Variety Protection Act, which offers the developer or inventor of a new crop variety the legal right to protect his variety from being exploited by others, was enacted by Congress in 1970.

This new law will bring little change in the operations of most Illinois farmers. The farmer who normally buys seed from a seedsman each year will not be affected by the new law. Neither will the farmer who prefers to save his own seed. The farmer who saves some or all of his production to sell as seed to neighbors will be affected by the new law. This farmer may sell seed to a neighbor if the farmer to whom he sells does not sell seed from the crop that he produces.

The inventor or owner of a new variety may choose between two types of protection. He may elect to exclude others from selling the variety or offering it for sale. With this type of protection he protects his rights through the civil courts. He may also elect that seed of his variety may be sold by variety name only as certified seed. Sale of seed, protected in this manner, by variety name as uncertified seed will constitute a violation of the Federal Seed Act.

Before the Plant Variety Protection Act came into effect, the inventor of a new crop variety had no legal claim to the subsequent propagation of the variety or the sale of seed from it. Anyone and everyone could produce and sell seed of the variety. This left little or no opportunity for the inventor to recover the cost of the research that went into the variety.

Consequently, private variety developers had no incentive to develop new varieties. The new law will encourage private industry to invest money and personnel in developing new varieties and the long-term effect should be better varieties in the self-pollinated crops such as soybeans.

SOYBEANS

Planting Date

Soybeans should be planted in May. The full-season varieties will yield best when planted in early May. Earlier varieties often yield more when planted in late May than in early May. The loss in yield of the full-season varieties when planting is delayed until late May is minor as compared with the penalty for planting corn late. Therefore, the practice of planting soybeans after the corn acreage has been planted is an accepted and wise practice.

The loss in yield of soybeans becomes more severe when planting is delayed past early June. However, the penalty for late-planted corn is proportionally greater and the danger of wet or soft corn becomes such a threat that soybeans are, under many conditions, a better crop for late planting than corn (Table 5).

Planting Rate

A planting rate that results in 10 to 12 plants per foot of row at harvest in 40-inch rows, 6 to 8 plants in 30-inch rows, 4 to 6 plants in 20-inch rows, or 3 to 4 plants in 10-inch rows will provide maximum yield for May and very early June planting. Higher populations usually result in excessive lodging. Smaller populations often yield less, and the plants branch more and pod lower. This contributes to greater harvesting loss.

Populations should be increased by 50 to 100 percent for late June or early July plantings.

Row Width

If weeds are controlled, soybeans will yield more in narrow rows than in the traditional 40-inch row (Table 6).

Table 5. — Yields of Soybeans Planted on Four Dates, Urbana, 1970

Variety	Date of planting			
	May 7	May 21	June 8	June 19
	Bushels per acre			
Corsoy	56	62	49	42
Beeson	57	55	52	47
Calland	56	51	47	40

Table 6. — Soybean Yields for Row Spacings of 10, 20, 30, and 40 Inches, Urbana, 1965-1966

Variety	40 inches	30 inches	20 inches	10 inches
	Bushels per acre			
Wayne	47.0	51.2	52.4	53.6
Harosoy	38.8	42.0	45.0	48.0

Table 7. — The Ability of Soybeans to Compensate for Loss of Stand, Urbana, 1969

Treatment	Percent of original stand	Yield (bu./A.)
Six plants per ft. of row	100	50
Three plants per ft. of row	50	50
Three 40-inch gaps	50	41
Five 24-inch gaps	50	44
Four plants per ft. of row	66	51
Two 40-inch gaps	66	43
Five 16-inch gaps	66	47
Five plants per ft. of row	80	50
Two 24-inch gaps	80	47
Five 9.6-inch gaps	80	47

Since late-planted soybeans are not as tall as those planted in early May, the advantage for using narrow rows increases as planting is delayed past early June. Soybeans planted after the small-grain harvest should be planted in rows at least as narrow as 30 inches and 20-inch rows are better.

When To Replant

An experiment at Urbana in 1969 demonstrates the ability of soybeans to compensate for loss of stand. The soybeans were planted in 30-inch rows and thinned when in the second-leaf stage to stands of 50, 66, and 80 percent of the original stand of six plants per foot of row. Plots were 20 feet long and the reductions in stand were accomplished by a uniform removal of plants and by removing all plants for specified distances in the row. For instance, three gaps of 40 inches in 20 feet of row equals 50 percent of the original stand. The results of this experiment shown in Table 7 may be valuable when the question of whether to replant must be answered.

Seed Source

To insure growing a good crop you must do a good job of selecting seed. When evaluating seed quality, consider the percent germination, percent pure seed, percent inert matter, percent weed seed, and the presence of disease and damaged kernels.

Samples of soybean seed taken from the planter box as farmers were planting showed that home-grown seed was inferior to seed from other sources (Tables 8 and 9). The germination and pure seed content of home-grown seeds were lower. Weed seed content, inert material (hulls, straw, dirt, and stones), and other crop seeds (particularly corn) in home-grown seed were higher.

Farmers who purchased certified seed obtained a higher quality seed on the average than farmers purchasing uncertified seed.

Table 8. — Uncertified Soybean Seed Analysis by Seed Source

	Germination	Pure seed	Weed seed	Inert matter	Other crops
	Percentages				
Home grown.....	79.6	95.5	.02	2.29	2.27
Neighbor grown...	80.8	97.5	.01	2.06	.41
Seed dealer.......	81.2	97.8	.001	1.48	.77

Table 9. — Certified and Uncertified Soybean Seed Analysis

	Samples	Germination	Pure seed	Weed seed	Inert matter	Other crops
		Percentages				
Uncertified....	363	80.2	95.5	.02	2.6	2.0
Certified......	56	84.2	98.7	.001	1.2	.2

This evidence indicates the Illinois farmer could improve the potential of his soybean production by using higher quality seed. The home-grown seed is the basic problem. Few farmers are equipped to carefully harvest, dry, store, and clean seeds, and to perform laboratory tests adequately to assure themselves of high-quality seed. Agriculture today is a professional enterprise. If a farmer is not a professional seed producer and processor, he may be well advised to market his soybeans and obtain high-quality seed from a reputable professional seedsman.

The state seed tag is attached to each legal sale from a seed dealer. Read the analysis and consider if the seed being purchased has the desired germination, purity of seed, and freedom from weeds, inert material, and other crop seeds. The certified tag verifies that an unbiased non-profit organization (the Illinois Crop Improvement Association) has conducted inspections in the production field and in the processing plant. These inspections make certain the seeds are of a particular variety as named and have met certain minimum seed-quality standards. Some seedsmen may have a higher seed quality than others. It pays to read the tag.

Varieties

Soybean varieties are divided into maturity groups according to their relative time of maturity (Table 10). Varieties of Maturity Group I are nearly full season in northern Illinois, but too early for good growth and yield farther south. In extreme southern Illinois the Maturity Group IV varieties range from early to midseason in maturity.

Maturity Group I

Chippewa 64 is an early variety adapted to the northern states and performs like its namesake Chippewa, except that it carries resistance to phytophthora root rot. Chippewa and Chippewa 64 account for about two-thirds of the soybean acreage in Wisconsin and Minnesota, but grow them only in northern Illinois and only when you want earliness, since the later varieties outyield them throughout Illinois.

Rampage was released in 1970. It matures 1 to 2 days earlier than Hark or 2 to 3 days later than Chippewa 64. It is 1 inch shorter than Chippewa 64 in height and slightly less lodging resistant. Rampage is susceptible to phytophthora root rot, but resistant to shattering.

Hark is a variety adapted to northern Illinois where it has yielded as well as most Group II varieties, but less than Amsoy. It has good height for an early variety, but has a tendency to shatter when grown in central Illinois where it ripens early while the weather is still warm. This variety, like Wayne, may show iron-deficiency chlorosis when planted on soils of high pH (7 +).

A-100 is an early variety similar to Hark in maturity. It is a farmer selection from Minnesota. It is shorter than Hark but more resistant to shattering and has yielded about the same as Hark. Its tendency to lodge is slightly greater than Hark.

Maturity Group II

Harosoy and **Harosoy 63** are similar except that Harosoy 63 is resitant to phytophthora root rot. This can be of great importance on low ground or in wet springs when phytophthora can cause severe stunting and killing of susceptible Harosoy. Harosoys were the top-yielding varieties in northern Illinois before the release of Amsoy. Continue to use Harosoy 63 on land subject to flooding or where phytophthora root rot is a problem, since Amsoy is very susceptible. Both varieties have a tendency to shatter when conditions are overly dry at harvest time.

Corsoy was released in 1967. It is similar to Amsoy in growth habit, but averages 2 inches shorter. It is susceptible to phytophthora root rot, so grow it where this disease is not a problem. Corsoy has yielded 1 to 2 bushels per acre more than Amsoy and matured 1 to 3 days earlier. Lodging resistance of Corsoy is slightly less than Amsoy. Corsoy and Amsoy should replace much of the acreage of older Group II varieties except where phytophthora root rot is present.

Protana was released in 1970 as a high-protein variety resistant to phytophthora root rot. It will range from 2 to 4 percent higher in protein than currently grown commercial soybean varieties. It matures about two days later than Amsoy and is comparable to Amsoy in lodging resistance and seed size. It is 3 to 4 inches shorter. Yield of Protana is slightly less than Amsoy and Corsoy.

Provar was released in 1969 as a special purpose high-protein variety. It will range from 2.5 to 4.5 percent higher in protein than most other soybean varieties. It matures one day later than Corsoy and two days earlier than

Amsoy. It is comparable to Amsoy in lodging resistance, but is 3 to 4 inches shorter. It is susceptible to phytophthora root rot and yields slightly less than Corsoy or Amsoy.

Amsoy is a high-yielding variety, second only to Corsoy among the Group II varieties, and is a very popular variety. It is very susceptible to phytophthora root rot and purple stain of the seed coat. Purple stain is occasionally a problem, usually occurring in southern Illinois. The lodging resistance of Amsoy is superior to most other Group II varieties.

Amsoy 71 was developed at Purdue University. It is similar to Amsoy, except that it is resistant to phytophthora root rot, while Amsoy is susceptible.

Beeson is resistant to phytophthora root rot. It was released by Purdue University in August, 1968. The variety has yielded nearly as well as Amsoy when root rot was not present. In the presence of root rot, Beeson has yielded much more than Amsoy or Corsoy. Beeson matures about 3 days later than Amsoy and 6 days later than Corsoy. Lodging resistance of Beeson is slightly greater than Amsoy or Corsoy. It is similar in height to Corsoy and 1 to 3 inches shorter than Amsoy. It has a spreading leaf canopy.

Maturity Group III

Wayne is a high-yielding variety in central and south central Illinois. It has some tendency to shatter and develops iron-deficiency chlorosis (yellowing of leaves) on high-lime soils (pH 7+). It is susceptible to pod and stem blight, so at times will have poor seed quality. Its advantages are resistance to bacterial pustule and high yields.

Calland has phytophthora root rot resistance and was released by Purdue University in August, 1968. It has yielded nearly as well as Wayne in the absence of phytophthora root rot. Where phytophthora root rot is severe, Calland has yielded much more than Wayne. Calland matures 1 to 2 days later than Wayne, averages about 1 inch taller, and has a little greater resistance to lodging.

Adelphia, released in New Jersey in 1966, showed resistance to a seed-quality problem similar to the one in southern Illinois. The yield of Adelphia has been lower than Wayne and other Group III varieties. The variety has a high seed quality. Interest is being maintained in Adelphia to test for resistance to the purple stain and other seed-quality problems that often occur in southern Illinois.

Williams was developed by the USDA in cooperation with the University of Illinois and was released in 1972. It is superior to other varieties adapted to central and southern Illinois in seed quality (freedom from wrinkling, growth cracks, greenishness, and moldy or rotten seeds). It matures about 3 days later than Wayne but is similar in plant height and seed size. Williams is superior to both Wayne and Calland in lodging and shatter resistance. It is resistant to bacterial pustule and powdery mildew. Williams is classed as susceptible to phytophthora root rot but appears to have some tolerance to this disease.

Maturity Group IV

Bonus was developed by the USDA in cooperation with Purdue University. It matures about 2 days earlier than Cutler 71 and grows about 3 to 4 inches taller. The seed of Bonus is smaller than Cutler 71 and the quality (freedom from wrinkling, growth cracks, greenness, and moldy or rotten seeds) is better. Bonus is resistant to phytophthora root rot and susceptible to Frogeye Race 2, bacterial pustule, and downy mildew. It tends to shatter more than Cutler 71. Bonus is comparable to other varieties in oil content, but is 1 to 2 percent higher in protein content.

Wye was developed by the USDA in cooperation with the University of Maryland. It was released in 1972. It matures 2 to 3 days later than Cutler 71. Wye grows about 6 inches shorter and is a little more resistant to lodging than Cutler 71. It is susceptible to bacterial pustule, downy mildew, and phytophthora root rot. It is resistant to Frogeye Race 2 and shattering. Limited testing in Illinois indicates that its performance may not be equal to Cutler 71 and Bonus.

Clark and Clark 63 are similar, except Clark 63 is resistant to bacterial pustule leaf spot and phytophthora root rot. Bacterial pustule is a widespread leaf spot disease in southern Illinois, and in wet fields phytophthora root rot can cause severe damage in that area. Neither disease will develop on Clark 63, so this is the preferred variety. The high yield and excellent lodging resistance of these two varieties made them the leading varieties in southern Illinois.

Patterson was released by the High Plains Research Foundation of Plainview, Texas. It is as early as other Group IV varieties, and was tested at five locations in the state in 1966. It matured later than Clark 63 and earlier than Kent, but was distinctly lower in yield (5 to 40 percent below Clark 63) and had poor standability.

Cutler, a high-yielding variety, is moderately susceptible to phytophthora root rot. It was released in 1968 by Purdue University. In the absence of phytophthora root rot, Cutler yields 3 to 4 bushels more than Clark 63 and 1 bushel more than Kent. Cutler is 2 to 3 days later maturing than Clark 63 and 5 days earlier than Kent.

Cutler 71 was developed at Purdue University. It is similar to Cutler, except that it is resistant to phytophthora root rot and Cutler is susceptible.

Custer variety is resistant to soybean cyst nematode and phytophthora root rot. It was released from the University of Missouri in 1967. Custer matures 7 days later than Clark 63, has less lodging resistance, grows about 4 inches taller, has lower oil and protein percentages, and

Table 10. — Characteristics and Parentage of Major Soybean Varieties in Illinois

Maturity group and variety	Parentage and year released[a]	Flower color	Pubescence color	Pod color	Seed luster	Hilum color[b]
0						
Grant	Lincoln X Seneca (1955)	white	lt. brown	brown	shiny	black
Traverse	Lincoln X Mandarin (Ottawa)(1965)	white	gray	brown	shiny	yellow
XK 111	L. Teweles Seed Co. (1971)	white	gray	tan	dull	buff
I						
XK 505	L. Teweles Seed Co. (1971)	purple	brown	brown	intermediate	black
Chippewa	Lincoln^2 X Richland (1954)	purple	brown	brown	shiny	black
Chippewa 64	Chippewa^8 X Blackhawk (1964)	purple	brown	brown	shiny	black
Rampage	Clark X Chippewa	purple	brown	brown	shiny	black
Bombay	farmer selection (1966)	purple	gray	tan	shiny	yellow
Hark	Hawkeye X Harosoy (1966)	purple	gray	brown	dull	yellow
A-100	farmer selection (1959)	white	gray	brown	shiny	buff
SRF 100	Soybean Research Foundation (1971)	purple	brown	brown	shiny	black
Anoka-II	42-37 X Korean (1969)	purple	brown	brown	shiny	yellow
Dunn	Grant X Chippewa (1969)	purple	lt. brown	brown	shiny	black
SRF 150	Soybean Research Foundation (1972)	purple	gray	brown	dull	yellow
II						
Marshall	Improved Variety Research, Inc. (1971)	purple	gray	gray	dull	buff
Harosoy	Mandarin (Ottawa)^2 X AK (Harrow)(1951)	purple	gray	brown	dull	yellow
Harosoy 63	Harosoy^8 X Blackhawk (1963)	purple	gray	brown	dull	yellow
Carsoy	Harosoy X Capital (1967)	purple	gray	brown	dull	yellow
Lindarin 63	Lindarin^8 X Mukden (1963)	purple	gray	brown	dull	buff
Magna	[Mandarin (Ottawa) X Jogun] X	purple	gray	brown	dull	yellow
Peterson Jade	Peterson Seed Co. (1972)	purple	gray	brown	dull green	buff
Prize	[Mandarin (Ottawa) X Kanro] (1967)	purple	gray	tan	dull	yellow
Provar	Harosoy X Clark (1969)	purple	brown	brown	dull	brown
Protana	[CX291-42-1 (Mukden X C1069) X CX258-2-3-2(PI65.338 X C1079) (1970)]	purple	gray	brown	dull	imp. black
Amsoy	Adams X Harosoy (1965)	purple	gray	tan	shiny	yellow
Amsoy 71	Amsoy 8 X C1253 (Blackhawk X Harosoy) (1971)	purple	gray	tan	shiny	yellow
Hawkeye 63	Hawkeye^7 X Blackhawk (1963)	purple	gray	brown	dull	imp. black
Beeson	(Blackhawk X Harosoy) X Kent (1968)	purple	gray	brown	shiny	imp. black
Marshall	Improved Variety Research, Inc. (1971)	purple	gray	gray	dull	buff
XK505	L. Teweles Seed Co. (1971)	purple	brown	brown	intermediate	black
III						
Adams	Illini X Dunfield (1948)	white	gray	tan	shiny	buff
Shelby	Lincoln^2 X Richland (1958)	purple	brown	brown	dull	black
Wayne	(Lincoln, Richland, CNS) X Clark (1964)	white	brown	brown	shiny	black
Calland	(Blackhawk X Harosoy) X Kent (1968)	purple	brown	brown	dull	black
Adelphia	(Sib of Kent) X Adams (1966)	white	gray	tan	shiny	buff
SRF 300	Soybean Research Foundation Variety (1969)	white	brown	brown	shiny	black
SRF 307	Soybean Research Foundation (1971)	white	brown	brown	shiny	30% brown, 70% black
SRF 307B	Soybean Research Foundation (1972)	white	brown	brown	shiny	brown
Seedmakers 1-E	Seedmakers, Inc. (1971)	purple	gray	tan	shiny	yellow
Williams	Wayne X L 57-0034 (1972)	white	brown	tan	shiny	black
IV						
Bonus	C12 66R X C 1253 (1972)	purple	gray	brown	dull	imp. black
Clark	Lincoln^2 X Richland (1953)	purple	brown	brown	dull	black
Clark 63	(Clark^7 X CNS) X (Clark^6 X Blackhawk) (1963)	purple	brown	brown	dull	black

Table 10. — Concluded

Maturity group and variety	Parentage and year released[a]	Flower color	Pubescence color	Pod color	Seed luster	Hilum color[b]
IV						
Bellatti L263	farmer selection (1965)	purple	brown	brown	dull	black
Patterson	introduced from Morocco (1965)	white	gray	tan	dull	yellow
Cutler	(Lincoln X Ogden) X Clark (1968)	purple	brown	brown	shiny	black
Cutler 71	Cutler[4] X Kent — Rpo rxp — SL5 (1971)	purple	brown	brown	shiny	black
Custer	(Peking X Scott) X Scott X Blackhawk (1967)	purple	gray	brown	shiny	imp. black
Kent	(Lincoln X Ogden) (1961)	purple	brown	brown	intermed.	black
Delmar	(P.I.70218 X Lincoln X FC33,243 (1963)	white	gray	brown	dull	yellow
Scott	(Sib of Lee) (Lincoln X Richland) (1958)	purple	gray	brown	shiny	imp. black
SRF 400	Soybean Research Foundation (1971)	purple	brown	brown	dull	black
SRF 450	Soybean Research Foundation (1972)	purple	brown	brown	shiny	black
Wye	2nd cycle intermated population of Adams, Lincoln, Perry, Wabash, C799, C985, FC (1972) 33,243, and L46-1503	white	brown	brown	shiny	black
V						
Dare	Hill X Roanoke X Ogden (1965)	white	gray	tan	shiny	buff
Dyer	Hill X (Lee[2] X Peking)[6] (1967)	purple	brown	tawny	shiny	black
Hill	(Dunfield X Haberlandt) X Sib of Lee (1959)	white	brown	tan	shiny	brown
Mack	[(NC55(3) X S62-5-16-12) X RA-63-19-2] X Lee 68 (1972)	purple	brown	tan	shiny	black
VI						
Ogden	Tokio X PI 54,610 (1942)	purple	gray	brown	dull[c]	imp. black
Hood	Roanoke X line from Ogden X CNS (1958)	purple	gray	tan	shiny	buff
Lee	S-100 X CNS (1954)	purple	brown	tan	shiny	black
Pickett	[(Sib of Lee)[6] X Dorman] X [Lee[4] X Peking] (1965)	purple	gray	tan	shiny	imp. black
Pickett 71	Pickett X Phytophthora Res. Lee (1971)	purple	gray	tan	shiny	imp. black

[a] Superscript indicates the number of crosses in a backcrossing program.
[b] imp. = imperfect.
[c] Seed coat of Ogden is green. All others listed have yellow seed coat.

Table 11. — Soybean Variety Performance at Urbana, Illinois, 1969-1971

Maturity group and variety	Maturity date	Lodging	Plant height	Seed quality	Seeds per pound[a]	Seed content: Protein	Seed content: Oil
		score[b]	*inches*	*score*[c]	*number*	*percent*	*percent*
I							
Chippewa 64	Aug. 31	1.3	33	2.4	2,900	41.5	22.1
Hark	Sept. 7	1.3	35	1.6	2,700	41.8	22.5
II							
Corsoy	Sept. 8	1.5	36	1.9	2,900	40.1	22.6
Amsoy 71	Sept. 11	1.4	41	1.9	2,700	39.8	22.9
Beeson	Sept. 13	1.5	38	2.4	2,400	39.9	22.3
III							
Wayne	Sept. 23	2.3	43	2.4	2,700	41.8	21.8
Calland	Sept. 27	2.1	43	2.9	2,600	40.1	21.4
Williams	Sept. 27	1.5	43	2.0	2,600	40.6	22.6
IV							
Bonus	Oct. 2	2.3	48	2.1	2,600	43.1	21.7
Cutler	Oct. 6	1.6	44	2.1	2,400	40.7	21.9
Cutler 71	Oct. 6	1.8	46	2.3	2,400	40.1	22.2
Kent	Oct. 9	1.9	43	2.3	2,500	39.8	22.4

[a] USDA Regional Uniform Test average.
[b] Lodging score: 1 = erect, 5 = prostrate.
[c] Seed quality score: 1 = excellent, 5 = very poor (wrinkled, shriveled, green, moldy, imperfect seed coat, or other defects).

Table 12. — Disease Resistance of Soybean Varieties

Maturity group and variety	Phytophthora root rot	Bacterial pustule	Bacterial blight	Downy mildew	Frogeye leaf spot Race 2
I					
Chippewa 64	++	−	+	−	−
Rampage	−−	−	−	−	−
Hark	−−	−	−	−	−
A-100	−	−	−	−	−
II					
Harosoy 63	++	−	−	+	−
Provar	−−	−	−	−	−−
Corsoy	−−	−	−	+	−
Amsoy	−−	−	−	+	−
Amsoy 71	++	−	−	+	−
Beeson	++	−	−	+	+
III					
Wayne	+	++	−	−−	+
Calland	++	−	−	+	−
Williams	+	++	−	−−	−
IV					
Bonus	++	−	−	−−	−−
Clark 63	++	++	−	−−	−
Cutler	+	−	−	−	+
Cutler 71	++	−	−	−	++
Kent	−	−	−	+	++
V					
Dare	+	++			

++ = resistant; + = slightly susceptible; − = susceptible; −− = very susceptible.

has yielded 2 to 3 bushels per acre less than Clark 63 in the absence of the cyst nematode. Consider Custer only where the soybean cyst nematode is present.

Kent is a late variety over much of Illinois, but in the southern quarter of the state it ripens at the same time as earlier varieties do farther north. It has been a top-yielding variety in the southern quarter. It has excellent lodging resistance, but in some years it has a tendency to shatter when it is not harvested immediately after ripening.

Delmar was released in Delaware and Maryland. It is similar to Kent in maturity and shows some advantages in seed quality, but usually yields less than Clark 63 and Kent. It is resistant to root-knot nematode, which is a major problem in some states but has been of minor importance in Illinois.

Scott is recommended in southeastern Missouri and matures at about the same time as Kent. It has shown no advantage over Kent in Illinois tests.

Maturity Group V

Mack was developed by the USDA in cooperation with the Arkansas Agricultural Experiment Station. It was released in 1972. Mack grows about 2 inches shorter than Dare and is comparable in maturity. It is resistant to bacterial pustule, phytophthora root rot, cyst nematode race 3, and shattering. It is comparable to other group V varieties in oil and protein content. Mack has not been tested in Illinois, however its performance in the Delta region has been comparable to Dare.

Dare is a 1965 release and was increased by certified seed growers in Missouri, Oklahoma, Maryland, Virginia and North Carolina. It has had limited testing in the southern tip of Illinois and has performed very well. It is suggested for growing in that area whenever a late variety is desired because it has outyielded Hill, Ogden, and Lee, and it does not have the poor seed quality of the Group IV varieties. It has moderate resistance to phytophthora root rot.

Dyer is an early maturing variety in Group V that was released in 1967 by the USDA and agricultural experiment stations of Mississippi and Tennessee. It is resistant to soybean cyst nematode, two root-knot nematodes, bacterial pustule, wildfire, and target spot. It is more susceptible to phytophthora root rot than Hill and less shatter resistant than Hill. Dyer has yielded slightly less than Hill in the absence of soybean cyst nematode.

Hill is a late-maturing variety that has been grown on a relatively small acreage in the bottomlands in extreme

Table 13. — Soybean Yields 1971-73; Bushels per Acre

Variety	DeKalb	Pontiac	Urbana	Girard	Edgewood	Belleville	Eldorado
Corsoy	49.9	43.3	59.5	53.7	40.7	....	....
Wells	49.1	42.2	54.5	50.5	43.4	....	....
Amsoy 71	49.2	40.0	55.3	48.3	41.1	....	....
Beeson	50.1	40.0	57.6	46.4	38.9	....	....
Chippewa	38.4	37.2	....	....	....	....	....
Hark	43.6	40.1	....	....	....	....	....
Wayne	....	....	50.8	48.6	43.4	48.9	40.1
Calland	....	....	54.5	41.6	42.7	50.3	46.0
Williams	....	....	57.0	47.5	44.8	53.4	47.5
Bonus	....	....	....	....	44.8	51.3	42.5
Cutler 71	....	....	....	....	46.7	50.0	44.3
Kent	....	....	....	....	46.8	49.1	46.0

southern Illinois. It will probably be replaced by the more productive Dare. Other late-maturing varieties that should be replaced by Dare in this extreme southern tip of the state include extremely late-maturing varieties such as Ogden, Hood, and Lee.

Parentage, maturity comparisons, and characteristics of most of these varieties are shown in Tables 10, 11, and 12. Yield records of many of these varieties at various locations are shown in Table 13.

Private Varieties

Several soybean varieties developed by privately financed research programs have been released recently. These varieties are handled within the seed trade as proprietary items, i.e., the property of the developer.

Following are brief descriptions of several private varieties. These have met the National Certified Soybean Variety Review Board criteria of distinctiveness and as meriting certification.

SRF-100 is a narrow-leaf variety of Group I maturity developed by the Soybean Research Foundation. In plant type, oil and protein content, and maturity it is quite similar to Chippewa 64. It has purple flowers, tawny pubescence, brown pods, shiny yellow seed coat, and black hila. It is resistant to phytophthora root rot. Unlike Chippewa 64 it has lanceolate-shaped leaves and bears a considerable number of four-seeded pods. Seed size of SFR 100 is slightly smaller than Chippewa 64.

SRF-150 is a narrow-leaf variety developed by the Soybean Research Foundation. This variety matures about two days earlier and grows about 1 inch shorter than Hark. It is comparable to Hark in lodging resistance. It has purple flowers, gray pubescence, dull yellow seed coat, and yellow hila.

SRF-300 was developed by the Soybean Research Foundation, Mason City. The variety is similar to Wayne in maturity and lodging resistance. The leaves are narrow and lance shaped. It is susceptible to phytophthora root rot. SRF-300 grows about an inch taller than Wayne. The seed of SRF-300 is somewhat smaller than Wayne seed. Seed of SRF-300 is available only from member companies of the Soybean Research Foundation.

SRF-307 is a narrow-leaf variety of Group III maturity developed by the Soybean Research Foundation. This variety is a sister strain of SRF 300 and is very similar to SRF 300 in all aspects except that approximately 30 percent of seeds have brown hila (the remaining 70 percent are black), and the yield has been considerably higher than SRF 300.

SRF-307B was developed by the Soybean Research Foundation. It is the same as SRF-307 in plant and seed appearance with the exception that all hila are brown.

SRF-400 is a narrow-leaf variety of Group IV maturity developed by the Soybean Research Foundation. In plant type, oil and protein content, and maturity it is quite similar to Clark 63. It has purple flowers, tawny pubescence, brown pods, black hila, and dull yellow seed coat, and is resistant to phytophthora rot. Unlike Clark 63, it has lanceolate-shaped leaves and bears many four-seeded pods. Seed size averages 14.3 grams per 100 seeds compared with 16.1 for Clark 63.

SRF-450 is a narrow-leaf variety developed by the Soybean Research Foundation. SRF-450 matures about two days earlier and grows about 1 inch taller than Kent. It is comparable to Kent in lodging resistance. It has purple flowers, brown pubescence, brown pods, shiny yellow seed coat, and black hila.

Bellatti L263 originated as a selection from Bavender Special. It is similar to Clark in yield, maturity, standability, and appearance. Bellatti L263 was released in 1965 by Mr. Louis Bellatti, Mt. Pulaski.

Seedmakers 1-E was developed by Louis Bellatti, Mt. Pulaski, Illinois, and is distributed by Seedmakers, Inc., Princeville, Illinois.

Seedmakers 1-E is comparable to Wayne in maturity, grows 6 to 8 inches taller and is less lodging resistant. It has purple flowers, gray pubescence, tan pods, shiny yellow seed coat, and yellow hila.

Marshall was developed by Improved Variety Research, Inc., Adel, Iowa. It is comparable to Amsoy in maturity, plant height, and lodging resistance. It is a little higher in protein and lower in oil than Amsoy and has purple flowers, gray pubescence, gray pods, dull yellow seed coat, and a buff hila.

XK-111 was developed by the L. Teweles Seed Co., Clinton, Wisconsin. It is a very early variety and is comparable to Merit in maturity. It has white flowers, gray pubescence, tan pods, a dull yellow seed coat, and buff hila.

XK-505 was developed by the L. Teweles Seed Co., Clinton, Wisconsin. It grows about 3 inches taller than Amsoy and matures one to two days later. It has purple flowers, brown pubescence, brown pods, and yellow seed coat with black hila. It is resistant to phytophthora rot.

Fertilizing Soybeans

Farm magazines in recent years have reported some fantastic soybean yields from contest winners. Since most contestants fertilize their contest acres irrespective of soil test levels, it is easy to gain the impression that the high yields are a direct result of applying extra fertilizer. The Agronomy Department has conducted extensive research on very high rates of N, P, and K. Before examining some of the results, here is a review of current suggestions for liming and fertilizing soybeans.

Lime. Soybeans have the same pH requirements as corn. So a goal of 6.0 or slightly above is reasonable for a soybean-corn, cash-grain system and a goal of pH 6.5 is advised for a cropping system that includes alfalfa or clover.

Phosphorus and potassium. See Table 4, page 8, and Table 43, page 44. Soybeans give a large response to direct fertilization on soils that test low in phosphorus and potassium. Response to phosphorus on a very low-testing ($P_1 = 5$), dark prairie soil showed average 1967 to 1969 yields to be as follows: 25 bushels per acre with no fertilization; 52 bushels from 30 pounds of P_2O_5 (12 pounds of P); 54 bushels from 60 pounds of P_2O_5 (26 pounds of P); and 55 bushels from 90 pounds of P_2O_5 (39 pounds of P). These amounts of fertilizer were applied each year.

Broadcasting amounts indicated by soil tests is the preferred method in most cases. Row fertilizer is suggested where a farmer has a one-year lease or is extremely short of capital and must invest the minimum amount in fertilizer on a year-to-year basis.

Place row-applied fertilizer at least 1½ inches to the side and slightly below the seed level. "Pop-up" fertilizer, which involves a small amount in direct contact with seed, is unsafe for soybeans. In research conducted at Dixon Springs by George McKibben, stand was reduced to one-half by applying 50 pounds of 7-28-14 and to one-fifth with 100 pounds.

Research has shown clearly that soybeans can feed efficiently on soil fertility that was built up for preceding crops and that they do not need direct fertilization where fertility is high.

Manganese. Manganese deficiency (stunted plants with green veins in yellow or whitish leaves) is common on high-pH (alkaline), sandy soils, especially during cool, wet weather in late May and June. Suggested treatment is to spray 10 pounds of manganese sulfate (containing 2.5 pounds of manganese) per acre in 25 gallons of water when the beans are 6 to 10 inches tall. If the spray is directed on the row the rate can be cut in half. Some fertilizer dealers have other manganese formulations that you can apply according to instructions. Broadcast application on the soil is ineffective because the manganese becomes unavailable in soils with high pH.

Iron. Wayne and Hark soybean varieties often show iron deficiency on soils with a very high pH (usually 7.4 to 8.0). The symptoms look like manganese deficiency. Most of the observed deficiencies have been on Harpster, a "shelly" soil that occurs in low spots in some fields in central and northern Illinois. This problem appeared on Illinois farms only since the Wayne variety was introduced in 1964.

Soybeans often outgrow the stunted, yellow appearance of iron shortage. As a result it has been difficult to measure yield losses or decide whether or how to treat affected areas. Sampling by U.S. Department of Agriculture scientists in 1967 indicated yield reductions of 30 to 50 percent in the center of severely affected spots. The yield loss may have been caused by other soil factors associated with very high pH and poor drainage rather than by iron deficiency itself. Several iron treatments were ineffective in trials near Champaign and DeKalb in 1968. Minnesota, which has had far more experience than Illinois with iron deficiencies, reports that "there is no known solution as yet."

In summary, the same pH, P_1, and K soil tests are suggested for corn and soybeans. Maintenance or buildup applications may be made ahead of either corn or soybeans. No nitrogen is recommended for soybeans. Sideband placement of fertilizer is suggested for certain situations, but "pop-up" applications are discouraged.

Table 14. — Soybean Yields From Broadcast Applications of Fertilizer (Soil Tests Before Treatment Were: pH 5.9, P_1 90, and K 285; South Farm, Urbana, Illinois, 1965)

N	P_2O_5 (P)	K_2O (K)	Bushels per acre
0	0	0	57.1
0	75(33)	75(60)	55.7
0	150(65)	150(120)	58.5
75	75(33)	75(60)	56.8
150	150(65)	150(120)	56.1
300	300(131)	300(240)	57.2

Manganese should be applied on some high-pH sands. Methods for iron treatment are not established.

Results of extra high fertilization. Several experiments have been conducted in Illinois on extra heavy applications of fertilizer on soil that was already high according to soil tests.

Here are some typical results:

A. Direct fertilization (Table 14).

The differences are small and appear to be unrelated to fertilizer added, since the average of all treated plots is slightly below the untreated-plot yield.

B. Combination of fresh and residual fertilizer and manure (Table 15).

There is no consistent effect of extra fertility. Treatment 4 appears to be slightly better than untreated plot No. 1, but this is offset by apparent reductions for treatments 2 and 3. This is typical variability encountered in field trials. The results are interpreted as no response to extra high fertility, either fresh or residual. Soil tests on plots 2, 3, and 4 were extremely high, with P_1 testing from 225 to 408 and K testing from 558 to 1,086.

C. Row fertilizer and localized lime (Table 16).

There was no increase from fertilizer or lime or a combination of the two. The apparent reductions for some treatments are probably normal field variations.

D. Other high-fertility treatments.

Many other experiments on heavy fertilization have been conducted by Illinois agronomists: nitrogen rates up to 1,400 pounds; nitrogen sidedressing up to 200 pounds at two growth stages; manure up to 80 tons per acre for six years with and without 160-60-60; and subirrigation with a nutrient solution each week.

The result of these experiments support the fertility suggestions for soybeans that were outlined at the beginning of this review.

Table 15. — Soybean Yields From 7-Year Fertility Plots With and Without Fresh Application, South Farm, Urbana, Illinois, 1968

Treatment	Bushels per acre
None	56.4
40 tons of manure and 500 lb. N, 250 P_2O_5 (K_2O each year for 7 years)	54.3
Same as 2, plus 0-250-250 in 1968	52.6
Same as 2, plus 250-250-250 in 1968	57.8

Table 16. — Soybean Yields From Row Applications of Fertilizer and Lime; Phosphorus (P = 40) and Potassium (K = 300) Tests Were at Suggested Levels and pH Was Slightly Low (5.8); South Farm, Urbana, Illinois, 1965

Treatment	Bushels per acre
None	59.1
200 lb. 6-24-24 (2 in. side, 2 in. below)	56.3
250 lb. hydrated lime	56.9
200 lb. 6-24-24 and 250 lb. hydrated lime	58.1
200 lb. 6-24-24 and 250 lb. fine limestone	59.4

WHEAT

Time of Seeding

Wheat varieties that are resistant to Hessian fly may be planted before the "fly-free date." Varieties susceptible to Hessian fly should not be planted until the fly-free date. The average fly-free date suggested by Extension entomologists for different areas of the state are shown in Table 17.

Table 17. — Average Date of Seeding Wheat for Highest Yield

County	Average date of seeding wheat for highest yield	County	Average date of seeding wheat for highest yield
Adams	Sept. 30-Oct. 3	Lee	Sept. 19-21
Alexander	Oct. 12	Livingston	Sept. 23-25
Bond	Oct. 7-9	Logan	Sept. 29-Oct. 3
Boone	Sept. 17-19	Macon	Oct. 1-3
Brown	Sept. 30-Oct. 2	Macoupin	Oct. 4-7
Bureau	Sept. 21-24	Madison	Oct. 7-9
Calhoun	Oct. 4-8	Marion	Oct. 8-10
Carroll	Sept. 19-21	Marshall-Putnam	Sept. 23-26
Cass	Sept. 30-Oct. 2		
Champaign	Sept. 29-Oct. 2	Mason	Sept. 29-Oct. 1
Christian	Oct. 2-4	Massac	Oct. 11-12
Clark	Oct. 4-6	McDonough	Sept. 29-Oct. 1
Clay	Oct. 7-10	McHenry	Sept. 17-20
Clinton	Oct. 8-10	McLean	Sept. 27-Oct. 1
Coles	Oct. 3-5	Menard	Sept. 30-Oct. 2
Cook	Sept. 19-22	Mercer	Sept. 22-25
Crawford	Oct. 6-8	Monroe	Oct. 9-11
Cumberland	Oct. 4-5	Montgomery	Oct. 4-7
DeKalb	Sept. 19-21	Morgan	Oct. 2-4
DeWitt	Sept. 29-Oct. 1	Moultrie	Oct. 2-4
Douglas	Oct. 2-3	Ogle	Sept. 19-21
DuPage	Sept. 19-21	Peoria	Sept. 23-28
Edgar	Oct. 2-4	Perry	Oct. 10-11
Edwards	Oct. 9-10	Piatt	Sept. 29-Oct. 2
Effingham	Oct. 5-8	Pike	Oct. 2-4
Fayette	Oct. 4-8	Pope	Oct. 11-12
Ford	Sept. 23-29	Pulaski	Oct. 11-12
Franklin	Oct. 10-12	Randolph	Oct. 9-11
Fulton	Sept. 27-30	Richland	Oct. 8-10
Gallatin	Oct. 11-12	Rock Island	Sept. 20-22
Greene	Oct. 4-7	St. Clair	Oct. 9-11
Grundy	Sept. 22-24	Saline	Oct. 11-12
Hamilton	Oct. 10-11	Sangamon	Oct. 1-5
Hancock	Sept. 27-30	Schuyler	Sept. 29-Oct. 1
Hardin	Oct. 11-12	Scott	Oct. 2-4
Henderson	Sept. 23-28	Shelby	Oct. 3-5
Henry	Sept. 21-23	Stark	Sept. 23-25
Iroquois	Sept. 24-29	Stephenson	Sept. 17-20
Jackson	Oct. 11-12	Tazewell	Sept. 27-Oct. 1
Jasper	Oct. 6-8	Union	Oct. 11-12
Jefferson	Oct. 9-11	Vermilion	Sept. 28-Oct. 2
Jersey	Oct. 6-8	Wabash	Oct. 9-11
Jo Daviess	Sept. 17-20	Warren	Sept. 23-27
Johnson	Oct. 10-12	Washington	Oct. 9-11
Kane	Sept. 19-21	Wayne	Oct. 9-11
Kankakee	Sept. 22-25	White	Oct. 9-11
Kendall	Sept. 20-22	Whiteside	Sept. 20-22
Knox	Sept. 23-27	Will	Sept. 21-24
Lake	Sept. 17-20	Williamson	Oct. 11-12
LaSalle	Sept. 19-24	Winnebago	Sept. 17-20
Lawrence	Oct. 8-10	Woodford	Sept. 26-28

Early seeded wheat is not only subject to attack by Hessian fly, it is also subject to damage by disease, especially if it is planted more than 10 days or two weeks prior to the Hessian fly-free date. Therefore, even the varieties that are resistant to the insect should not be planted extremely early.

Rate of Seeding

Rate-of-seeding trials involving several different wheat varieties have been conducted in Illinois. The results of these trials indicate that one and a half bushels (90 pounds) of good seed is adequate when planting at the normal time. The rate may be increased if seeding is delayed well past the fly-free date.

Depth of Seeding

Wheat should not be planted more than 1 to 2 inches deep. Deeper planting may result in poor emergence. This is particularly true of the semi-dwarf varieties because coleoptile length is positively correlated with plant height.

Width of Row

Research on row width shows no advantage for planting wheat in rows narrower than the 7 or 8 inches, which is considered normal. Yield is not improved by planting in narrower rows. It is usually reduced by wider rows as the following table shows.

Row spacing	*Two-year average yield at Urbana*
8 inch spacing	37.8 bushels
16 inch spacing	31.6 bushels
24 inch spacing	27.2 bushels

Varieties: Hard Red Winter

Centurk was developed at the University of Nebraska and released in 1970. The name Centurk is a contraction of "Centennial Turkey" derived from the Turkey wheat parentage in the cross and the upcoming centennial of the introduction of Turkey wheat into the United States in 1873-74. Centurk matures at the same time as Scout 66, but is from 4 to 6 inches shorter. It possesses good rust resistance and has yielded better than other hard wheats in Illinois.

Ottawa is a red chaff variety released in Kansas in 1960. It is similar to Pawnee in yield and maturity, but it has better grain quality and improved straw strength.

Table 18. — Yield Record of Leading Soft and Hard Wheat Varieties in Agronomy Department Tests

	DeKalb			Urbana			Brownstown[a]
	1973 yield	Test weight	1972–73 average yield	1973 yield	Test weight	1972–73 average yield	1971–72 average yield
Soft Wheat							
Abe	44	59	..	65	59	67	..
Arthur	40	60	47	63	59	67	71
Arthur 71	43	59	51	63	59	65	72
Benhur	40	58	47	61	58	59	65
Blueboy	45	53	46	74	50	69	79
Blueboy II	46	53	..	85	54	84	..
McNair 4832	38	55	..	64	55	80	..
Monon	40	58	49	56	57	56	71
Oasis	45	58	..	72	59	..	..
Hard Wheat							
Centurk	42	58	53	52	55	54	69
Gage	41	59	50	56	58	52	51
Homestead	31	59	..	53	56	..	..
Parker	33	59	43	47	58	49	63
Pawnee	38	60	45	53	58	48	48
Sentinel	42	59	..	54	55	..	..

[a] 1973 yields are not reported because of the effects of water and disease damage.

Table 19. — 1973 Wheat Variety Demonstration Yields, Hard Wheat Varieties

County or location	Centurk		Gage		Parker		Pawnee		Triumph 64	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
Greene			36.0	....	35.0	....	32.0	....	35.0	....
Macon	60.9	56.5	48.5	60.0	57.4	62.0	51.5	60.0	60.7	62.0
Madison	59.3	57.0	47.7	57.0	46.7	59.5	35.6	58.5	38.6	58.0
Mason	40.8	....	31.7	....	35.5	....	30.1	....	30.6	....
St. Clair #1	35.8	51.0	....	....	35.4	56.0	....	....	....	....
St. Clair #2	34.2	57.0	....	....	46.8	60.0	....	....	....	....
Schuyler	45.5	56.0	45.0	58.0	42.3	58.0	41.1	58.0	44.8	59.0
Shelby	71.4	....	55.1	....	64.2	....	64.2	....	62.0	....
Average for 6 locations	55.6	56.0	45.6	58.0	49.2	60.0	44.5	59.0	47.3	60.0

It is resistant to stem rust but is susceptible to loose smut, which could become a problem. Ottawa has an excellent yield record in Illinois yield trials and on Illinois farms. Though its chaff color is principally red, it normally has a small number of white chaff heads and certain environmental conditions can increase this number.

Gage, released by Nebraska in 1963, appears to be well adapted to Illinois. Similar to Pawnee in maturity and straw strength, it has improved resistance to rust and soil-borne mosaic. Gage has performed well in Illinois trials, generally outyielding both Pawnee and Ottawa by several bushels per acre. It is comparable to Pawnee in straw strength.

Scout, a 1964 release from Nebraska, has yielded well in Illinois trials. It is similar to Gage in maturity, straw height, and strength. It is susceptible to soil-borne mosaic and leaf rust.

Parker is a white chaff variety released in Kansas in 1966. It matures earlier than Gage or Pawnee but slightly later than Triumph. Parker has shorter straw than other hard wheat varieties grown in Illinois. Straw strength is excellent. It is resistant to leaf rust and races A and B of Hessian fly. It is susceptible to soil-borne mosaic, stem rust, bunt, and loose smut. The kernel is mid-sized to small, but test weight is high.

Triumph is a bearded white chaff wheat developed in Oklahoma in 1940. It is shorter than Pawnee and matures three or four days earlier. It is susceptible to mosaic, leaf and stem rust, and bunt; however it has a good test weight and yield record in Illinois.

Varieties: Soft Red Winter

Abe is a soft red winter wheat variety released by Purdue University and the USDA in 1972. The parentage of Abe is similar to that of Arthur. Abe is similar to Arthur in lodging resistance, maturity, and weight per bushel. Under some conditions it will be slightly shorter.

Abe is resistant to Hessian fly, leaf rust, stem rust, powdery mildew, and soil-borne mosaic.

Arthur is a 1967 release by the Purdue Agricultural Experiment Station and the USDA. It has been a high-yielding variety in Illinois tests with excellent test weight. It is as winter hardy as Monon, is beardless, white chaffed, and early maturing, and has a short, stiff straw. Arthur responds well to high fertility. It is moderately resistant to leaf rust, and has good resistance to stem rust, powdery mildew, loose smut, soil-borne mosaic, and race A of the Hessian fly.

Arthur 71, released in 1971 by Purdue, is comparable to Arthur, except it is resistant to races A and B Hessian fly and is more resistant to leaf rust than Arthur.

Benhur was released in 1966 by the Purdue Agricultural Experiment Station and the USDA. It is a white chaff, beardless variety that matures 1 to 2 days earlier than Monon and under some conditions is as much as 3 inches shorter. It is superior to Monon in leaf and stem rust, Hessian fly, and lodging resistance. Under some conditions the chaff and stems may turn dark in color. This tendency, inherited from one of its parents, does not affect its yield.

Monon, a beardless white chaff variety, was released by Purdue in 1959. It grows 2 or 3 inches shorter than Knox and matures about 1 day earlier. It has more lodging resistance than Knox and Vermillion and is equal to Vermillion and better than Knox in winter hardiness. Monon is resistant to soil-borne mosaic. It is susceptible to stem rust, loose smut, bunt, and powdery mildew.

Blueboy is a very short, stiff-strawed, white chaff beardless variety developed at North Carolina State University. It matures 7 to 8 days later than Monon and Benhur, weighs 3 to 4 pounds less per bushel than they do, and is susceptible to the rusts and Hessian fly. Blueboy overwintered in 1968-69 and 1969-70 without noticeable cold damage. It was damaged at Urbana during the 1970-71 winter and severely damaged at DeKalb that year. It is apparently more winter hardy than most varieties developed for the southeastern United States, but may be damaged under severe winter conditions in Illinois.

Blueboy II is similar to Blueboy in maturity, winter hardiness, plant height, and lodging resistance. It is superior to Blueboy in weight per bushel and in leaf rust resistance.

Timwin is a soft red winter wheat variety released by the University of Wisconsin. It is a bearded white chaff variety which is very winter hardy. It is short-strawed, moderately resistant to lodging, and matures 3 to 5 days later than Monon. It has good tolerance to the rusts, but is susceptible to loose smut and Hessian fly.

Varieties: Hard Red Spring

Pembina, released in Canada, is an early variety. It is beardless, has white chaff, and is rust resistant.

Table 20. — 1972 Wheat Variety Demonstration Yields, Soft Wheat Varieties

County or location	Abe		Arthur		Arthur 71		Blueboy		Blueboy II		McNair 4823	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
Dixon Springs	56.8	54.0	46.1	53.0	57.8	54.0	65.1	53.3	54.3	52.0	46.6	53.0
Ewing	33.6	57.0	27.1	57.0	40.4	57.0	52.5	56.0	43.6	56.0	26.0	57.0
Gallatin	49.4	....	35.7	....	44.8	....	46.6	....	42.3	....	34.5	....
Greene	43.0	....	40.0	....	42.0	....	38.0	....	40.0	....	43.0	....
Jackson	38.2	58.0	52.2	57.0	37.8	58.0	44.9	52.0	35.8	53.0	33.6	54.0
Macon	63.2	67.0	60.7	61.0	66.1	61.0	85.1	56.0	79.5	57.0	56.8	57.5
Madison	57.0	58.0	47.8	57.0	50.2	58.0	59.4	55.5	54.3	55.5	33.6	58.0
Mason	36.6	....	37.9	....	37.9	....	28.7	....	36.3	....	32.2	....
Massac	56.7	59.0	30.1[a]	57.0	49.4	58.0	53.8	55.0	41.1	54.0	46.2	58.0
Monroe	75.4	57.5	....	....	72.5	59.0	72.5	51.0	69.4	53.0	65.7	54.5
Randolph	38.2	....	29.7	57.5	36.7	57.5	46.8	56.5	44.7	57.0	25.3	58.0
Richland	67.4	....	72.0	....	....	....	67.4	....	71.5	....	60.4	....
Schuyler	57.2	57.0	43.7	57.0	41.3	57.0	52.2	48.0	60.0	51.0	53.9	53.0
Shelby	66.9	....	65.4	....	63.1	....	76.0	....	71.3	....	61.6	....
St. Clair #1	42.0	55.0	15.1[a]	50.0	36.6	53.0	31.8	41.0	31.4	44.0	24.7	42.0
St. Clair #2	55.0	57.0	35.0	56.0	37.5	56.0	45.0	55.0	38.3	55.0	40.0	56.0
Wayne	36.6	....	31.1	....	29.7	....	19.1	....	20.5	....	19.8	....
White	28.8	60.0	27.4	59.5	30.4	57.0	24.2	51.0	23.2	51.0	29.1	52.0
Williamson	59.6	55.0	65.6	56.0	62.6	55.0	61.5	51.0	58.1	49.0	46.5	49.0
Average for 15 locations	48.0	58.0	43.0	56.0	45.0	57.0	50.0	52.0	47.0	52.0	39.0	54.0

[a] Poor stand due to water.

Chris is a beardless hard red spring wheat of medium height and maturity with moderately stiff straw. It is resistant to prevalent races of stem rust, leaf rust, and black chaff. It has good test weight and satisfactory milling and baking qualities. It was released by Minnesota in 1965.

Table 21. — Hard Red Spring Wheat Variety Yields at DeKalb, Illinois

	1973		1971–73	
	Bu./A.	T.W.	Bu./A.	T.W.
Chris	27	59	35	55
Era	28	57	36	54
Fletcher	24	57	33	54
Lathrop	28	58	35	55
Polk	29	60	35	57
Selkirk	27	55	35	52
Waldron	28	56	37	54

Crim, released in Minnesota in 1963, is resistant to stem rust, but susceptible to leaf rust and loose smut. Its grain quality is satisfactory.

Era is a semi-dwarf hard red spring wheat variety released by Minnesota in 1971. It is resistant to stem rust, leaf rust, black chaff, and bunt.

Fletcher is a semi-dwarf hard red spring wheat released by Minnesota in 1970. It is resistant to stem rust, leaf rust, black chaff, and bunt.

Polk, released by the University of Minnesota in 1968, is a bearded variety of medium height and maturity. It has a moderately stiff straw, and good resistance to the common races of leaf and stem rust and to black chaff and bunt. Test weight is excellent.

Waldron was released by North Dakota in 1969. It is beardless with a trace of awned plants. It is earlier and has stronger straw than Chris and Polk. It is resistant to the common races of leaf rust and to stem rust.

Selkirk was released in Canada in 1953. It is a beardless, white chaff variety of medium height and maturity and good straw strength.

Fertilizing Wheat

Among Illinois field crops wheat is second only to corn in response to fertilizer.

Phosphorus. Wheat requires a large amount of *readily available phosphorus* in the fall. Phosphorus stimulates early growth, promotes winter survival, and helps make the young plant capable of high yield in the following year.

Suggested applications of phosphorus-supplying fertilizer for wheat in Illinois given in Table 22 are based on P_1 soil tests.

If you do not have the results of a P_1 soil test, apply 30 to 60 pounds of available P_2O_5 (13 to 26 pounds P) through the drill or broadcast about 60 to 120 pounds P_2O_5 (26 to 53 pounds P). The lower figure in both cases is for fields on which considerable phosphorus has previously been added.

The Department of Agronomy at the University of Illinois has revised the interpretation of the P_1 test for corn based upon the available phosphorus in the soil profile, but the interpretation of the test for wheat will be the same for all soils until new data show that a change should be made.

Nitrogen. The most profitable rate of nitrogen fertilizer is reached by balancing the likely increase in yield of

Table 22. — Applications of Available Phosphorus for Wheat (P_2O_5 and Equivalent Pounds P)

P_1 test level	Percent of possible yield	Pounds of P_2O_5 or P to be added per acre based on the P_1 test					
		P_2O_5			P		
		Broadcast		Through planter or drill	Broadcast		Through planter or drill
10–15	Below 47	90[a] to 150[a]	+ or	30 or 90[a]	39[a] to 65[a]	+ or	13 or 39[a]
20	57	60 to 120[a]	+ or	30 or 80	26 to 53[a]	+ or	13 or 35
30	72	60 to 90[a]	or	60	26 to 39[a]	or	26
40	82	60	or	30 to 60	26 or 13 to 26		
60	92			30	13		

[a] The soil test will likely increase about 1 pound for every 9 pounds of P_2O_5 fertilizer (4 pounds of P) applied. Rates of 120 and 150 pounds are for those who desire a rapid buildup in available phosphorus and for all fields on which alfalfa, clover, or lespedeza will be seeded unless the P_1 test is already 50 or above.

wheat against likely reduction in stand and vigor of alfalfa or clover if seeded in the wheat (Table 23).

Wheat will usually respond to extra nitrogen up to the point where lodging begins. Greatest increases for nitrogen are on light-colored forest soils (formed under native cover of trees rather than prairie grasses). The moderately dark-colored prairie soils of south central Illinois are also relatively low in organic matter and thus respond well to nitrogen. Coarse-textured soils (sands, sandy loams, and gravelly loams) generally need extra nitrogen because nitrates leach readily from the root zone in these soils.

Fall application. The amount of nitrogen needed for good fall growth is not large because the total uptake in roots and tops is not likely to exceed 30 to 40 pounds per acre. The suggested rate for applying nitrogen in a mixed fertilizer through the drill on light- and moderately dark-colored soils is therefore only 15 to 20 pounds. The safe upper limit for N plus K to avoid seedling injury is about 40 pounds per acre.

On dark-colored soils nitrogen is not needed at planting time.

Potassium. Wheat is not very responsive to potassium unless the soil test is below 100. The potassium fertilizer applied before planting or at planting time is therefore aimed mainly at meeting the needs of the forage legume to be seeded in the wheat or as part of a general soil buildup or maintenance treatment.

Table 23. — Total Nitrogen Applications (Fall Plus Spring) for Different Soil Situations and Varieties

Soil situation	For fields with alfalfa or clover seedings (pounds)		For fields with no alfalfa or clover (pounds)	
	Abe Arthur	Other adapted varieties	Abe Arthur	Other adapted varieties
Soils **low** in capacity to supply nitrogen: inherently low in organic matter (light colored), no manure, alfalfa, or clover in the preceding year	50–70	40–60	70–90	50–70
Soils **medium** in capacity to supply nitrogen (compare situation to **low** above and **high** below)	30–50	20–40	50–70	30–50
Soils **high** in capacity to supply nitrogen (light-colored soils that regularly have legumes or manure and all deep, dark-colored soils)	20–30	0	40–50	20–30

OATS

Spring oats are a cool weather crop. Cool weather is especially important during the kernel filling stage. Therefore early planting is important for top yield. They should be planted as soon as you can get the land ready.

Oats respond to a good seedbed. Where they follow corn plowing is best. But if this is impractical, better oat yields will result if the stalks are shredded before disking.

Illinois tests show a 7- to 10-bushel advantage for drilling as compared with broadcasting. The normal seeding rate when planted by drilling is 2 to 2½ bushels per acre.

Varieties of Spring Oats

Brave is a high-yielding variety from Illinois. It has excellent smut resistance, some tolerance to septoria, and tolerance to barley yellow dwarf virus. Its test weight is adequate, quality good, and seed color yellow. Brave has fair straw strength but is not quite equal to Newton in this respect. Generally an early variety, Brave appears to be well adapted throughout Illinois.

Chief. Released by the South Dakota Agricultural Station in 1972, Chief matures at the same time as Garland. Grain color is yellow with about 2 percent of the kernels being white. It grows about 2 inches taller than Garland, but is comparable in lodging resistance and kernel weight. It is resistant to leaf rust.

Clintford was developed at Purdue from the cross of a Clintland type with Milford. Milford was introduced from Wales for its excellent straw strength. Clintford is the first variety in the United States to use this source of straw strength. The grain is a light brownish white (or light yellowish white in some seasons), large, plump, and very high in test weight. Clintford has very short, stiff straw with large-diameter stems. It matures about 2 days earlier than Clintland 64. Clintford has a compact panicle that distinguishes it from other varieties grown in Illinois.

Clintland 64 was released by the Indiana Agricultural Experiment Station and is very similar to Clintland 60, except for improved leaf-rust resistance. Clintland 64 is one of the most leaf-rust-resistant varieties currently available. The variety is not resistant to barley yellow dwarf virus.

Dal. Released by the Wisconsin Agricultural Experiment Station in 1972, Dal is comparable to Froker in height and maturity. It is resistant to the rusts and smut. Straw strength is about equal to Froker. Dal kernels, which have a whitish color, contain about 2.5 percent more protein than other commonly grown varieties.

Diana is a yellow oat released by Purdue University in 1966. It matures about the same time as Garland, yields above Clintland 64, and possesses good test weight and straw strength. Diana is medium in height, has good resistance to leaf rusts, and is resistant to most races of stem rust.

Froker is a yellow oat released by the University of Wisconsin in 1970. It is late maturing, similar to Lodi. Froker has improved leaf rust resistance, resistance to most races of stem rust, and good resistance to smut. Straw height is similar to Portal but with greater strength.

Garland, released by Wisconsin, performs very well in northern and central Illinois. A sister selection of Dodge and Goodfield, Garland has shown good performance in Urbana and DeKalb trials and in county demonstrations. It has good test weight, stands well, and has resistance to some races of smut.

Grundy is a yellow oat variety released by the Iowa Agricultural Experiment Station in 1972. It is similar to Jaycee in maturity, lodging resistance, and plant height. It is resistant to some but not all races of leaf rust. It is susceptible to stem rust and barley yellow dwarf virus.

Holden was released by the Wisconsin Agricultural Experiment Station in 1967. The variety matures slightly later than Garland. Its yield has been 5 to 8 percent greater per acre than Garland in northern Illinois, but slightly below Garland in central and south-central Illinois. The grain of Holden has a yellow hull, a well-filled kernel, and a good test weight that is equal to Garland. Holden is resistant to older races of leaf rust and intermediate-to-susceptible to newer races. It has resistance to smut and some races of stem rust.

Jaycee is an early maturing, high-yielding variety developed at the University of Illinois. The grain color is light brownish to yellowish white. It produces fairly large, plump kernels with groat percentage and test weight similar to Newton. Jaycee is very short strawed (1 to 3 inches shorter than Goodfield), and has stood well under Illinois conditions until maturity. Jaycee loses its strength rapidly after maturity. Harvest Jaycee as soon after maturity as is possible to avoid high field losses. It has barely yellow dwarf virus tolerance that is superior to any variety now available for growing in Illinois. It is resistant to some, but not all, races of leaf and stem rust. Jaycee is resistant to races of smut that have occurred in Illinois.

Kota was developed by South Dakota State University. It is similar to Portal in height, heading date, maturity date, test weight, and kernel size. It is moderately resistant to lodging and to stem and crown rust. It is resistant to smut and has some tolerance to the barley yellow dwarf virus.

Newton was released by Indiana in 1955. This variety has both Nemaha and Clinton in its parentage, and combines the best characteristics of each. Generally, it has

Table 24. — University of Illinois Oat Variety Yields

	DeKalb			Urbana[a]			Brownstown[a]		
	1973		1972–73	1972		1972–73	1972		1971–72
	Bu./A.	T.W.	Bu./A.	Bu./A.	T.W.	Bu./A.	Bu./A.	T.W.	Bu./A.
Clintford	47.9	30.0	60.0	85.4	38.0	88.0	110.1	40.0	97.0
Clintland 64	58.0	28.0	71.0	79.4	34.0	77.0	86.8	37.0	80.0
Dal	65.3	28.0	72.0	87.8	33.0	....	104.4	34.0	....
Diana	46.1	28.5	60.0	85.7	34.0	87.0	118.0	37.0	99.0
Froker	61.0	30.5	65.0	81.8	34.0	77.0	97.9	36.0	....
Garland	55.5	29.0	77.0	82.0	34.0	88.0	104.9	37.0	93.0
Grundy	31.1	29.0	55.0	88.0	35.0	....	114.0	37.0	....
Holden	57.8	29.0	71.0	82.5	34.0	87.0	107.0	37.0	92.0
Jaycee	34.7	26.5	57.0	93.2	36.0	99.0	122.3	38.0	104.0
Newton	53.9	30.0	61.0	87.9	34.0	86.0	109.1	39.0	95.0
Otee	52.4	28.0	64.0	88.4	35.0	91.0	116.0	36.0	103.0
Otter	69.8	27.0	81.0	96.7	35.0	101.0	99.5	36.0	88.0
Orbit	62.4	27.0	73.0	87.3	33.0	97.0	113.2	35.0	99.0

[a] 1973 test abandoned because of wet harvest or water damage.

large, plump kernels and good straw strength. Newton shows some tolerance to barley yellow dwarf virus and has some rust resistance, but it is susceptible to several of the newer races of rust. It is also susceptible to septoria.

Orbit is a white oat released from Cornell University. It is short-strawed, lodging resistant, and matures three to five days later than Newton. It is resistant to smut, stem rusts, and some of the leaf rusts. Orbit has about the thickest hull among current varieties. The heavy hulls lower the groat-to-hull percentage.

Otter is a white oat released by the University of Minnesota in 1970. It matures about the same time as Garland and is of similar height. Straw strength is good. Otter is resistant to smut. It has fair to good resistance to leaf and stem rusts. The yields of Otter have been high and its test weight slightly below most varieties, but the groat percentage has been high.

Portal was released by the Wisconsin Agricultural Experiment Station in 1967, and is a variety that matures in midseason in Illinois. Portal is similar to Garland in most characteristics but has yielded 5 to 10 percent more than Garland. The test weight and straw strength of Portal are slightly less than Garland. It is taller than Garland and matures a little later than Garland. The variety has a yellow hull and resistance to smut and most races of stem rust. Portal has more resistance to leaf rust than most varieties available at present, equaling Clintland 64.

Winter Oats

Winter oats are not as winter hardy as wheat and are adapted to only the southern one-third or one-quarter of the state. U.S. Highway 50 is about the northern limit for winter oats.

Since the crop is somewhat winter tender and is not attacked by Hessian fly, planting in early September is highly desirable. Experience has shown that oats planted before September 15 are more likely to survive the winter than those planted after September 15.

The same type of seedbed is needed for winter oats as for winter wheat. The fertility program should be comparable to that for spring oats. Seeding rate is 2 to 3 bushels per acre when drilled.

Fertilizing Oats

Since an oat field usually has a forage seeding in it, the fertilizer application must be planned to meet the needs of both crops. Both have high phosphorus requirements. Suggested treatments are slightly lower than for wheat (Table 22, page 23), because oats are less valuable than wheat.

Oats have a relatively low potassium requirement, so plan the application to meet the needs of the legume seeding or to build up the soil-test level (Table 43, page 44), or both.

A large proportion of Illinois oat fields would benefit from nitrogen fertilizers. Varieties have become progressively shorter, with stiffer straw, so they resist lodging and give a yield increase with higher rates of nitrogen.

On highly fertile, dark-colored soils in livestock systems of farming where lodging is still likely, no extra nitrogen is suggested. Where no manure or legume crops are used in central and northern Illinois, use 40 to 60 pounds. On light-colored soils that have not regularly had either legume crops or manure, 80 pounds of nitrogen is about right.

In all fields where you make a legume seeding, apply slightly less nitrogen than is normally recommended for the oats. This will improve the seeding more than enough to offset the reduction in oat yield.

CROPS FOR LATE PLANTING

In most years flooding or some other disaster makes replanting of corn and soybeans necessary somewhere in Illinois.

When this happens the most common questions are: Is it too late to replant with corn or soybeans? If it is not too late, how early a variety should be used? If it is too late for corn or soybeans is there any other crop that can be substituted for feed grain or cash-grain production.

Any answer to these questions assumes that (1) weather conditions following replanting will favor immediate germination and emergence, (2) that rainfall and temperatures will favor normal growth and development, and (3) that the first killing frost in the fall will be as late or later than average.

The following are estimates of how late corn and soybeans may be planted in Illinois when favorable weather and growing conditions follow replanting.

Starting in the northwestern corner of the state where the first killing frost can be expected before October 5, June 15 is the latest date that early varieties of corn can be planted with reasonable assurance that they will be mature (30 to 35 percent moisture) before the first frost. Make the shift to early varieties in late May.

As the average date of the first killing frost moves later into October the latest date for planting corn for grain moves later into June.

In the northern third of the state you can move the planting date later into June about the same number of days that the first frost falls after October 5.

In the southern two-thirds of the state (this is especially true of the southern one-third) you can move the planting date proportionally later into June because of the higher temperatures during the remainder of the growing season. In central Illinois where the average killing frost occurs on October 15, corn planted as late as July 5 has a 50-percent chance of maturing before frost.

Unless the need for grain or silage is especially great, planting corn later than July 5 to 10 is of questionable merit because yields are likely to be low.

Soybeans have the ability to greatly shorten their vegetative period and may be planted later than corn with reasonable assurance that they will mature before frost. In northern Illinois, where the first killing frost is expected about October 5, early varieties such as *Chippewa 64* and *Hark* may be expected to mature when planted as late as the last of June. The later varieties, such as Harosoy 63 and Corsoy, may be used until the middle of June.

In north central Illinois you can plant *Harosoy 63* and *Corsoy* until early July and you can use varieties of the maturity of Amsoy until mid-June.

In central Illinois Wayne and varieties of similar maturity will mature when planted by mid-June. Use *Amsoy, Harosoy 63,* and *Corsoy* until July 5 to 10.

The growing season in southern Illinois is long enough that most of the varieties normally grown in the area will mature when planted as late as July 5 to 10.

When you must plant soybeans late, use the tallest variety that has a reasonable chance to mature. One of the problems with late-planted soybeans is short plant height and low podding. Dry weather aggravates this.

Other grain crops that mature in a short time and may be used in an emergency are sorghum and buckwheat.

Varieties of sorghum that will mature in 90 to 100 days are sometimes used for late planting. The penalty for planting sorghum late is often not so great as it is for corn and other crops. If the crop is being grown as a cash crop, arrangements for a market should be made ahead of planting. Some elevators prefer not to handle sorghum. Local livestock feeders or feed mills may be interested in the crop.

Another problem usually associated with sorghum is that of drying the grain. The grain should be harvested as soon as it is mature. Often this will be before the plant is dry and the grain will be too wet to store without drying.

Buckwheat may mature in 75 to 90 days. It can be planted as late as July 10 to 15 in the northern part of the state and late July in southern Illinois.

The crop is sensitive to both cold and hot weather. It will be killed by the first frost in the fall. Yields will be disappointingly low if it blooms during hot weather.

The market for buckwheat is limited unless you plan to use it for livestock feed. Be sure of a market before you plant it.

BARLEY

Both spring and winter barley may be grown in Illinois. Spring barley is best adapted to the northern one-quarter or one-third of Illinois, but it has been grown successfully as far south as Champaign County. Winter barley has been grown as far north as Will County, but is best adapted to the southern half of the state.

Plant spring barley early or about the same time as spring oats at 1½ to 2 bushels per acre. Harvest the crop as soon as it is ripe because of the danger of excessive lodging. Fertility requirements are essentially the same as for spring oats.

Winter barley is not as winter hardy as the commonly grown varieties of winter wheat. For this reason winter barley should be planted about 10 days to two weeks earlier than wheat. Sow with a drill and plant at the rate of 2 bushels of seed per acre.

The fertility requirements for winter barley are similar to those for winter wheat with the exception that less nitrogen will be required. Most winter barley varieties are less resistant to lodging than wheat varieties. Winter barley cannot stand "wet feet," therefore should not be planted on land that tends to be low and wet.

Watch out for army worms and chinch bugs. Both prefer barley to almost any other crop.

Winter Varieties

Paoli is a new six-row winter barley from Purdue University. It is early maturing, very winter hardy, short and stiff strawed, and has short rough awns that are persistent, making is moderately difficult to thresh. The earliness of Paoli may be helpful for double-cropping programs. It was very high yielding in the 1971 trial at Brownstown.

Barsoy is an early winter barley from the Kentucky Agricultural Experiment Station. It has a good yield record. The earliness of Barsoy allows it to fit well into a double-cropping program.

Spring Varieties

Burk is a new spring barley from the Wisconsin Agricultural Experiment Station and performed well in 1972 (Table 25). Malting quality status of Burk is undetermined.

Larker is the most popular spring barley variety in Minnesota, Wisconsin, and Iowa. It has yielded well in Illinois. It is an approved malting variety. It has good straw strength and kernel plumpness.

Nordic is a spring barley variety developed and released by the North Dakota Agricultural Experiment Station. It is similar to Larker in maturity and lodging resistance. It has plumper kernels and better disease resistance. The malting quality status of Nordic has not definitely been established.

Table 25. — Spring Barley Yields at Urbana and DeKalb

	Urbana			DeKalb		
	1973		1972–73	1973		1972–73
	Bu./A.	T.W.	Bu./A.	Bu./A.	T.W.	Bu./A.
Beacon	43	38	58	50	43	61
Bonanza	38	41	57	52	44	64
Burk	39	43	62	47	46	66
Conquest	45	41	58	62	42	67
Cree	34	38	43	42	44	47
Dickson	36	40	44	47	44	50
Larker	38	43	58	57	45	68
Nordic	40	41	58	53	44	64
Traill	27	39	45	45	45	54

Table 26. — Winter Barley Performance at Urbana and Brownstown

	Urbana			Brownstown[a]		
	1973		1972–73	1972		1971–72
	Bu./A.	T.W.	Bu./A.	Bu./A.	T.W.	Bu./A.
Barsoy	70	49	71	63.9	48	80
Harrison	100	48	83	63.9	48	83
Jefferson	92	44	76	78.8	43	81
Lakeland	94	46	76	73.5	45	88
Paoli	95	46	73	72.8	45	90
Schuyler	44	91	53	70.1	43	88

[a] The 1973 test was abandoned because of water damage.

TRITICALE

Triticale is a new crop resulting from the crossing of wheat and rye. The crop is still in the developmental stage. The varieties currently available are usually deficient in some characteristic such as winter hardiness, poor seed set, or shriveled seed. In addition, they are of feed quality only. They do not possess the milling and baking qualities needed for use in human food.

The potential exists, however, for plant breeders to correct these deficiencies. When this is done the crop may be especially valuable for its high protein content and high protein quality.

A limited testing program on the Agronomy South Farm and the Northern Illinois Experiment Field in DeKalb County indicates that the crop is generally lower yielding than winter wheat and spring oats. There are both spring and winter types of triticale available. The yields of two spring types are given in Table 27.

Table 27. — University of Illinois Triticale Variety Trials, 1972

Variety	Urbana		DeKalb	
	Bu./A.	T.W.[a]	Bu./A.	T.W.[a]
T209..................	66.8	47.3	42.0	34.6
Rosner..................	60.9	44.1	38.7	33.0

[a] Test weight in pounds per bushel.

HAY, PASTURE, SILAGE, AND SEED PRODUCTION

High Yields

Thick, vigorous stands of grasses and legumes are needed for high yields. A thick stand of grass will cover nearly all the ground. A thick stand of alfalfa is about 30 plants per square foot the seeding year, 10 plants per square foot the second year and 5 plants per square foot for succeeding years.

Vigorous stands are obtained and maintained by adequate fertilization, selection of disease-resistant and insect-resistant varieties, selection of varieties exhibiting rapid growth and recovery growth, protection of the stand from insects, and timely harvests.

Establishment

Spring seeding date for hay and pasture species in Illinois is as early in April or late March as a seedbed can be prepared. An exception is when seedings are made in a winter-sown companion crop. In winter companion crops, hay and pasture species should be seeded about the time of the last snow.

Spring seedings in oats should be done at the time the oats are seeded.

Spring seedings are more successful in the northern half of Illinois than in the southern half. The frequency of success in the southern one-quarter to one-third of the state indicates late-summer seedings may be more desirable than spring seedings. Spring seedings are usually more successful than late-summer seedings in the northern one-quarter of Illinois.

Late-summer seeding date is August 10 in the northern one-fourth of Illinois, August 30 in central Illinois, and September 15 in the southern quarter of Illinois. Seedings should be made close to these dates and not more than five days later to assure that the plants become well established before winter.

Seeding rates for hay and pasture mixtures are shown in Table 39 on page 37. These rates are for average conditions and when seeded with a companion crop in the spring or without a companion crop in late summer. Higher rates can be used to obtain high-yields from alfalfa seeded without a companion crop in the spring. Higher seeding rates than described in Table 39 have proven economical in northern and central Illinois when alfalfa was seeded as a pure stand in early spring and two or three seeding-year harvests taken. Seeding at 18 pounds of alfalfa per acre has produced 0.2 to 0.4 ton higher yield than seedings at 12 pounds per acre in northern and central Illinois, but not in south central Illinois (Table 28).

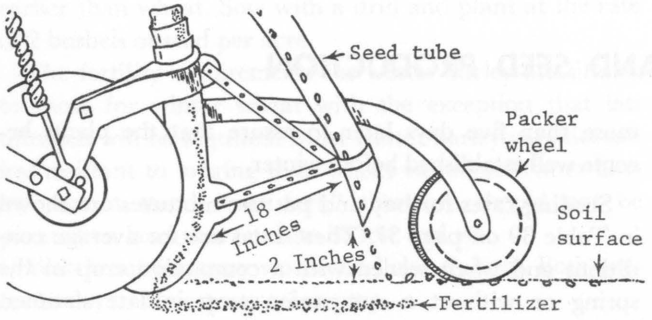
Seeding methods, either broadcast or band seeding, are most successful when weeds are destroyed, crop residues are incorporated, the soil is firmed, and the soil is fertile or properly fertilized. Broadcast seedings are as successful and high yielding as band seedings when soils are fertile

Table 28. — Accumulated Dry-Matter Yields of Alfalfa Seeded Alone in the Spring Over 2-, 3-, and 4-Year Periods at Three Locations, 1967-70

Seeding rate (lb. per acre)	Brownstown (2 years)	Urbana (4 years)	DeKalb (3 years)
		Tons per acre	
12.............	6.73	19.22	13.20
18.............	6.81	19.64	13.57
24.............	6.49	19.69	13.53

and seeding conditions good. Band seeding may have some advantage over broadcast seedings on low-fertility soils and where crusting soils are a problem. Band seeding is placing a high-phosphate fertilizer 1½ to 2 inches deep in the soil with a grain drill and placing the forage seeds on the soil surface through a flexible tube from the seed box, dropping the seed about 18 inches behind the disk opener of the drill (Fig. 5).

Forage crop seeds are small and should be seeded no deeper than one-fourth to one-half inch. These seeds need to be in close contact with soil particles. Firming the seedbed with a corrugated roller before seeding and rolling the seed into contact with the soil with a corrugated roller or press wheel after seeding is the best known method of seeding forages.



Placement of high-phosphate fertilizer with grain drill. (Fig. 5)

Fertilizing and Liming With or Before Seeding

Lime. Apply lime at rates suggested in Figure 6, page 38. If rate requirements are in excess of 5 tons, apply half before the primary tillage (in most cases, plowing) and half before the secondary tillage (harrowing, disking). Apply rates of less than 5 tons at one time, preferably after plowing, but either before or after is acceptable.

Nitrogen. No nitrogen is suggested for soils above 2.5 percent organic matter. Up to 20 pounds per acre may help assure rapid seedling growth of legume-grass mixtures on soils with less than 2.5 percent organic matter. If seeding a pure grass stand, 50 to 100 pounds per acre in the seedbed is suggested. If band seeding, apply nitrogen with phosphorus through the grain drill. For broadcast seedings, apply broadcast with phosphorus and potassium.

Phosphorus. Apply all phosphorus at seeding time (Table 29) or broadcast part of it with potassium. For band seeding reserve a minimum of 30 pounds of P_2O_5 per acre. For broadcast seeding, broadcast all the phosphorus with potassium preferably after primary tillage and before final seedbed preparation.

Table 29. — Suggested Rates for Phosphorus Applied Before Seeding, Based on Expected Yield in Seeding Year for Alfalfa and Alfalfa-Grass Mixtures

P_1 test — Soil region (see map, page 38)			Broadcast seeding — Expected yield per acre		Band seeding — Expected yield per acre	
low	*med.*	*high*	2-3 tons	3-5 tons	2-3 tons	3-5 tons
			Pounds of P_2O_5 per acre			
25	15	10	120	180	60	90
30	20	15	90	150	50	80
38	30	20	60	90	30	60
45	40	30	60	60	30	40
60	50	40	..	..	30	30

Table 30. — Suggested Rates for Potassium Applied Before Seeding, Based on Expected Yield During the Seeding Year for Alfalfa and Alfalfa-Grass Mixtures

K test level	Expected yield, tons of dry matter per acre — 2-3	3-5+
	Pounds K_2O to apply per acre	
90 or less	160	220
91-120	120	180
121-150	80	140
151-180	0	100
181 and above	0	0

Potassium. Broadcast application of potassium is preferred (Table 30). For band seeding, you may safely apply a maximum of 30 to 40 pounds K_2O per acre in the band with phosphorus. The response to band fertilizer will be mainly from phosphorus unless the K soil test is very low (perhaps 100 or less). For broadcast seeding, apply all the potassium after the primary tillage. You can apply up to 300 pounds of K_2O per acre in the seedbed without damaging seedlings.

Maintenance Fertilization

Nitrogen. The species grown, period of use, and yield goal determine optimum nitrogen fertilization (Table 31).

Kentucky bluegrass is shallow rooted and susceptible to drouth. Consequently, the most efficient use of nitrogen by bluegrass is from an early spring application. September applications are second choice. September fertilization stimulates both fall and early spring growth.

Orchardgrass, smooth bromegrass, tall fescue, and reed canarygrass are more drouth tolerant than bluegrass and can effectively use higher rates of nitrogen than bluegrass. Because more uniform pasture production is obtained by splitting the high rates of nitrogen, two or more applications are suggested.

Table 31. — Nitrogen Fertilization of Hay and Pasture Grasses

Species	Nitrogen per acre (pounds): Early spring	After first harvest	After second harvest	Early September
Kentucky bluegrass	60–80			(see text)
Orchardgrass	75–125	75–125		50[a]
Smooth bromegrass	75–125	75–125		50[a]
Reed canarygrass	75–125	75–125		50[a]
Tall fescue for winter use		100–125	100–125	

[a] Optional if extra fall growth is needed.

Make the first application in March in southern Illinois, early April in central Illinois, and mid-April in northern Illinois if extra spring growth can be utilized. If spring growth is adequate without extra nitrogen, the first application may be delayed until after the first harvest or grazing cycle to distribute production throughout the summer more uniformly. Total production will likely be reduced. The second application of nitrogen is usually made after the first harvest or first grazing cycle. However, this application may be deferred until August or early September to stimulate fall growth.

Legume-grass mixtures should not receive nitrogen if legumes make up *30 percent or more* of the mixture. The main objective is to *maintain the legume,* so emphasis should be on phosphorus and potassium rather than nitrogen.

After the legume has declined to less than 30 percent of the mixture, the objective in fertilizing is to *increase the yield of grass.* The suggested rate of nitrogen is about 50 pounds per acre when legumes make up 20 to 30 percent of the mixture, and 100 to 200 pounds when legumes are less than 20 percent of the mixture. To maintain pure grass stands refer to the discussion above.

Phosphorus. This nutrient may be applied in large amounts, adequate for two to four years. The annual needs of a hay or pasture crop are determined from yield, nutrient content of the forage harvested, and nutrient-supplying capacity for a particular soil (Fig. 7, page 40). Grasses, legumes, and grass-legume mixtures contain about 11 pounds of P_2O_5 (4.8 pounds of P) per ton of dry matter. Soils that are low in nutrient-supplying power need to have 100 percent of the nutrients that are removed in forage replaced by fertilization. Soils that are high in nutrient-supplying power require 50-percent replacement of nutrients removed (Table 32). Annual fertilization needs are shown in Table 32 for three yield levels on the major soil regions. Annual fertilization is determined by dry-matter yield, multiplied by composition multiplied by percent of nutrient to be supplied.

Potassium. Potassium is needed in large amounts by grasses to balance high rates of nitrogen fertilization. As nitrogen rates increase, the percent nitrogen in the plant tissue also increases. All the nitrogen applied to grasses may not be converted to protein and may remain as non-protein nitrogen in the plant. Potassium helps the plant convert nitrogen to protein.

Legumes feed heavily on potassium. Potassium is a key element in maintenance of legumes in grass-legume stands and is also credited with improving winter survival.

Potassium rates are determined from yield, nutrient content in the forage that is harvested, and nutrient-supplying capacity of a particular soil. Grasses, legumes, and grass-legume mixtures contain about 50 pounds of K_2O (41.5 pounds of K) per ton of dry matter. Annual fertilization needs are shown in Table 30 for three yield levels in the major soil regions. Annual fertilization is determined by dry-matter yield multiplied by composition multiplied by percent of nutrient to be supplied.

Table 32. — Suggested Annual Maintenance Fertilization for Alfalfa, Grasses, and Alfalfa-Grass Mixtures After Soil Tests Are Built to High Levels

Nutrient-supplying power rating of soil[a]	Phosphorus[b]: Percent of nutrients to be supplied by fertilization	Yield expected or obtained (tons dry matter per acre): 5	7	10	Potassium: Percent of nutrients to be supplied by fertilization	Yield expected or obtained (tons dry matter per acre): 5	7	10
		Pounds P_2O_5 per acre				*Pounds K_2O per acre*		
Low	100	55	77	110	100	250	350	500
Low to medium	80	44	62	88	90	225	315	450
Medium	70	38	54	77	80	200	280	400
Medium to high	60	33	46	66	70	175	245	350
High to medium	50	28	38	55	60	150	210	300
High	50	28	38	55	50	125	175	250

[a] See Figures 7 and 8 on pages 40 and 43.
[b] Rates sufficient for four years may be applied at one application.

Potassium may be applied at any convenient time. Usually this will be after the first harvest or in September.

Boron. Boron deficiency symptoms appear on second and third cuttings of alfalfa during drouth periods in some areas of Illinois. But yield increases from boron fertilization have been infrequent. There is no recommendation for general application of boron in Illinois. If you suspect there is a boron deficiency, topdress strips in your alfalfa fields with 30 pounds per acre of household borax (3.3 pounds of actual boron).

Other micronutrients. Sulfur is often suggested as limiting growth of forages in some areas of the midwest. We have no research to confirm the need to add sulfur for forage crops in Illinois.

Management

Seeding year. Spring-seeded hay crops and pastures in a companion crop will benefit by early removal of the companion crop. Oats, wheat, or barley should be removed when the grain is in the milk stage. If these small grains are harvested for grain, it is important to remove the straw and stubble as soon as possible. As small grain yields increase, greater competition is being expressed on underseeded legumes and grasses and fewer satisfactory stands are being established by the companion crop method. Forage seedings established with a companion crop may have one harvest taken by late August in northern Illinois, by September 10 in central Illinois, and by September 25 in southern Illinois.

Spring-seeded hay crops and pastures without a companion crop should be ready for harvest 65 to 70 days after an early April seeding. Weeds will very likely need to be controlled about 30 days after seeding unless a preemergence herbicide was used. A postemergence herbicide, 4-2,4-DB, is effective against most broad-leaved weeds. Leafhoppers often become a problem between 30 and 45 days after an early April seeding and will need to be controlled to obtain a vigorous high-yielding stand.

Second and third harvests may follow the first harvest at 35- to 40-day intervals. The last harvest of the season should be in late August for the northern quarter of Illinois, by September 10 for the central section, and by September 20 for the southern quarter of Illinois.

Established stands. Maximum dry-matter yield from alfalfa and most forages is obtained by harvesting or grazing the first cutting at nearly full bloom and each succeeding harvest every 40 to 42 days thereafter until September. This management produces a forage that is relatively low in digestibility. It is suitable for livestock on maintenance, will produce slow weight gain, and can be used in low-production feeding programs. High performance feeding programs need a highly digestible forage. The optimum compromise between high digestibility and dry-matter yield of alfalfa is to harvest or graze the first cutting at the late-bud-to-first flower stage and to make subsequent cuttings or grazings at 35-day intervals. Rotational grazing is essential to maintain legumes in pastures. A rotational grazing program should provide for 5 to 7 days of grazing and 30 to 35 days of rest.

Winter survival and vigor of spring growth are greatly affected by the time of the fall harvest. A high level of root reserves (sugars and starches) is needed. Root reserves decline following a harvest as new growth begins. About three weeks after harvesting, root reserves are depleted to a low level and the top growth is adequate for the photosynthesis to support the plant's needs for sugars. Root reserves are replenished gradually from this point until harvested or until the plant becomes dormant in early winter. Harvests made in September and October affect late-fall root reserves of alfalfa more than do harvests made in the summer. A recovery growth period from early September to late October is needed to store a high level of root reserves. A harvest may be taken late in October after the plants are dormant in central and southern Illinois on well-drained soils. See Table 33 for fall management suggestions.

Table 33. — Acceptable Fall Harvesting Dates for Alfalfa in Illinois by Regions

	Northern	Central	Southern
	Harvest dates		
September	1	10	20
October	No	25	30

Species

Alfalfa is the highest yielding perennial forage crop suited to Illinois, and its nutritional qualities are nearly unsurpassed. Alfalfa is an excellent hay crop species and can be used in pastures with proper management as mentioned above.

Bloat in ruminant animals is often associated with alfalfa pastures. Balanced soil fertility, including grasses in mixtures with alfalfa, maintaining animals at good nutritional levels, and using bloat-inhibiting feed amendments are methods to reduce or essentially eliminate the bloat hazard.

Many varieties of alfalfa are available. An extensive testing program has been underway in Illinois for many years. A summary of variety performance is presented in Table 34. Bacterial wilt resistance is usually necessary if alfalfa is to persist in most Illinois fields beyond 4 or 5 years. Moderate resistance to bacterial wilt enables alfalfa to persist up to 4 or 5 years. Susceptible varieties usually decline in a stand severely in the third year of production and may die out in the second year under intensive harvesting schedules.

Other diseases and insects are problems and some varieties have particular resistance to these problems. You should question your seedsman concerning these attributes of the varieties being offered to you.

Red clover is the second most important hay and pasture legume in Illinois. It does not have the yield potential of alfalfa under good production conditions, but can persist in more acid conditions and under more shade competition than alfalfa. Although red clover is physiologically a perennial, root and crown diseases limit the life of red clover to two years. Efforts are underway to breed more disease resistance into red clover, hoping to find a variety with a longer life.

Red clover does not have as much seedling vigor or as rapid seedling growth rate as alfalfa. Therefore, red clover does not fit into a spring seeding without a companion crop program as well as alfalfa.

There are fewer varieties of red clover than of alfalfa. Mammoth red clover has increased in use during the last two or three years. Yields of mammoth red clover have been lower than most of the improved varieties of medium red clover.

Ladino clover is an important legume in pastures, but has received little attention recently because of its short-lived character. The very leafy nature of ladino makes it an excellent legume for swine. It is a very high-quality forage for ruminant animals also, but problems of bloat are frequently experienced.

Ladino lacks drouth tolerance because its root system is rarely as deep as red clover or alfalfa.

Birdsfoot trefoil has been popular in permanent pastures in northern Illinois. It has a long life, but becomes established very slowly. Seedling growth rate is much slower than alfalfa or red clover.

A root rot has made birdsfoot trefoil a short-lived crop throughout southern Illinois. A recent variety, Dawn, may have adequate resistance to persist throughout the state.

Crownvetch is a relatively new legume for Illinois farmers. As a forage crop, crownvetch is much slower in seedling emergence, seedling growth rate, early season growth, and recovery growth than alfalfa or red clover. Growth rate is similar to birdsfoot trefoil. The potential of crownvetch as a hay or pasture plant seems restricted to very rough sites and soils of low productivity.

Sainfoin is a legume introduced into western United States from Russia. This species has failed to become well enough established in Illinois tests to make valid comparisons with alfalfa, red clover, and others. Observations indicate sainfoin has slow growth rate and recovery growth and is not well suited to the humid conditions of Illinois.

Hairy vetch is an annual legume that has limited value as a hay or pasture species. Low production and its viny nature have discouraged much use.

Lespedeza is a popular annual legume in the southern one-third of Illinois. It comes on strong in mid-summer when most other forage plants are at their low ebb in production. It survives on soils of low productivity and is low yielding. It does not produce as well as a good stand of alfalfa even in mid-summer nor will it encroach on a good alfalfa stand. As alfalfa or other vigorous pasture plants fade out of a pasture, lespedeza may enter.

Timothy is the most popular hay and pasture grass in Illinois. Timothy is not as high yielding and has less mid-summer production than smooth bromegrass. There is a limited amount of effort being expended to develop new varieties.

Smooth bromegrass is probably the most widely adapted, high-yielding species for northern and central Illinois. Smooth bromegrass combines well with alfalfa or red clover. It is productive, but has limited summer production when moisture is short and temperatures are high. It produces well in spring and fall and can utilize high-fertility programs. There are a few improved varieties and breeding work continues.

Orchardgrass is one of the most valuable grasses for hay and pasture use in Illinois. It is adapted throughout the state, being marginally winter hardy for the northern one-fourth of the state. Orchardgrass heads out relatively early in the spring, thus should be combined with early flowering alfalfa varieties. Orchardgrass is one of the more productive grasses in mid-summer. It is a high-yielding species and several varieties are available. Newer varieties are being developed.

Reed canarygrass is not widely used, but has growth attributes that demand consideration. Reed canarygrass is the most productive of the tall perennial grasses that are well suited to Illinois hay and pasture lands. It tolerates wet soils but also is one of the most drouth resistant and can utilize high fertility. It is coarser than orchardgrass or bromegrass, but not as coarse as tall fescue. Grazing studies indicate reed canarygrass will produce good gains equal to bromegrass, orchardgrass, or tall fescue under proper grazing management. Reed canarygrass should be considered for grazing during spring, summer, and early fall. Cool temperatures and frost retard the growth and induce dormancy earlier than with tall fescue.

Tall fescue is a popular grass for beef cattle in southern Illinois. It is especially useful for winter pasture. Tall fescue is most palatable during spring and late fall. Summer production and palatability are low. Tall fescue is a high-yielding grass, outstanding in performance when used properly. Tall fescue is marginally winter hardy for the northern one-fourth of the state.

Sudangrass, sudangrass hybrids, and sorghum-sudangrass hybrids are annual grasses that are very productive in late summer. These grasses need to be seeded each year on a prepared seedbed. The total season production by these grasses may be less than from perennial grasses with equal fertility and management. However, these annual grasses fill a need for quick supplemental pastures as green feed. These tall, juicy grasses are difficult to make into high-quality hay. Sudangrass and sudangrass hybrids have finer stems than the sorghum-sudan hybrids, thus will dry more rapidly and should be chosen for hay purposes over the sorghum-sudan hybrids. Crushing the stems with a hay conditioner will help speed the drying rate.

Table 34. — Leading Alfalfa Varieties Tested Two Years or More in Illinois, Given as Percentage of Yield of Check Varieties[a]

Variety	Bacterial wilt	Nor. Ill.	Cen. Ill.	So. Ill.
A-24	S[b]	105	97	90
Alfa	S	99	103	104
Anchor	R[c]	110	99	99
Apex	S	104	101	98
Arnim	S	96	103	104
ATRA-55	R	107	104	...
Bonus	MR[d]	88	103	102
Cayuga	R	105	104	99
Cherokee	S	103	103	107
Dominor	R	109	102	111
Europa	S	95	100	104
Flamande	S	96	104	98
Flamande SC118	S	102	100	104
Flandria	S	102	109	105
Frank's Langmeiler	S	97	100	106
Glacier	S	97	101	106
Gladiator	R	98	108	100
Haymor	S	99	103	106
Iroquois	R	105	97	94
Kanza	R	90	104	96
Lanser	R	100	102	106
Milfeuil	S	93	101	108
Orchies	S	98	106	106
Pat 30	S	100	103	98
Promor	R	105	92	100
Saranac	R	107	105	105
Socheville	S	...	111	103
Superstan	...	104	101	98
Team	S	105	102	99
Tempo	R	101	108	109
Thor	R	108	100	102
Titan	R	104	104	101
T3X-5	...	102	106	100
Warrior	S	100	99	103
Weevlchek	R	109	103	101
WL 210	MR	110	103	114
WL 215	R	106	103	...
WL 300	R	102	...	105
WL 303	MR	109	106	109
WL 306	R	112	104	...
123	R	104	101	111

[a] The check varieties were Vernal, Ranger, Atlantic, Buffalo, and Narragansett. The performance of a variety was tested against one or more of these check varieties appearing in the trials.
[b] S = susceptible.
[c] R = resistant.
[d] MR = moderate resistance.

Varieties of Hay and Pasture Crops

Alfalfa. There are many privately developed varieties available. Private varieties are usually marketed through a few specific dealers. Not all varieties under test or recently tested by the University of Illinois are available in Illinois.

The listing of alfalfa variety performance in Table 34 is summarized by compiling test data information since 1961. Some varieties may have been in test every year since 1961 and others only recently. However, each variety appearing in this list has been in test at least two years.

Red clover varieties (Table 35) are mostly from the U.S. Department of Agriculture and state experiment stations. Private breeders are becoming active in red clover variety development.

Other hay and pasture crop varieties and their use and performance are listed in Tables 36, 37, and 38.

Forage Mixtures

Mixtures (Table 39) of legumes and grasses are usually desired. Yields tend to be greater with mixtures than either the legume or the grass alone. Grasses are desirable additions to legume seedings to fill in where the legume ceases to grow, to reduce the bloat hazard with ruminant animals, to reduce late winter heaving damage, to increase drying rate, and perhaps to improve animal acceptance. Mixtures of two or three well-chosen species are usually higher yielding than mixtures of five or six species of which some are often not particularly well suited.

Table 35. — Red Clover Variety Yields, Urbana

Variety	Anthracnose resistance	Tons dry matter per acre		
		Urbana		DeKalb
		1968–1969	1970–1971	1971
Chesapeake	Southern	3.56		
Kenland	Southern	3.24	3.08	2.39
Pennscott	Southern	3.18		
Dollard	Northern	3.60		
Lakeland	Northern	3.78	3.42	3.14
LaSalle	Northern	3.40		
Mammoth	....	3.42		3.35
Altaswede	....	2.96		

Table 36. — Smooth Bromegrass Varieties

Variety	DeKalb 1971-73	Urbana 1971-73	Brownstown 1971-72
	Average tons dry matter per acre per year		
Baylor	3.27	3.26	1.33
Blair	3.42	3.44	1.31
Sac	3.03	3.54	1.40
Southland	3.33	3.35	1.54

Table 37. — Orchardgrass Varieties

Variety	DeKalb 1971-73	Urbana 1971-73	Brownstown 1971-72
	Average tons dry matter per acre per year		
Boone	2.59	2.79	1.67
Brage	2.42	...	1.20
Dayton	2.62	3.17	1.36
Hallmark	2.31	3.00	1.52
Napier	2.54	3.09	1.32
Sterling	2.52	2.95	1.67

Pollination of Legume Seeds

Illinois has always been an important producer of legume seeds, particularly red clover. From 1967 to 1969 both yields and acreage of red clover dropped noticeably. During the same period, honey bee numbers (hives) also decreased to a new estimated low of 76,000 colonies by 1970. As recently as 1958 there were 140,000 colonies in the state, yet an insufficient number of bees were present at that time near most red clover fields. Honey bees visit medium red clover well during second bloom and pollinate it as they collect pollen and some nectar. A colony on the Agronomy Farm at Urbana in 1967 collected from 54 to 99 percent of its daily pollen intake from red clover between July 12 and August 3. Prior to that time they were more interested in the other clovers.

If you produce red clover seed, do so on the second crop and use at least two colonies of honey bees per acre within or beside the field. On large fields place them in two or more groups. Research has shown a decrease in pollination and seed set if the bees are more than about 800 feet from the plants requiring pollination. Bring the hives to the field as soon as it comes into bloom. There are not sufficient bumble bees to provide pollination, and seed yields may continue to drop as honey bees become even more scarce in the state. Proper use of honey bees for pollination has the potential of doubling or tripling red clover seed yields.

White and yellow sweetclovers are highly attractive to bees and other insects. However, probably because of their large number of blossoms, their seed yields increase when colonies of honey bees are placed nearby. Yields of up to 1,400 pounds per acre have been produced in the Midwest by using six colonies of bees per acre. One to two hives per acre will provide reasonably good pollination.

Crownvetch is not attractive to bees and requires special techniques to produce a commercial crop of seed. Best yields have been obtained by bringing strong, new hives of bees to the fields every eight to ten days. In place of such special provisions, one or more hives of honey bees per acre of crownvetch are of value.

The effects of insect pollination on annual lespedeza, such as Korean, have not been investigated. However, the perennial lespedezas require insect pollination to produce a crop of seed, and honey bees can be used for this.

Many legumes grown in Illinois for pasture or for purposes other than seed production are visited by honey bees and other insects. Alfalfa, birdsfoot trefoil, and alsike, white, and Ladino clovers all provide some pollen and nectar and, in turn, are pollinated to varying degrees. Soybeans are visited by honey bees, especially in late July and early August. Unfortunately, the bee visits do not have any effect on yields of soybeans.

Table 38. — Other Hay, Pasture, and Silage Crop Varieties

Crop	Variety	Origin	Use	Relative maturity (days)[a]
Ladino clover	Merit	Iowa	Pasture	
Birdsfoot trefoil	Empire	New York	Pasture	
	Dawn	Missouri	Pasture	
	Viking	New York	Hay and pasture	
	Leo	Canada	Hay and pasture	
Crownvetch	Penngift	Pennsylvania	Erosion and pasture	
	Chemung	New York	Erosion and pasture	
	Emerald	Iowa	Erosion and pasture	
Smooth bromegrass	Achenbach	Kansas	Hay and pasture	
	Baylor	Rudy Patrick Co.	Hay and pasture	
	Blair	Rudy Patrick Co.	Hay and pasture	
	Fox	Minnesota	Hay and pasture	0
	Lincoln	Nebraska	Hay and pasture	0
	Saratoga	New York	Hay and pasture	
	Sac	Wisconsin	Hay and pasture	
	Southland	Oklahoma	Hay and pasture	
Orchardgrass	Boone	Kentucky	Hay and pasture	−1
	Brage	Barzen of Minneapolis, Inc.	Hay and pasture	
	Danish	Denmark	Hay and pasture	+10
	Dayton	Rudy Patrick Co.	Hay and pasture	
	Hallmark	Farm Forage Res. Coop.	Hay and pasture	+3
	Napier	Rudy Patrick Co.	Hay and pasture	0
	Pennlate	Pennsylvania	Hay and pasture	+10
	Pennmead	Pennsylvania	Hay and pasture	+5
	Potomac	Maryland	Hay and pasture	0
	Sterling	Iowa	Hay and pasture	+3
	S-37	Wales	Hay and pasture	+11
Tall fescue	Alta	Oregon	Pasture	
	Fawn	Oregon	Pasture	
	Goar	California	Pasture	
	Kenmont	Kentucky	Pasture	
	Kenwell	Kentucky	Pasture (more palatable)	
	Ky-31	Kentucky	Pasture	
Timothy	Clair	Kentucky	Hay	0
	Climax	Indiana	Hay	+15
	Verdant	Wisconsin	Hay	+20

[a] Maturity relative to a popular variety within the species.

Table 39. — Forage Seed Mixture Recommendations for Rotation and Permanent Pastures, Hay Crops, Hog Pastures, and Horse Pastures

For Hay Crops

Central and Northern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	12 lb.
Alfalfa	8 lb.
Bromegrass	6 lb.
Alfalfa	8 lb.
Bromegrass	4 lb.
Timothy	2 lb.
Alfalfa	8 lb.
Timothy	4 lb.

Poorly drained soils	
Alsike clover	5 lb.
Timothy	4 lb.
Reed canarygrass	8 lb.
Alsike clover	3 lb.
Birdsfoot trefoil	5 lb.
Timothy	2 lb.

Drouthy soils	
Alfalfa	8 lb.
Bromegrass	6 lb.
Alfalfa	8 lb.
Tall fescue (south and central Illinois only)	6 lb.

Southern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	8 lb.
Orchardgrass	6 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.

Poorly drained soils	
Reed canarygrass	8 lb.
Alsike clover	4 lb.
Tall fescue	6 lb.
Alsike clover	4 lb.
Redtop	4 lb.
Alsike clover	4 lb.

Drouthy soils	
Alfalfa	8 lb.
Orchardgrass	4 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.
Alfalfa	8 lb.
Bromegrass	6 lb.

For Horse Pastures

Central and Northern Illinois

Alfalfa	6 lb.
Smooth bromegrass	6 lb.
Kentucky bluegrass	2 lb.
Smooth bromegrass	6 lb.
Kentucky bluegrass	2 lb.
Timothy	2 lb.
Ladino clover	½ lb.

Southern Illinois

Alfalfa	8 lb.
Orchardgrass	3 lb.
Kentucky bluegrass	5 lb.
Orchardgrass	6 lb.
Kentucky bluegrass	5 lb.
Ladino clover	½ lb.

Central Illinois

Alfalfa	6 lb.
Orchardgrass	3 lb.
Kentucky bluegrass	2 lb.
Orchardgrass	6 lb.
Kentucky bluegrass	2 lb.
Ladino clover	½ lb.

For Hog Pastures

(for anywhere in Illinois)

Alfalfa	6 lb.
Ladino	2 lb.

For Rotation and Permanent Pastures

Central and Northern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	6 lb.
Bromegrass	5 lb.
Timothy	2 lb.
Alfalfa	6 lb.
Orchardgrass[a]	4 lb.
Alfalfa	6 lb.
Orchardgrass[a]	4 lb.
Timothy	2 lb.
Orchardgrass[a]	6 lb.
Ladino clover	½ lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass[a]	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.
Birdsfoot trefoil	5 lb.
Timothy	2 lb.
Bromegrass	8 lb.
Ladino clover	½ lb.
Tall fescue	10 lb.
Orchardgrass[a]	8 lb.

Poorly drained soils	
Alsike clover	3 lb.
Ladino clover	¼ lb.
Timothy	4 lb.
Birdsfoot trefoil	5 lb.
Timothy	2 lb.
Reed canarygrass	8 lb.
Alsike clover	3 lb.
Ladino clover	¼-½ lb.
Alsike clover	2 lb.
Tall fescue	8 lb.
Ladino clover	½ lb.

Drouthy soils	
Alfalfa	6 lb.
Bromegrass	5 lb.
Alfalfa	6-8 lb.
Orchardgrass[a]	4 lb.
Alfalfa	6-8 lb.
Tall fescue	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass[a]	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.

Southern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	8 lb.
Orchardgrass	4 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.
Tall fescue	8 lb.
Ladino clover	½ lb.
Alfalfa	8 lb.
Bromegrass	6 lb.
Timothy	2 lb.
Orchardgrass	6 lb.
Ladino clover	½ lb.
Tall fescue	10 lb.
Orchardgrass	8 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.

Poorly drained soils	
Alsike clover	2 lb.
Tall fescue	8 lb.
Ladino clover	½ lb.
Reed canarygrass	8 lb.
Alsike clover	3 lb.
Ladino clover	½ lb.

Drouthy soils	
Alfalfa	8 lb.
Orchardgrass	4 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.

[a] Central Illinois only.

SOIL TESTING AND FERTILITY

Soil Testing

Soil testing is the most important single guide to the profitable application of fertilizer and lime. When soil test results are combined with information about the nutrients that are available to the various crops from the soil profile the farmer has a reliable basis for planning his fertility program on each field.

Sampling every 4 years is strongly suggested. Sampling instructions are available from soil testing laboratories.

The most common mistake is to take too few samples to represent the field adequately. Following shortcuts in sampling may produce unreliable results and lead to higher fertilizer costs or lower returns or both.

What tests to have made. Illinois soil testing laboratories are equipped to test soils for pH (soil acidity), P_1 (available phophorus), P_2 (reserve phosphorus), and K (potassium). No test for nitrogen has proved successful enough to justify a recommendation by University of Illinois agronomists that laboratories provide the test.

Soil tests for certain secondary and micronutrients may warrant consideration under particular circumstances. Tests may be made for most of them but the interpretation is less reliable than the tests for lime, phosphorus, and potassium. Complete field history and soil information are therefore important in interpreting the tests for treatments. Crops differ in their nutrient requirements and this affects the choice and usefulness of special tests. The boron test, for example, is useful for alfalfa and the manganese test is useful for soybeans.

Secondary and micronutrient tests may be useful for:

1. Trouble shooting — diagnosing symptoms of abnormal growth. Paired samples representing areas of good and poor growth are needed for analyses.
2. "Hidden-hunger checkup" — identifying deficiencies before symptoms appear. Soil tests have little value in indicating marginal levels of secondary and micronutrients when crop growth is apparently normal. For this purpose plant analysis may yield more useful information.

For a more complete discussion of secondary nutrients, micronutrients, and plant analysis, see pages 41 and 42.

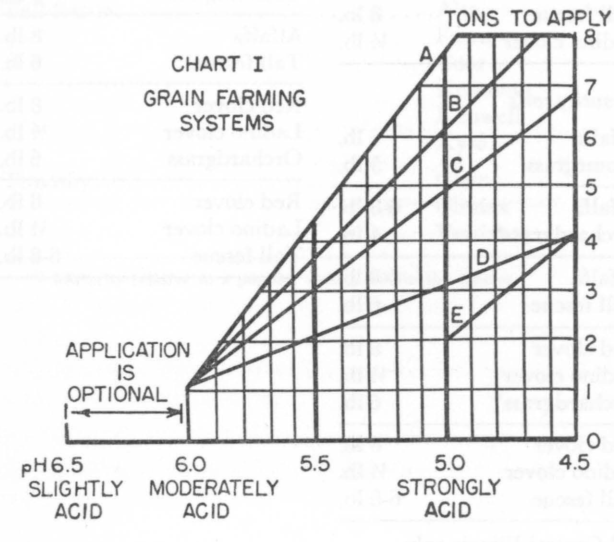
Lime

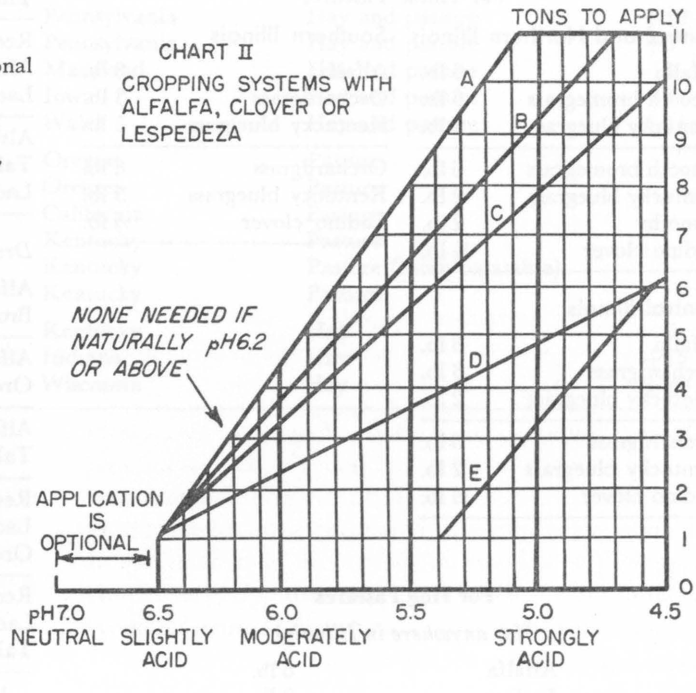
The liming program is being short-changed on a growing number of Illinois farms. The tonnage of limestone in Illinois ranged from 4.7 to 4.9 million tons from 1963 to 1966, but declined to 3.7 to 4.1 million tons from 1967

Suggested limestone rates based on soil type, pH, and cropping system. (Fig. 6)

STEPS TO FOLLOW

1. Use Chart I for grain systems, Chart II for alfalfa, clover, or lespedeza.
2. Decide which soil class fits your soil:
   A. Silty clays and silty clay loams (dark).
   B. Silty clays and silty clay loams (light and medium). Silt and clay loams (dark).
   C. Silt and clay loams (light and medium). Sandy loams (dark). Loams (dark and medium).
   D. Loams (light). Sandy loams (light and medium). All sands.
   E. Muck and peat.
3. Find your soil's pH along the bottom of the chart.
4. Follow up the vertical line until it intersects the diagonal line, A, B, C, D, or E that fits your soil.
5. Read the suggested rate of limestone along the right side.





to 1970. A random sampling of 1,706 fields in 74 counties from 1967 to 1969 showed that 34 percent were too acid for top yields of corn and soybeans and 64 percent were too acid for alfalfa. Since then the amount of limestone applied has declined. Soil test results indicate a substantial number of farmers have built their soil test levels for phosphorus and potassium unnecessarily high, but have neglected limestone (Tables 40, 41, and 42, page 41).

Farmers who regularly apply 150 to 200 pounds of nitrogen in an intensive corn cropping system are advised to test their soil every four years and apply limestone if needed. Even lower nitrogen rates will cause sandy soils to become acid rapidly.

The tonnage of limestone in Illinois had been holding steady since 1963, but dropped sharply in 1968, caused partly by an unfavorable fall for spreading.

Suggested pH goals. For cropping systems with alfalfa and clover, aim for a pH of 6.5 or above unless the soils are pH 6.2 or above without ever having been limed. In those soils neutral soil is just below plow depth and it will probably not be necessary to apply limestone.

For cash-grain systems (no alfalfa or clover), maintaining a pH of at least 6.0 is a realistic goal. If the soil test shows that the pH is 6.0, apply limestone to prevent a drop in pH below 6.0. Farmers may choose to raise the pH to still higher levels. After the initial investment, it costs little more to maintain a pH of 6.5 than 6.0. The profit over a 10-year period will be affected very little, since the increased yield will about offset the original cost of the extra limestone (2 or 3 tons per acre) plus interest.

Research indicates that a profitable yield response from rasing the pH above 6.5 in cash-grain systems is unlikely.

Liming treatments based on soil tests. The limestone requirements in Fig. 6 are based on these assumptions:

1. A 9-inch plowing depth. If plowing is less than 9 inches deep, reduce the amount of limestone; if more than 9 inches, increase the lime rate proportionately.

2. Typical fineness of limestone: 90 percent through 8-mesh; 60 percent through 30-mesh; 30 percent through 60-mesh. If the limestone is not as fine as indicated above and if a quick effect is desired, apply more limestone than indicated in the charts.

3. A calcium carbonate equivalent (total neutralizing power) of 90 percent. The rate of application may be adjusted according to the deviation from 90.

Buying limestone on the basis of quality. You should buy limestone on the basis of quality, as you would seed or a tractor or any other item. Premium limestone should sell for a premium price. Limestone with a neutralizing power of 105 is worth one-half more than limestone of the same fineness but with a neutralizing power of only 70. Your county Extension adviser has information on the quality of limestone available to you.

If high initial cost is not a deterrent, you may apply the entire amount at one time. If cost is a factor and the amount of limestone is 6 tons or more, apply it in split applications of about two-thirds the first time and the remainder three or four years later. (See page 30 for lime program for forages.)

Calcium-Magnesium Balance in Illinois Soils

Soils in northern Illinois contain more magnesium than those in central and southern sections because of the high magnesium content in the rock from which the soils developed. This has caused some to wonder whether the magnesium was too high. There have been reports of suggestions from some laboratories located outside Illinois that either gypsum or low-magnesium limestone from southern Illinois quarries should be applied. At the other extreme some laboratories have told southern Illinois farmers to buy high-magnesium limestone from northern quarries.

No one operating a soil-testing laboratory or selling fertilizer in Illinois has put forth any research to justify concern over the calcium:magnesium ratio.

Based upon a study of the available information on (a) the calcium:magnesium ratio in Illinois soils, and (b) the tolerance of field crops to a wide range in Ca:Mg ratios, *there is no agronomic reason to recommend* either that farmers in northern Illinois bypass local sources which are medium to high in magnesium and pay a premium for low-magnesium limestones from southern Illinois, or that farmers in southern Illinois order limestone from northern Illinois quarries because of magnesium content.

Phosphorus

Illinois has been divided into four regions in terms of inherent phosphorus-supplying power of the soil below the plow layer in dominant soil types (Fig. 7).

High phosphorus-supplying power means:

1. The test for available phosphorus (P_1 test) is relatively high.

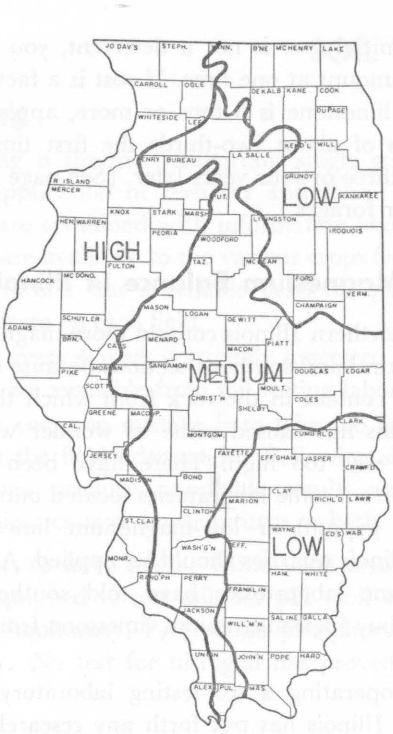
2. The conditions are favorable for good root penetration and branching in the subsoil and substratum.

Low phosphorus-supplying power may be caused by one or more of these factors:

1. A low supply of available phosphorus in the soil profile because (a) the parent material was low in P; (b) phosphorus was lost in the soil-forming process; or (c) the phosphorus is made unavailable by high pH (calcareous) material.

2. Poor internal drainage that restricts root growth.

3. A dense, compact layer that inhibits root penetration or spreading.



Phosphorous-supplying power. (Fig. 7)

4. Shallowness to bedrock, sand, or gravel.
5. Drouthiness, strong acidity, or other conditions that restrict crop growth and reduce rooting depth.

Regional differences in P-supplying power are shown in Fig. 7. Parent material and degree of weathering were the primary factors considered in determining the various regions.

The "High" region occurs in western Illinois. The primary parent material was more than 4 to 5 feet of loess. The soils are leached of carbonates to depths of more than 3½ feet. Roots can easily spread in the moderately permeable profiles. The loess was high in phophorus.

The "Medium" region occurs in central Illinois with an arm extending into northern Illinois and a second arm extending into southern Illinois. The primary parent material was more than three feet of loess over glacial till, glacial drift, or outwash. Some sandy areas with low "P" supplying power occur in the region. Compared to the high region, more of the soils are poorly drained and have less available phosphorus in the subsoil and substratum horizons. Carbonates are likely to occur at shallower depths than in the high region. The soils in the northern and central areas are generally free of root restrictions. Soils in the southern arm are more likely to have root restricting layers within the profile. "P" supplying power of soils of the region is likely to vary with natural soil drainage. Soils with good internal drainage are likely to have high available P levels in the subsoil and substratum. If internal drainage is fair or poor, P levels in the subsoil and substratum are likely to be low or medium.

In the "Low" region in southeastern Illinois, the soils were formed from 2½ to 7 feet of loess over weathered Illinoian till. The profiles are more highly weathered than in the other regions and are slowly or very slowly permeable. Root development is more restricted than in the "High" and "Medium" regions. Subsoil phosphorus levels may be rather high by soil test in some soils of the region, but this is partially offset by conditions that restrict rooting.

In the "Low" region in northeastern Illinois, the soils were formed from thin (less than 3 feet) loess over glacial till. The glacial till ranges in texture from gravelly loam to clay in various soil associations of the region. The tills are generally low in available phosphorus. In addition, shallow carbonates further reduce the P-supplying power of the soils of the region. High bulk density and slow permeability in the subsoil and substratum restrict rooting on many soils of the region.

The three regions are separated to show broad differences between them. Parent material, degree of weathering, native vegetation, and natural drainage vary within a region and cause variation in P-supplying power. It appears, for example, that soils developed under forest cover have more available subsoil phosphorus than those developed under grass. Whether this is offset by a lower amount of phosphorus in organic matter in the surface has not been determined.

The importance of soil profile distribution of phosphorus may be different for corn, soybeans, small grains, and deep-rooted perennial legumes. The significance of phosphorus levels below plow depth is likely to depend on the depth of rooting at the time during the growing season when phosphorus is most needed. This point is discussed in connection with fertilizer suggestions for each crop.

Additional research is needed to refine the differences within and among regions in P-supplying power in Illinois soils.

Goals for the P_1 test. The following goals are suggested. They may be adjusted when additional data are obtained.

Phosphorus-supplying power	*P_1 test goal*
Low	40–50
Medium	35–45
High	30–40

Specific suggestions for the application of phosphorus to each crop are on pages 7, 8, 18, 23, and 30.

Rock phosphate. Illinois farmers still apply a considerable amount of rock phosphate. Rock phosphate contains about 3 percent "available" (citrate soluble) P_2O_5 and this portion (about 1/10 of the total) is as available as that in other phosphorus-supplying fertilizers.

The remainder of the phosphorus is in the apatite form and depends upon the action of soil acids to make it available. Hence, the most economic use of rock phosphate is related to soil pH.

pH 6.5 or above. Rock phosphate is not likely to be as economical a source of phosphorus as phosphates derived from treating rock with acid or heat.

pH 6.0 to 6.5. This is a transition range. Rock phosphate and more readily available forms may be equally profitable up to pH 6.5 if: (1) alfalfa, clover, lespedeza, or birdsfoot trefoil are an important part of the cropping system; (2) the soil is inherently moderately acid; and (3) ACP cost-sharing assistance is available. Otherwise forms other than rock are likely to have an advantage.

pH 6.0 or below. There is enough soil acidity to provide for reaction with phosphate rock and thus rock is likely to be a satisfactory source of phosphorus when large amounts are broadcast in a soil-buildup program.

Applications of rock phosphate are based upon a test that involves a stronger acid extractant (P_2 test) than that used to measure available phosphorus (P_1 test).

Fertility Status of Corn and Soybean Fields

A survey of 1,706 fields in corn and soybeans in 74 counties from 1967 to 1969 produced the data in Tables 40, 41, and 42.

Phosphorus. About one-third of the fields (32.3 percent) are definitely low in available phosphorus (Table 39), over one-fourth (26.8 percent) are near suggested levels, 40.9 percent are above suggested levels and, of those, 15.8 percent are unrealistically high. Some of the very high tests may represent only the small area in the field that was sampled rather than the entire field. Extremely high tests may be caused by an old manure pile or burning of brush or corncobs.

Potassium. About 16.4 percent of the fields are low to very low in potassium for all crops, 18.1 percent slightly low, and 19.6 percent are unnecessarily high (Table 42).

Table 40. — pH of Surface Soils in 1,706 Fields Sampled in 1967 to 1969

pH	Percent of fields	Evaluation
Below 5.0	2	Manganese toxicity is common below 5.0.
5.1–5.5	11	Needs lime for all crops. Unsuited without liming to grow alfalfa or clover. pH
5.6–6.0	21	5.6–6.0 is slightly low for corn and soybeans.
	(34)	
6.1–6.5	30	Optimum pH.
6.6–7.0	22	
	(52)	
7.1–7.5	11	Alkaline. Watch for manganese deficiencies in soybeans and oats, and iron deficiencies in Wayne soybeans.
Above 7.5	3	
	(14)	

Some of the highest test results for potassium may have been found on small areas where some residue had been burned.

Research at a few locations shows responses of corn to potassium at soil tests above 241. At present fertilizer prices farmers may choose to aim for a test of 300 rather than 241.

Some interesting relationships showed up among soil tests and plant analyses as described below.

Zinc increased in corn with increasing P. This was unexpected, but can readily be explained if the highest P tests are on livestock farms where manure would add both P and zinc or where top farmers had applied some micronutrients including zinc.

Zinc and manganese in both corn and soybeans decreased at both sampling stages as pH of the soil increased.

Magnesium decreased in both crops and at both dates when potassium increased either in the soil or in the plant. This suggests that magnesium deficiencies may be caused

Table 41. — P_1 Soil Tests on Surface Soils of 1,706 Fields Sampled in 1967 to 1969

P_1 test	Percent of fields	Evaluation
Below 11	3.2	Low for all crops and soils. Buildup application suggested.
11–20	12.2	
21–30	16.9	
	(32.3)	
31–40	15.2	Reasonable goals for corn and soybeans depending somewhat on phosphorus-supplying power of soil (Fig. 7, page 38). Phosphorus should be applied for wheat, alfalfa, and clover.
41–50	11.6	
	(26.8)	
51–100	25.1	Very high. Maintenance amounts or less needed.
101–200	11.5	Unrealistically high. No application needed.
Above 200	4.3	
	(15.8)	

Table 42. — Potassium Tests on Surface Soils of 1,706 Fields Sampled from 1967 to 1969

K test	Percent of fields	Evaluation
Below 121	3.4	Very low; soils need broadcast applications for buildup.
121-180	13.0	
	16.4	
181-240	18.1	Slightly low.
241-300	21.9	Optimum. Maintenance applications only needed.
301-400	24.0	
	45.9	
401-800	14.4	Very high. No K needed for at least two years.
801-1,100	2.6	Unrealistically high.
Above 1,100	3.4	Unrealistically high.
	19.6	

by heavy K applications on soils that are borderline in magnesium supply.

How To Handle Very High Soil Tests

A recent study in one Illinois county showed that farmers who already had the highest P_1 soil tests were still applying the most phosphorus in fertilizer. In other words, they were ignoring the results of their soil tests.

What advice should dealers, extension advisers, soil testers, and others give to farmers whose soil test reports are *very high* in P and K? In order to earn and keep the respect and confidence of top farmers, sooner or later all who advise farmers must face up to that question. It won't go away. It will arise even more frequently in the future.

Improved practices that continuously raise yield goals call for higher nitrogen levels. A practice that raises the potential yield by 10 percent may, in fact, raise the most profitable nitrogen rate by 20 percent.

Not so with phosphorus and potassium. As yield levels rise, more P and K will, of course, be needed to *replace the nutrients removed* in the harvested crop. But that is a relatively small amount, 9 pounds extra P_2O_5 and 6 pounds K_2O for example, for 175 bushels of corn compared with 150 bushels.

Both theory and field research show that a soil test level for P or K that produces 98 percent of maximum yield at the 100-bushel level will also produce about 98 percent yield at the 175-bushel yield level. This is because the feeder roots of crops actually contact only 5 to 10 percent of the available phosphorus and potassium in the soil volume occupied by the roots. The higher the crop yield, the larger the root system and thus the more of the available P and K that are reached. It seems likely that there will be *little upward adjustment in the suggested goals* for soil test levels over the next five to ten years.

Here is how the situation is handled in the soil test report forms from the University of Illinois. The person reporting the test marks one of the following that best describes the soil test level:

1. Phosphorus *is below* the most profitable level. Phosphorus applications should, therefore, be large enough not only to meet the needs of the next crop but to raise the soil test level.

2. Phosphorus *is at* the suggested goal. You may broadcast phosphorus this year and thereafter at the rate of 50 pounds of P_2O_5 per year (100 for 2 years, 150 for 3 years) to at least maintain the test level until the field is sampled again.

3. Phosphorus *is well above* the level believed to be needed. Hence no yield increase is likely from an application of phosphorus this year.

4. Phosphorus is so high that you run the risk of creating problems with other nutrients.

A similar set of choices is given on the potassium report.

Polyphosphates

Polyphosphates are becoming important sources of phosphorus in fertilizers. Here is a brief explanation of how polyphosphates differ from ordinary phosphates.

Except for a small amount of metaphosphate, phosphorus has been supplied until recently in the orthophosphate form. It is the form believed to be used by plants. Polyphosphates are formed when a water molecule — H_2O — is split off and two or more of the remaining units hook up together into a larger molecule. In simple terms then polyphosphates are mixtures of these "waterless" phosphate units linked together in groups of two up to ten. Actually, the superphosphoric acid used to manufacture fertilizers is about one-half orthophosphate and one-half a mixture of polyphosphates.

In order for the phosphorus in polyphosphate to become usable by crops, it must add water and convert to orthophosphate. This likely presents few problems because one-half of the phosphorus is already the ortho form and thus usable, and polyphosphates soon convert to orthophosphate in soils. The conversion is rapid in acid soils but slower where the pH is neutral or above.

Polyphosphates have three properties not already mentioned that differ from orthophosphates:

1. They form complexes in liquid fertilizers that prevent the precipitation of impurities found in wet-process (green) phosphoric acid.

2. They permit higher analysis in fertilizers.

3. They may somewhat increase the availability of certain micronutrients.

Based on the fact that half the phosphorus is already in ortho form and the remainder will likely convert within a few weeks at most, and because of the general scarcity of micronutrient problems, Illinois agronomists feel that fertilizers with polyphosphates are as good as, but not superior to, the usual phosphorus sources.

High Water Solubility of Phosphorus

The degree of water solubility of the portion that is listed as available P_2O_5 on the fertilizer label is of little importance for typical field crop and soil conditions of medium to high levels of available phosphorus in the soil, typical rates of application on good farms, and broadcast placement. There are exceptions.

For band placement of a small amount of fertilizer that is designed to produce early growth stimulation, at least 40 percent of the phosphorus should be water soluble for application to acid soils and preferably 80 percent for calcareous soils. The phosphorus in nearly all fertilizers sold in Illinois is at least 50 percent water soluble.

For broadcast application on soils that are below pH 7.0, water solubility is not important; for calcareous soils, a high degree of water solubility is desirable, especially on soils that are shown by soil test to be low in available phosphorus.

Potassium

Illinois is divided into four general regions based on potassium-supplying power (Fig. 8). There are, of course, important differences among soils within these general regions because of differences in the seven factors listed below.

Inherent potassium-supplying power depends mainly on:

1. The amount of clay and organic matter. This influences the exchange capacity of the soil.
2. The degree of weathering of the soil material. This affects the amount of potassium that has been leached out.
3. The kind of clay mineral.
4. Drainage and aeration. These influence K uptake.
5. pH (very high calcium and magnesium reduce K uptake).
6. The parent material from which the soil formed.
7. Compactness or other conditions that influence root growth.

Potassium-supplying power. The black areas are sands with low potassium-supplying power. (Fig. 8)

Sandy soils are low in potassium-supplying power because they are low in exchange capacity and cannot hold much reserve K. In addition, minerals from which sandy soils develop are low in K.

The silt loams in the "Low" area in southern Illinois (claypans) are relatively older soils in terms of soil development and consequently much more of the potassium has been leached out of the root zone. Furthermore, wetness and a platy structure in the upper subsoil may interfere with rooting and with K uptake early in the growing period even though roots are present.

Soils in northeastern Illinois that were formed from medium- to fine-textured till are quite high in potassium by soil test, but restricted drainage may reduce potassium uptake during the early part of the growing season. As a result, those soils with wetness problems have only a medium rating in the ability to supply potassium to crops.

A soil-test goal of 241 to 300 is suggested for all the regions. Research at a few locations shows responses of corn to potassium at soil tests above 241. At present fertilizer prices farmers may choose to aim for a test of 300 rather than 241. Rates of potassium suggested in the buildup period and for maintenance on soils that are classified low or medium in supplying power are larger than on those soils that are classified high (Table 43).

Research results show that a few soils respond to potassium applications even at tests above the suggested goal of 241 to 300. Research to identify these soils is continuing. It appears they are very dark, moderately fine textured, and poorly drained.

Tests on soil samples that are taken *before May 1* or *after September 30* should be adjusted downward as follows: subtract 30 for dark-colored soils in central Illinois; subtract 45 for light-colored soils in central and northern Illinois; subtract 60 for medium- and light-colored soils in southern Illinois; subtract 45 for fine-textured bottomland soils.

On soils that have a very low potassium test, you may apply the suggested initial applications (even up to 300 pounds of K_2O per acre) at one time or you may apply two-thirds the first year and one-third the second year. Approximate maintenance amounts are suggested (60 pounds of K_2O per year or 120 pounds to last two years) for the third and fourth year or until the field is resampled. Specific suggestions for potassium applications for individual crops are given in other sections.

Phosphorus, Potassium, and Lime Applications in No-Plow Systems

Chisel-, zero-, and other tillage systems that do not use the moldboard plow have been adopted by many Illinois farmers. (See pages 51 and 52 for a discussion of these

Table 43. — Potassium Application Rates Based on Tests on Samples Taken Between May 1 and September 30: See Text Above for Adjustment in Interpretation for Samples Taken Before May 1 or After September 30

Soil test range, lb.	Estimated percent of maximum possible yield: Corn, soybeans, alfalfa, clover	Wheat, oats	Potassium rates for first application to last 2 years: Soils low in potassium-supplying power K_2O, lb.	K, lb.	Soils medium to high in potassium-supplying power K_2O, lb.	K, lb.
90 or less........	75 or less	90 or less	300	250	These soils are seldom this low.	
91–120..........	76 to 81	91 to 94	270	225		
121–150..........	82 to 90	95 to 98	240	200	210	175
151–180..........	91 to 93	98 or more	210	175	180	150
181–210..........	94 to 95	98 or more	180	150	150	125
211–240..........	96 to 97	98 or more	150	125	120	100
241–300..........	98 or more	98 or more	120	100	Test every 4 years and apply enough to maintain the test.	
Above 300........	98 or more	98 or more				

systems.) As these newer tillage systems provide less soil mixing and do not invert the plow layer, P and K fertilizers and limestone are concentrated near the surface (Table 44). Concern has been expressed that these systems will result in loss of efficiency of fertilizer use. However, uptake of nutrients and corn yields have not suffered as a result of the surface concentrations, even in a dry year such as 1971 at DeKalb (Table 45). Experiments at Urbana, Dixon Springs, and in other states have given similar results. Although it does not now appear that the no-plow tillage systems will result in problems associated with fertilizer use, plowing once every three or four years will provide an oportunity to mix fertilizers and lime deeper into the soil. P and K can, of course, be placed at chisel depth with an attachement on the chisle plow.

What about a liming program? If anhydrous ammonia, aqua, nitrogen solutions, or dry nitrogen fertilizers are placed 8 to 10 inches deep, zones of soil acidity will develop. Since the neutralizing effect of limestone moves down rather slowly, there is a possibility that soil acidity will become at least a short-term problem below the depth that limestone is mixed in chisel or zero-tillage systems.

However, moldboard plowing every three to four years will provide an opportunity to apply and adequately mix limestone through the plow layer.

Table 44. — The Effect of Tillage Method and Phosphorus Rate on Soil Test Phosphorus, DeKalb, 1970-71

P_2O_5[a] lb./A.	Primary tillage	Soil depth, inches: 0-2	2-4	4-6	6-8
		(Soil test P, ppm.)			
120	Chisel	41	21	8	4
	Moldboard	18	22	24	13

[a] Phosphorus was applied before primary tillage. All plots were disked after primary tillage and before soil samples were taken. Samples taken in the spring of 1971.

Effects of Crop-Production Technology on Environmental Quality

Agriculture has a tremendous impact on the environment. The basic purpose of agriculture is, in fact, to manage part of the environment in order to meet the food and fiber needs of mankind. Agriculture in the United States has been eminently successful in meeting these needs. To date, agricultural management decisions have been based mainly upon economic considerations; restrictions being limited to those necessary by a clear health hazard. Society is now asking all segments of the economy, including agriculture, to reassess their roles in relation to environmental quality.

There is a fundamental difference between the way that farmers view the environment as a receptacle for waste products as compared to industries and municipalities. Farmers have a vested interest in not polluting surface waters with nitrogen, phosphorus, organic matter, pesticides, and silt. Farmers recognize that these production factors represent financial investments, hence, farmers will not intentionally lose them to surface or ground water. Neither does agriculture intentionally use lakes and streams to dissipate its waste products. Livestock wastes and crop residues have historically been returned to the land (with a few exceptions) in order to maintain soil productivity. Municipalities and industries, on the other hand, have in the past intentionally utilized streams

Table 45. — The Effect of Tillage Method and Phosphorus Rate on Corn Yield, DeKalb, 1970-71

P_2O_5 (lb./A.)	Chisel (Bu./A.)	Moldboard (Bu./A.)
0	86	89
60	123	126
120	131	130

and lakes to dissipate heat, sewage effluent, and industrial wastes.

The "Intrusion" of Plant Nutrients

From reading popular, nontechnical environmental literature one gains the impression that many persons view the application of commercial fertilizers as an intrusion of plant nutrients into a virgin environment, hence likely to upset the balance of nature. But until recently plant nutrient levels and the organic content of soils, far from being maintained at original levels, have been declining since farming began (Fig. 9). The downward trend in soil supplies of available phosphorus and potassium has only been reversed since about 1940. Many fields have been replenished to the point where some exceed virgin conditions for these nutrients. The downward trend in nitrogen and organic matter, however, has at best been arrested in some soils and perhaps reversed in a few isolated cases. The maintenance of soil organic matter is extremely difficult under cropping. Rebuilding it to original levels is not economically feasible. A practicable goal is to return to the soil large amounts of readily decomposable residues which will help compensate for the loss of humus.

From an environmental point of view, a compelling reason for using adequate amounts of fertilizer is to preserve the productive capacity of soils for future generations.

If, from the lack of adequate supplies of nitrogen, organic matter is allowed to continue to decline at the rate that it has during the past 100 to 200 years, soil structure will deteriorate, water infiltration capacity will be impaired, and productivity will decrease. As a result, future generations will have increasing difficulty not only in maintaining adequate production of food, but also in contending with floods, erosion, and sediment pollution.

Returning the plant nutrients contained in food and human wastes to agricultural land is sometimes suggested as a means of solving the problem of declining organic matter. For the foreseeable future, however, waste return will be limited to disposal programs on a relatively small proportion of the land rather than being a general recycling of nutrients to the fields from which they came. Nor is composting of residues a solution on large areas because the return of crop residues to the soil is already standard farming practice in most places. Composting is at best a return of only part of the nutrients that were removed in harvested crops or in animal products.

Trends in Nitrates in Water

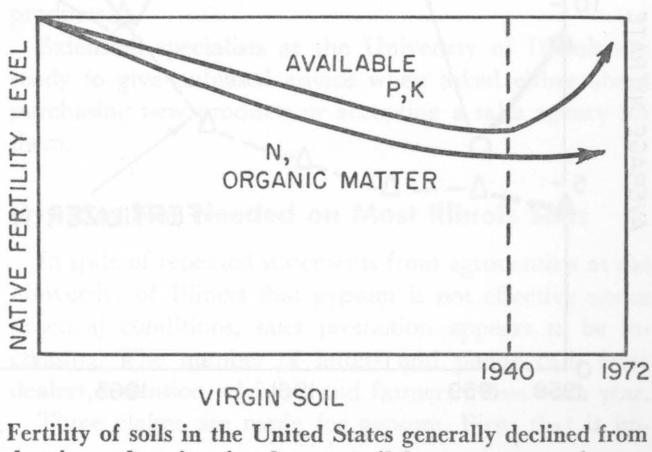
The nitrate content of surface and underground waters has received particular attention because of its possible role in eutrophication and the potential health hazard it poses, especially to infants. Nitrate levels above the suggested public health standard (10 mg./l. $NO_3 - N$, 45 mg./l. NO_3^-) are occasionally reported. Nitrate concentrations in the Illinois and Wabash rivers are variable, but appear to be increasing somewhat.

Five-year records on 16 smaller streams in Illinois reveal increases in some and decreases in others. Averages for the 16 were: 1962 — 1.8, 1963 — 1.7, 1964 — 1.8, 1965 — 1.9, and 1966 — 2.2 mg./l. $NO_3 - N$ (Harmeson and Larson, 1969).

Nitrates at Shelbyville are especially important because a new reservoir is beginning to fill and there is concern that excessive nitrates will adversely affect the use of the water. The relationship between nitrates in the river and fertilizer nitrogen (based upon trends for the state of Illinois rather than for only the Kaskaskia watershed above Shelbyville) is not impressive (Fig. 10). No explanation has been found for the sudden increase in nitrate content beginning in 1965 and persisting through 1969. The sharp decline in 1970 and 1971 may be due to removal by algae and pond weeds in Lake Shelbyville.

Accumulation of nitrates in the subsoil following excessive applications of nitrogen fertilizer has been found by several workers. In general the studies show that there is little accumulation below the crop rooting zone unless the rate of application exceeds the point at which yield increase ceases. Nitrates lost into tile lines would not show in such subsoil studies. If the growth rate for nitrogen fertilizer were projected indefinitely there would indeed be cause for alarm. Most agronomists would concede that a small proportion of farmers apply nitrogen at rates higher than those indicated as most profitable by research. Other farmers would, however, benefit from heavier applications. There are indications that the growth rate of nitrogen applications for the most heavily fertilized corn fields in the midwest has nearly leveled off since 1966.

The relationships of nitrogen application rate to nitrate buildup in the subsoil for different soil types and crops and the fate of such nitrates on both artificially



Fertility of soils in the United States generally declined from the time when farming began until large amounts of commercial fertilizer were introduced very recently. (Fig. 9)

drained and non-drained soils are of great importance in assessing potential effects on nitrates in surface and ground water. These relationships deserve high research priority.

Fertilizer Nitrogen vs. Other Sources

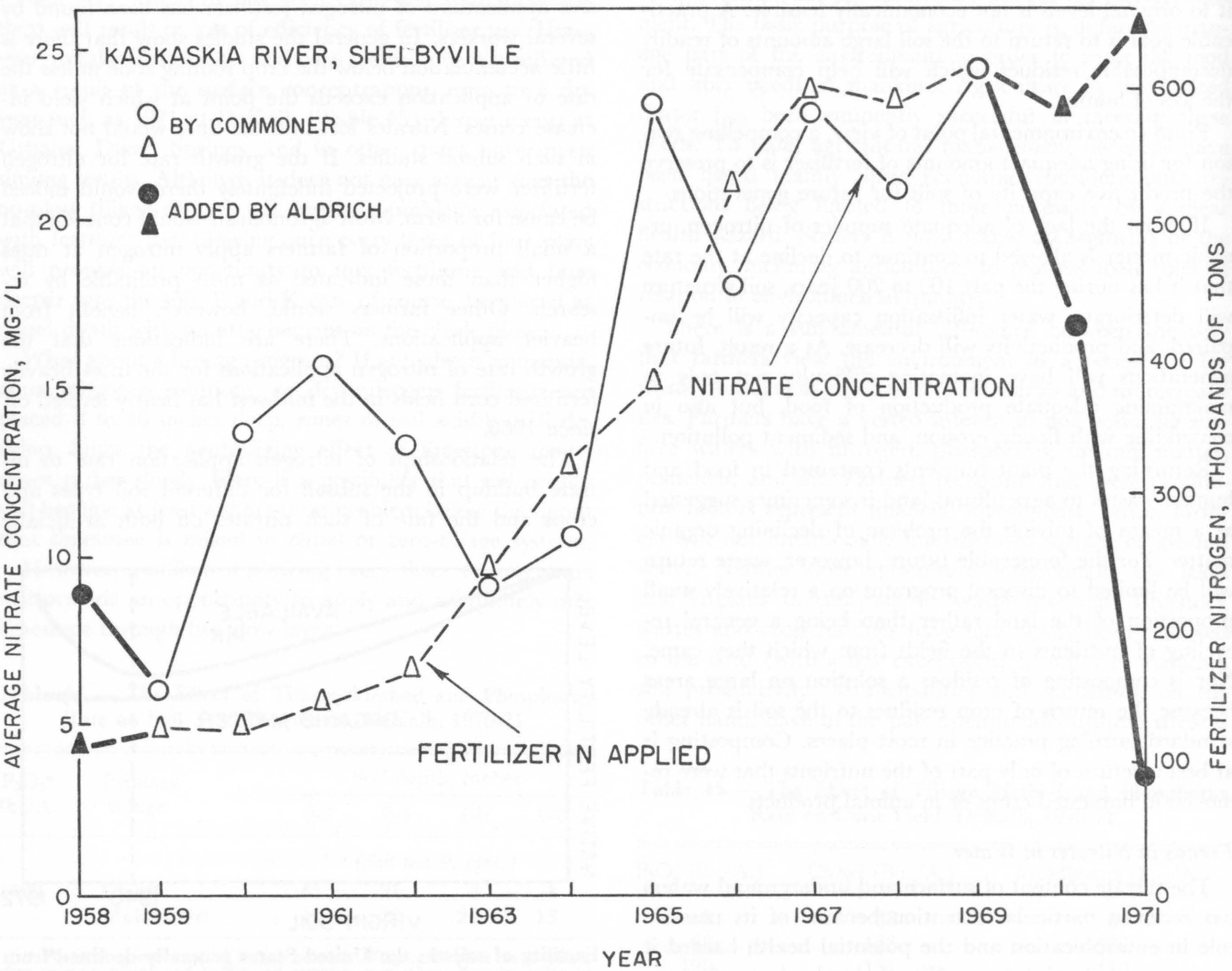
There is a common false impression among non-agriculturists that fertilizer nitrogen affects the environment differently than nitrogen from other sources. But nitrate ions derived from fertilizer are neither more nor less subject to leaching than nitrate ions from other sources. Nitrates (except for a small amount in some fertilizers) result from the nitrification of ammonium (NH_4^+) whether the nitrogen source is plant residues, animal waste, soil humus, or fertilizer. All major food crops except rice use mainly nitrate nitrogen. The total amount of nitrogen that must be available in the soil during the growing season is, therefore, approximately the same regardless of source.

There is little reason to believe that the amount of nitrate that moves into surface or ground water per unit of crop produced would be less if the nitrogen were supplied by sources other than nitrogen fertilizer.

Any concern for fertilizer nitrogen should be based upon its contribution to total nitrogen rather than upon the mistaken notion that it reacts differently within the soil.

Research in progress indicates that a substantial portion of the nitrates in central Illinois streams results from the application of commercial nitrogen fertilizer. This would not be surprising since there are no other major sources of nitrogen except that released from the mineralization of soil humus. There is very little livestock manure or nitrogen-fixing legumes in the agriculture of the region.

The practical question to be answered is not what proportions of nitrates in water derive from the various sources, but whether there are alternative strategies for



Change in nitrate concentration in the Kaskaskia River at Shelbyville, Illinois and in nitrogen fertilizer used in Illinois, 1958 to 1971. Long-term fertilizer data are not available for the watershed alone. (Fig. 10).

meeting food production needs that would result in fewer nitrates.

Benefits to the Environment From Technology in Agriculture

The undesirable effects of modern agriculture — possible excess plant nutrients in water, injury to nontarget species by certain insecticides, increased sediment from intensive cropping — are important problems, but as they have been widely publicized, they are not reexamined here. The enormous benefits to the environment from the application of science and technology to crop production have not been afforded similar acclaim.

Attention has been focused mainly on higher yields and increased efficiency of production from the application of fertilizer. Some significant environmental effects of fertilizers have generally been overlooked:

1. The deterioration in soil fertility previously discussed, which had proceeded inexorably from the first farming attempts of the settlers until about 1940, can now be arrested and in some cases reversed (Fig. 10).

2. Higher yields reduce the area required for food production, hence agriculture can be concentrated on the soils that are least erosive, thus reducing floods and sediment pollution with its associated burden of phosphorus, nitrogen, organic matter, and adsorbed pesticides.

3. Abundant nitrogen fertilizer provides farmers with increased flexibility in cropping patterns. For example, corn and other row crops can be concentrated on level to slightly rolling soils in midwestern states which are subject to relatively little erosion. Cropping systems that include extensive acreages of sod crops can be grown on more sloping fields. If legumes were the sole source of nitrogen, cropping with both row crops and sod crops would be required on all soils, irrespective of slope, thus resulting in greater erosion.

4. Higher yields per unit of land make possible the preservation of larger areas for recreation and wildlife habitat.

The utilization of available science and technology in agriculture has caused certain environmental problems. It is appropriate to challenge the justification for each practice and each subsystem of production. Many additional opportunities for reducing undesirable effects on the environment will be found. Research to identify these opportunities needs to be greatly accelerated either by shifts in priorities of presently available funds or by new sources of funds.

The basic cause of agriculture's increasing impact on the environment is the growing demand for food and fiber. Persons who propose to return to more primitive methods with less use of science and technology are generally unfamiliar with agriculture and with land-use capabilities.

Intensive utilization of available crop production technology on the best land, with some important exceptions, will likely meet the needs of society with the least undesirable impact on the environment.

Fertility "Quacks" Get New Life

It seems hard to believe that in this day of better informed farmers the number of letters, calls, and promotional leaflets about completely unproven products is increasing.

The claim is usually that Product X either: replaces fertilizers and costs less; makes nutrients in the soil more available; supplies micronutrients; or is a natural product that doesn't contain strong acids that kill soil bacteria and earthworms.

Research is such a magic word that people are conditioned to expect miraculous new products and thus the door is opened for the fertility quack.

The strongest position that legitimate fertilizer dealers, extension advisers, and agronomists can take is to *challenge these peddlers to produce unbiased research results to support their claims.* Farmer testimonials are no substitute for research! Incidentally, when a legitimate fertilizer company depends heavily upon farmer testimonials in its advertising, the selling job of the quack is made easier.

Agronomists can often refute the specific claims of the quacks on theory and with research results but they come up with new claims or fall back on the old cliche, "We don't know why it works, but it does." No one can effectively argue with the farmer who says "It works on *my* farm." Dozens of research trials on the same kind of soil are no match for the simple statement, "It works for me." That is what is so frustrating to dealers, agronomists, and extension advisers and so dangerous to farmers who depend upon farmer testimonials for unproven products.

Extension specialists at the University of Illinois are ready to give unbiased advice when asked either about purchasing new products or accepting a sales agency for them.

Gypsum Not Needed on Most Illinois Soils

In spite of repeated statements from agronomists at the University of Illinois that gypsum is not effective under practical conditions, sales promotion appears to be increasing. The number of letters and phone calls from dealers, extension advisers, and farmers grows each year.

Three claims are made for gypsum. First, that it improves soil structure; second, that it is a good source of calcium; third, that it supplies sulfur.

Gypsum improves alkali soils in desert and semi-desert areas of the western United States. Alkali soils contain too much sodium. The calcium in gypsum replaces the sodium which then leaches out of the root zone; the pH declines and the soil structure improves. The high pH soils in central and northern Illinois do not contain large amounts of sodium. They are already high in calcium and magnesium. Adding more calcium can't improve them. Gypsum did not improve structure and drainage on poorly drained clay soils in Illinois.

Illinois has tested gypsum treatments on high-sodium "slick-spot" soils (locally called scalds, hardpans, and deerlicks) that are scattered through southern and southwestern Illinois. In brief, the conclusions reached are:

1. Mixing gypsum at 10.7 tons per acre through the plow layer was ineffective.

2. Chiseling in 10.7 tons per acre of gypsum to a depth of two feet, combined with installing tile drains 30 feet apart, increased corn yield about 9 bushels.

3. Mixing 27.8 tons of gypsum to a depth of three feet, combined with tiles 10 feet apart, raised the yield 45 bushels; tiles 30 feet apart raised yields 41 bushels; and tiles 60 feet apart raised yields 20 bushels.

No profitable method has thus far been found in this research for the correction of slick spots with gypsum. The research is continuing with some modifications.

Salt-saturated areas around oil wells are also high in sodium and *may* respond to gypsum, provided the subsoil is permeable enough to allow rainwater to flush the displaced sodium down and out of the root zone. Unfortunately, in most cases the subsoil is compact and impermeable, and no one has yet found that treatment with gypsum improves this situation.

There is no evidence that the calcium:magnesium balance is a problem, hence there is no basis for applying gypsum in place of limestone (see page 39).

Gypsum supplies sulfur, but all Illinois soils appear to be well supplied with sulfur for field crops.

Gypsum is not a substitute for limestone on acid soils. It does not raise the pH.

In summary, there is no known need for gypsum treatment of Illinois soils. Anyone who wants gypsum for trial can find plenty of sources within the state where it can be purchased for $10 to $20 per ton or in some areas just for the cost of hauling.

SOIL MANAGEMENT AND TILLAGE SYSTEMS

Water Erosion Control

Bare soils with long slopes have a high potential for water erosion with the rainfall patterns that occur in Illinois. The damage of erosion depends upon soil characteristics. If a soil has horizons in the profile that are unfavorable for root development, water erosion can cause permanent soil damage even though the nutrients lost through erosion can be replaced through liming and fertilization. On soils that are free of root restricting horizons, water erosion damage is the result of nutrient removal to a large extent. The nutrients can be replaced through application of limestone and fertilizers, but result in added production costs. Soil particles that are eroded must be deposited eventually. Part of the deposition is in streams, lakes, or reservoirs, so water resource quality is lowered.

Effective erosion control systems usually include one or more of three features. First, the soil is protected with a cover of vegetation, such as a mulch of crop residues, as much of the time as possible. Second, the soil is tilled so that a maximum amount of water is absorbed with a minimum amount of runoff. Third, long slopes are divided into a series of short slopes so that the water cannot get "running room." Conservation tillage systems, discussed on pages 51 to 52, utilize one or both of the first two features. Terraces are effective because they divide long slopes into several short slopes. Strip cropping provides season-long vegetative cover on half or more of a slope and also divides a slope into shorter slope lengths.

Effective erosion-control systems must be designed for a particular situation. Contact your district conservationist with the Soil Conservation Service for technical assistance on erosion-control systems.

Fall Tillage

Chopping stalks, disking, plowing, or chiseling in the fall may help you get off to an early start the following spring. Fall tillage may also present problems if the hazards of wind and water erosion are not considered.

The kind and amount of fall tillage that is needed or desirable depends on the soil, slope, and previous crop, as well as on the seasonal demand for labor and machinery. Of course, weather conditions will have a major role in determining how much tillage is possible before freeze up late this fall or early winter.

The Previous Crop

The previous crop influences the kind and amount of residues that are left after harvest.

Corn residues are the heaviest in terms of tonnage and probably present the greatest problems. Shredding the stalks, or disking followed by fall plowing, or both operations, provide a bare soil surface over winter that may dry earlier in the spring. If the corn stover is not plowed in the fall, leaving the stalks standing without chopping or disking them may provide more wind erosion control than if stalks are shredded. Shredding may protect more of the soil surface against the beating action of rain and thus reduce water erosion. However, the shredded corn residues may mat down and result in wetter soils that dry more slowly in the spring.

Soybean residues are light in tonnage and present essentially no problem in handling. *Fall plowing of soybeans will increase the potential for severe wind erosion. Disking soybean fields in the fall will also create a severe wind-erosion problem.* The surface soil is loose following soybeans and this, combined with the small amount of residues, results in a potentially severe wind-erosion hazard if the soybean field is disked or plowed, or both, in the fall. Fall chiseling following soybeans results in a rougher surface and helps lessen the wind-erosion hazard. Following soybeans, crop yields with spring tillage (plow, disk, chisel, or no-till) have been as good as those with fall plowing in tests in Illinois and Iowa.

Small-grain residues may be plowed in late summer or early fall in preparation for fall seedings of wheat or alfalfa-grass mixtures or for corn or soybeans the following year. Plowing under weeds in the stubble will help reduce weed populations if stubble is plowed before weed seeds mature.

If legume seedings (for green manure) are made in the small grain, more nitrogen will be added by the legume if fall plowing is delayed until late fall (October 15 in northern Illinois, November 15 in southern Illinois). Late fall plowing of meadow crops will also provide additional time for nitrogen fixation by the legume. Grass, grass-legume, or legume meadows that are fall-plowed are less erosive than fall-plowed corn, small grain, or soybeans.

The Soil

Fall plowing decreases tillage problems on poorly drained soils that have high organic matter and silty clay or silty clay loam surface layers. These soils are usually wet in the spring and will develop poor physical conditions if tilled when too wet. If such soils are fall-plowed, large clods will slake down over winter so that spring seedbed preparation is much easier. *However, avoid fall plowing after soybeans on these soils because of the wind-erosion hazard.*

Dark-colored silt loam soils that are nearly level and have good to fair drainage present fewer tillage problems than the finer textured silty clay loams or silty clay soils.

Fall plowing may be desirable to help spread the labor load or because these soils occur in an intricate pattern with soils that are directly benefited by fall plowing.

Silt loam soils that have less than 2½ percent organic matter are likely to crust during the winter. (The publication "Color Chart for Estimating Organic Matter in Mineral Soils in Illinois," AG-1941, can be used to estimate organic matter content of the surface soils.) Spring tillage with moldboard plow, chisel plow, or disk, or zero tillage provide alternatives to fall plowing on low organic matter soils.

Sandy soils are subject to severe wind erosion if they are fall-plowed, and should be left with a vegetative cover as much of the time as possible.

Slope

The erosion hazard from fall plowing increases with percent and length of slope. Slopes of less than 2 percent can be safely fall-plowed, although soil erosion can be severe if they are more than 300 feet long and if spring rainfall is above normal in quantity and intensity. Soils with favorable subsoils on slopes of 2 to 4 percent can be fall-plowed on the contour if slope length is less than 150 feet. Longer slopes can be divided into a series of short slopes by leaving an unplowed strip a few feet wide every 150 feet. Severe erosion can occur on soils with unfavorable subsoils even on slopes of 2 to 4 percent.

Fall Disking

Disking cornstalks may aid fall plowing or chiseling. On soils that are too sloping for safe fall plowing, disking in the fall will incorporate part of the residues, loosen the soil, and result in earlier drying in the spring. Earlier seeding of oats or corn may be possible. Wind erosion will be slightly worse if cornstalks are disked in the fall. *Avoid disking in the fall following soybeans because of the danger of wind erosion.*

Fall Chiseling

Fall chiseling is a practice used by many farm operators who have developed tillage systems built around the chisel plow. Fall chiseling of cornstalks leaves part of the residue on the surface for wind and water erosion control. The soil is loosened so it dries earlier in the spring than if the field was untilled over the winter. Fall chiseling is especially important where the chisel plow system is used on dark-colored, poorly drained soils. Delays in spring operations or excessive drying often result if all chiseling is delayed until spring. The rough surface left after chiseling of soybean fields in the fall provides a barrier to soil blowing and reduces the hazard of wind erosion. The rough, chiseled surface is most effective if the chisel operation is carried out perpendicular to the prevailing wind.

Fall-Seeded Cover Crops

Fall seedings of spring oats provide effective control of wind and water erosion if they can be made early enough in the fall for the seeding to be established. The oats should germinate and make sufficient growth for soil protection if seeded by October 1 in the northern one-third of Illinois, by October 15 in the central one-third of Illinois, and by November 1 in the southern one-third of Illinois. Seed directly on fall-plowed fields or on soybean stubble at a rate of 1 to 1½ bushels per acre. Oats will be winter-killed. Seedbeds can be prepared with disk and harrow in spring. Fall-seeded rye can also be used as a winter cover and may provide some spring pasture. It may be necessary to use a contact herbicide such as Paraquat to kill the rye in spring in zero-tillage systems.

Summary

Fall tillage can help you get the jump on spring field work if you fit it to your cropping situation and your soil and slope conditions. By using fall tillage where it will benefit you and by avoiding fall tillage where wind and water erosion may be severe, you will have a good foundation on which to develop your tillage program.

Tillage Systems

Tillage operations are carried out to prepare a seedbed for planting and a root bed for the development of roots. Tillage is used to loosen or compact the soil, to handle crop residues, to control weeds, and to control or manage water. A variety of tillage systems can be used in crop production. These include conventional, reduced, mulch, and zero-tillage systems. Each has unique advantages and each has limitations.

Conventional Tillage

Conventional tillage uses a moldboard plow followed by liberal use of a disk, harrow, hoe, and cultivator. It is the standard of comparison for other systems.

Advantages:

1. Results in uniformly fine seedbed for easy planting.
2. Insecticides and herbicides may be incorporated as needed.
3. Flexible and adaptable to a wide range of soil, crop, and weather conditions.
4. Provides for efficient distribution of labor and machinery.
5. Necessary equipment readily available on most farms.
6. Results in yields as high as or higher than other systems over a wide range of soil and climatic conditions.

Limitations:

1. Highest cost because of the large number of operations (Table 46).

2. Often results in excessive tillage so that soil crusting and compaction may be problems.

3. Results in small aggregates (clods) so that water-intake rate is reduced.

4. Provides few surface depressions for temporary storage of rainfall.

5. Exposes bare, fine, or compact soil that is subject to wind and water erosion.

Reduced-Tillage Systems

Reduced-tillage systems also use the moldboard plow, but with reduction or elimination of secondary tillage with the disk, harrow, hoe, and cultivator. Plow-plant, wheel-track-plant, and cultivator-plant systems are examples. These systems are designed to provide good contact between seeds and moist soil in the seedling environment (row zone), and a rough, porous area between the rows (water management zone).

Advantages:

1. Reduces costs through elimination of some tillage operations (Table 46).

2. Less chance of forming surface crust.

3. Less compaction.

4. Faster initial intake of water and more water absorption before runoff begins.

5. A rough, porous area between the rows provides temporary storage for rainfall.

6. Reduction in runoff and water erosion.

Table 46. — Tillage Costs per Acre for Alternative Tillage Systems (Corn Following Corn)[a]

Operation	Cost for tillage operations with: Conventional	Plow-plant or wheel-track plant	Cultivator-plant	Chisel-plow	Zero-tillage
Shred stalks..	$ 2.00	$2.00	$2.00	$2.00	$2.00
Disk........	1.50	....	....	....	....
Plow........	5.00	5.00	5.00	....	....
Chisel......	....	....	....	4.00[b]	....
Disk........	4.00(twice)	....	....	....	....
Harrow......	1.00	....	....	1.00	....
Plant[c]......	3.00	3.00	4.00[d]	3.00	3.00
Harrow.....	1.00	....	....	....	....
Hoe........	1.00	....	....	1.00	....
Sweep......	3.00(twice)	1.50	1.50	1.50	....
Spray.......	....	....	....	....	1.50
Total tillage costs......	$21.50	$11.50	$12.50	$12.50	$6.50[e]

[a] Costs in this table are based on data in Illinois Extension Circular 1003.
[b] Many corn producers chisel in fall and again in spring. In these cases chisel charge should be $8 per acre.
[c] Includes applying chemicals with planter attachment.
[d] Cultivate and plant and apply chemicals in one trip over the field.
[e] Cost of chemicals ($5 to $10 per acre) must be added for comparison with other systems.

7. Provides for built-in weed control in rough, porous area between the rows.

8. Cultivator-plant system has flexibility and can be used with fall or spring plowing over a wide range of soil conditions.

Limitations:

1. The rough, porous surface may make planting operations more difficult.

2. Plow-plant and wheeltrack systems require special adaptation to large planters.

3. Plow-plant and wheeltrack systems "bunch" plowing and planting into a short period of time. This may be a problem with large acreages or in wet springs.

4. It is difficult to obtain good contact between seed and moist soil in silty clay loam and finer textured soils ("gumbo" soils).

5. Soil is bare and more subject to wind and water erosion than with mulch or zero tillage.

Mulch Tillage

Mulch-tillage systems use chisel, disk, or rotary tillage equipment so that the soil is not turned over as with a moldboard plow. Significant portions of the residues from the previous crop are left on the surface. With the chisel-plow system some secondary tillage with disk or harrow is usually used to prevent an excessively loose seedbed.

Advantages:

1. Lower cost than conventional tillage (Table 46) because there are fewer tillage operations and lower draft requirements.

2. Rough, porous surface (especially with chisel plow and disk) aids rapid water absorption.

3. More water can be absorbed before runoff and erosion begin.

4. Mulch protects soil from raindrop impact and reduces crusting and surface sealing.

5. Mulch slows velocity of runoff and lowers its capacity to carry soil.

6. Mulch protects soil from wind erosion.

7. Fall chiseling or disking of cornstalks will help speed drying of soil in spring so that planting can be done earlier than with moldboard plow systems used in spring.

8. Fall chiseling of soybean fields may reduce wind erosion. *Avoid fall disking following soybeans.*

9. Deep tillage with a chisel plow (deeper than moldboard plow depth) may shatter the plow or traffic pan if it is chiseled when dry.

Limitations:

1. Planters must be equipped to plant in crop residues.

2. Loose, trashy seedbeds may result in uneven emergence. (Use a disk or harrow after chiseling to firm the seedbed.)

3. Soil temperatures may be reduced, resulting in slow early growth of corn in the northern two-thirds of Illinois.

4. Crop residues may interfere with herbicides or cultivation, resulting in a more severe weed problem.

5. Crop residues may harbor corn insect pests.

6. Lime and fertilizer may accumulate near surface.

Zero Tillage

Zero-tillage systems consist of planting in an otherwise undisturbed seedbed. Herbicides are used to control weeds and other undesirable vegetation. Zero-tillage has been used for corn following corn, soybeans, small grain, and sod crops (grass or legume). Soybeans, wheat, and corn have been grown in zero- or no-tillage systems.

Advantages:

1. Lower tillage costs since planting and spraying are the only tillage operations (Table 46).

2. Provides the maximum control of wind and water erosion that is possible through tillage alone.

3. Provides a firm seedbed and earlier planting when compared with the spring moldboard plow system, especially in the southern one-third of Illinois.

4. Reduces compaction.

5. Conserves soil moisture.

Limitations:

1. Requires special planting equipment.

2. Results in low soil temperatures and slow early growth of corn in the northern two-thirds of Illinois.

3. Weeds, especially grass weeds, may be a severe problem because of the interference of crop residues with herbicides.

4. Poor stand may limit yields more frequently than with other systems.

5. Residues may harbor insects and rodents.

Strip Tillage

With strip tillage, a strip up to 16 inches wide is tilled in the row area with the area between the rows left untilled. The tillage may be done with a rotary tillage machine, chisels, or a till-planter.

Advantages:

1. Can be adapted to ridge planting to gain additional erosion control and to lessen soil temperature reduction.

2. Other advantages are similar to those listed for mulch and zero tillage.

Limitations:

1. Requires special equipment.

2. Other limitations are similar to those listed for mulch and zero tillage.

Tillage System Combinations

Tillage systems must be designed for a particular situation if they are to be most effective. A system that combines features of one or more of the systems described above may be the best bet to cope with the varying soil and crop-residue situations that exist on most farms. For example, a chisel plow, disk in the spring, or zero tillage may be used following soybeans to control wind erosion. If the soils are level and poorly drained, fall plowing with a moldboard plow may be used to minimize early growth problems with corn following corn. Use of the moldboard plow every 3 to 4 years will help provide better distribution of limestone and broadcast phosphorus and potassium applications (see pages 43 and 44).

Careful attention to weed and insect problems may help lessen the limitations of mulch and zero tillage. This is discussed in the next two sections.

Tillage System and Weed-Control Interactions

Weed problems may be acute where heavy corn residues are left on the surface. Several factors contribute to the problem.

First, the weed seeds are left on or near the surface with mulch and zero-tillage. With conventional tillage, the weed seeds are incorporated so that many are too deep for germination and emergence. They may eventually rot.

Second, the corn residues intercept the herbicides and prevent them from reaching the soil where they are most effective.

Third, the corn residues serve as a mulch and reduce evaporation. The soil at or near the surface has sufficient moisture for weed-seed germination. With conventional tillage the soil at the surface may be dry a higher percentage of the time so that the shallower weed seeds do not have sufficient moisture for germination.

With mulch and zero tillage it is especially important to select herbicides on the basis of the type of vegetation which is or will be present. The following suggestions may help you solve a weed problem with mulch or zero tillage. For rates and use suggestion, see pages 54 to 64.

For existing grass-sod vegetation, perennial grasses, and early emerging annual weeds, apply Paraquat at 1 quart per acre for a quick kill at planting time.

For corn AAtrex plus Ramrod, AAtrex plus Lorox (Lorox may damage corn), or AAtrex alone have been used preemergence for weed control. AAtrex plus oil is used for preemergence application to corn, but is used postemergence for weeds.

For corn following alfalfa Paraquat has not always given effective control of the alfalfa. Banvel has given effective control but should not be used if soybeans have already been planted nearby and have emerged. 2,4-D or Banvel plus 2,4-D is also a possibility for killing legumes. If perennial grass is growing with the alfalfa, Paraquat can be used to control the grass.

For broadleaf weeds that escape the initial treatment in corn, 2,4-D postemergence can be effective as a follow-up application.

For grass weeds in corn, a directed spray of Erik or Lorox may be helpful for postemergence control if there is sufficient height difference between corn and the weeds (see page 59).

For soybeans, Lorox plus Surfactant WK or Amiben along with Paraquat (1 quart per acre) have looked promising with zero-tillage planting in wheat stubble (double cropping).

The most effective weed control is achieved when the control measures are adapted for each situation. Watch for developing weed problems and be prepared to take corrective action as needed. Postemergence application of herbicides and row cultivation where feasible may mean the difference between success and failure of the tillage system.

Tillage and Insect Control

Damage from cornborer, common stalk borer, and other insects may be associated with cornstalk residues or grassy weed infestations, or both, in mulch-tilled and zero-tilled corn. In general, control measures with these tillage systems have not differed from those used with conventional tillage. Careful attention to the developing crop may help you recognize a potential insect problem soon enough for effective control. Specific recommendations are available in Illinois Extension Circular 899, "Insecticide Recommendations for Field Crops."

Tillage and Disease Control

Tillage systems can and do influence plant disease control. Clean tillage results in incorporation of the residues of the previous crop. The incorporated residue is then subject to biochemical decomposition. Disease-infected residue may be removed through decay. Clean tillage aids soil sanitation. Volunteer corn is more likely to be a problem if residues are left on the surface than if all residues are incorporated. If the volunteer corn is from disease susceptible hybrids, it may provide for early infection for diseases such as southern corn leaf blight. Although the plant disease potential may be greater with mulch tillage than with clean tillage systems, the erosion control benefits of mulch tillage are great and this benefit needs to be balanced against the disease potential. The use of resistant hybrids and varieties provides an effective tool to minimize plant disease problems. Modification of crop sequence and tillage practices may be used as desired to provide additional control if a disease problem appears very likely.

1974 FIELD CROPS WEED CONTROL GUIDE

This guide for using herbicides is based on research results at the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture. Although not all herbicides commercially available are mentioned, an attempt has been made to include materials that were tested and showed promise for controlling weeds in Illinois. Consideration was given to the soils, crops, and weed problems of the state.

Rainfall, soil type, and method of application influence herbicide effectiveness. Under certain conditions some herbicides may damage crops to which they are applied. In some cases chemical residues in the soil may damage crops grown later.

When deciding whether to use a herbicide, consider both the risk involved in using the herbicide and the yield losses caused by weeds. If you do not have much of a weed problem and if cultivation and other good cultural practices are adequate for control, do not use herbicides. Much of the risk can be decreased by following these precautions:

Caution

- Use herbicides only on those crops for which they are specifically approved and recommended.
- Use no more than recommended amounts. Applying too much herbicide may damage crops, may be unsafe if a crop is to be used for food or feed, and is costly.
- Apply herbicides only at times specified on the label. Observe the recommended intervals between treatment and pasturing or harvesting of crops.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label. Some individuals are more sensitive than others to certain herbicides.
- Guard against possible injury to nearby susceptible plants. Droplets and vapors from 2,4-D, MCPA, 2,4,5-T, and dicamba sprays may drift for several hundred yards. Take care to prevent damage to such susceptible crops as soybeans, grapes, and tomatoes. If it is necessary to spray in the vicinity of such crops, the amine form of 2,4-D is safer to use than the volatile ester form, but even with the amine form, spray may drift to susceptible crops. To reduce the chance of damage, calibrate and operate sprayers at low pressure with tips that deliver large droplets and high gallonage output. Spray only on a calm day or make sure air is not moving toward susceptible crop plants and ornamentals. Some farm liability insurance policies do not cover crop damage caused by the ester form of 2,4-D.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed. Avoid unnecessary exposure.
- Return unused herbicides to a safe storage place promptly. Store them in original containers, away from unauthorized persons, particularly children.
- Properly dispose of empty herbicide containers. Rinse and puncture metal containers and haul them to a sanitary landfill. Haul paper containers to a sanitary landfill or burn them.
- Since manufacturers' formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

This guide is for your information. The University of Illinois and its agents assume no responsibility for results from using herbicides, whether or not they are used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Cultural and Mechanical Control

Plan your weed control program to fit your situation and desires. Be prepared to modify your plans as required during the season. Most weed control programs combine good cultural practices, mechanical weed control, and herbicide applications. If weeds are not serious, herbicide applications may not be needed.

Good cultural practices include good seedbed preparation, adequate fertility, optimum stands, optimum row width, and proper seeding date.

Prepare a uniform, weed-free seedbed to help discourage weed growth and encourage corn and soybean germination. Incorporation of preplant herbicides should be a part of normal seedbed preparation. Excessive preplant tillage may intensify soil crusting.

Planting in relatively warm soils helps soybeans and corn compete better with weeds. Good weed control during the first three to five weeks is extremely important for both corn and soybeans. If weed control is adequate during that period, corn and soybeans will usually compete quite well with most of the weeds that begin growth later. Optimum row width and plant populations also help discourage weed growth.

Narrow rows will shade the centers faster and help the crop compete better with the weeds. There is interest in drilling soybeans in narrow rows, but it is usually preferable to keep rows wide enough to use cultivation as required. Present herbicides don't control all the weeds adequately and consistently enough to give up the option of cultivation.

Early cultivations are most effective when weeds are small. Use the rotary hoe after weed seeds have germinated, but before the majority of weeds have emerged. Operate the rotary hoe at 8 to 12 miles per hour and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

Even though you have used a preemergence or preplant herbicide, if it appears doubtful that it will give adequate control, use the rotary hoe while weeds are still small enough to be controlled.

Row cultivators should also be used while weeds are small. Throwing soil into the row can help smother small weeds, but be certain not to cover the crop. If a banded herbicide has given adequate weed control in the row, use shields to prevent soil movement into the row during the first cultivation. Cultivate shallow to prevent root pruning. Avoid excessive ridging as it may hinder harvesting and encourage erosion.

Preemergence or preplant herbicides may provide a convenient and economical means of early weed control, thus allowing delayed and faster cultivation. Some farmers eliminate some cultivations by broadcasting herbicides. If weeds are controlled there is little need for cultivating unless the soil is crusted.

Chemical Weed Control

Plan your chemical weed control program to fit your soil, crops, weed problems, farming operations, and personal desires. Be prepared to modify your plans as required during the season. Herbicide performance depends on the weather and on wise selection and application of the herbicide. Your decision to use a herbicide should be based on the nature and seriousness of your weed problem, as well as your preference for alternative methods and times for controlling weeds.

Corn or soybeans may occasionally be injured by some of the herbicides which are cleared for use on them. Crop tolerance ratings for the various herbicides are given in Table 49. Usually the benefits from weed control are much greater than the adverse effects from herbicides. Corn or soybeans that are under stress from soil crusting, depth of planting, or adverse weather are more subject to herbicide injury. Plants that are injured by a herbicide are likely to be more subject to disease.

Apply the herbicide at the time specified on the label. Most preemergence herbicides should not be applied after the crop has emerged. Be sure to select and apply the right herbicide rate to reduce the risk of crop injury. The application rate for some herbicides varies greatly with soil texture and organic matter (see herbicide application section on page 56).

You must also consider the kinds of weeds likely to be present. The herbicide selectivity table at the back of this guide lists the various herbicides and the relative control of various weeds. Most soybean herbicides do not give adequate control of some broadleaf weeds. If a serious broadleaf infestation is expected, it may be wise to plant corn since some of the corn herbicides are more effective on broadleaf weeds.

Crop planting intentions for the next season must also be considered. Where high rates of atrazine are used, such as to control quackgrass, you should not plant soybeans, small grains, alfalfa, or vegetables the following year. If you are considering planting wheat after soybeans be sure that the application of Treflan or similar herbicide is accurate, uniform, and sufficiently early to reduce the risk of wheat injury.

Several herbicides have more than one trade name.

Names of Some Herbicides

Trade	Common (generic)
AAtram	atrazine plus propachlor
AAtrex, Atrazine	atrazine
Amiben	chloramben
Banvel	dicamba
Basagran	bentazon
Bladex	cyanazine
Butoxone, Butyrac	2,4-DB
Cobex	dinitramine
Dyanap, Ancrack, Kleen-Krop	naptalam plus dinoseb
Eptam, Eradicane	EPTC
Evik	ametryne
Furloe, Chloro IPC	chlorpropham
Knoxweed	EPTC plus 2,4-D
Lasso	alachlor
Lorox	linuron
Maloran, Bromex	chlorbromuron
Outfox	cyprazine
Paraquat	paraquat
Planavin	nitralin
Premerge, Sinox PE	dinoseb
Preforan, Soyex	fluorodifen
Prefox	ethiolate plus cyprazine
Princep	simazine
Ramrod	propachlor
Sencor, Lexone	metribuzin
(several)	2,4-D
Solo	naptalam plus chlorpropham
Surflan	oryzalin
Sutan, Sutan+	butylate
Tenoran, Norex	chloroxuron
Tolban	profluralin
Treflan	trifluralin
Vernam	vernolate

Some herbicides have different formulations and concentrations under the same trade name. Where trade names are used in this publication, no endorsement is implied, nor is discrimination meant against similar products.

Herbicide Application Rates

Where trade names are used in this publication, rates refer to the amount of commercial product. Where common or generic names are used, rates refer to the amount of active ingredient unless a formulation is stated. Unless otherwise stated, rates are given on a broadcast basis.

The performance of some herbicides is influenced considerably by the organic-matter content of soil. You can estimate the organic-matter content of most Illinois soils by using the "Color Chart for Estimating Organic Matter in Mineral Soils in Illinois" (AG-1941), available from your county extension adviser or the Publications Office, College of Agriculture, University of Illinois, Urbana, Illinois 61801. For a more precise determination of organic matter, obtain a laboratory analysis.

After you know the approximate organic-matter content of soil, Table 47 can be used for selecting herbicide rates. Using this guide should help you select rates to provide adequate weed control and minimize herbicide residue.

Table 47. — Suggested Herbicide Rates for Illinois Soils

Percent organic matter	Pounds of active ingredient per acre				
	atrazine	cyanazine	linuron	chlor-bromuron	Metri-buzin
1	1.6	1.2[c]	½[c]	¾[c]	⅜[c]
2	1.6	2.0	1	1½	⅜
3	2.4	3.0	1½	2¼	½
4	3.2	3.6	2[b]	3[b]	⅝
5+	4.0[a, b]	4.0	2½-3[b]	3¾[b]	¾
	Commercial formulation per acre				
	AAtrex 80WP	Bladex 80WP	Lorox 50WP	Maloran or Bromex 50WP	Sencor 50WP
1	2	1½[c]	1[c]	1½[c]	¾[c]
2	2	2½	2	3	¾
3	3	3¾	3	4½	1
4	4	4½	4[b]	6[b]	1¼
5+	5[a, b]	5	5-6[b]	7½[b]	1½

[a] Do not follow with any crop except corn or sorghum the next growing season.
[b] Best adapted to soils with less than 4 percent organic matter. Consider another herbicide or a herbicide combination.
[c] Rates are for silt loam soils. Refer to text and labels for information on sandy soils.

Table 48 lists the amount of commercial herbicides to apply per acre for liquids or granules. For band applications, you should use the same amount of active ingredient of commercial product per treated acre as used in broadcast applications. However, for band application the total amount of herbicide used per field acre will be less because you do not treat the entire field. Use the following formula for calculating the amount of herbicide needed for band applications for various row spacings.

$$\frac{\text{band width (inches)}}{\text{row width (inches)}} \times \text{broadcast rate} = \text{rate per field acre}$$

Example: With a 36-inch row spacing and a 12-inch band, you will cover one-third (0.33) of the total field. If the broadcast rate is 30 pounds of granules per acre and the field size is 80 acres, then you will need 10 pounds of granules per field acre or 800 pounds for the 80-acre field. To calibrate granular applicators refer to the owner's manual and to Illinois Extension Circular 1008, Calibrating and Adjusting Granular Row Applicators (see page 66 for other publications and where to obtain them).

Table 48. — Amount[a] of Commercial Product To Apply per Treated Acre

Herbicide	Spray[b]	Granules[b]
	Corn	
AAtram		21-30 lb. (20G)
Atrazine 80W	2½-3¾ lb. (80 WP)	
AAtrex	2-3 qt. (4 DL)	
Bladex	1½-5 lb. (80 WP)	8-27 lb. (15G)
Eradicane	⅔ gal. (6 EC)	
Knoxweed	2 qt. (6 EC)	20 lb. (14G)
Lasso	2-3½ qt. (4 EC)	16-26 lb. (15G)
Ramrod	6-9 lb. (65 WP)	20-30 lb. (20G)
Sutan +	⅔ gal. (6 EC)	40 lb. (10G)
	Soybeans	
Amiben	6 qt. (2 S)	30 lb. (10G)
Cobex	⅔-1⅓ qt. (2 EC)	
Lasso	2-3½ qt. (4 EC)	16-26 lb. (15G)
Lorox[c]	1-6 lb. (50 WP)	
Maloran, Bromex[c]	2-8 lb. (50 WP)	
Planavin	⅔-2 lb. (75 WP)	
Preforan, Soyex	5-6 qt. (3 EC)	
Sencor[c]	¾-1¾ lb. (50 WP)	
Solo	4-8 qt. (4 EC)	20-40 lb. (20G)
Treflan	½-1¼ qt. (4 EC)	10-25 lb. (5G)
Vernam	1⅓-2 qt. (6 EC)	20-30 lb. (10G)

[a] Rates vary with soil texture and organic matter. Low rates are used on light-textured soils with low organic matter. Refer to Table 47, the text, and labels for exact rates for differing conditions.
[b] Active ingredient and formulation indicated in parentheses. Active ingredient is expressed as percent for wettable powders (WP) and granules (G), and in pounds per gallon for emulsifiable concentrates (EC), water dispersible liquids (DL), and solutions (S).
[c] Rates are for silt loam to silty clay loam soils. Crop injury can occur on sands and sandy loam soils. Refer to label for rates and precautions for sandy soils.

Calibration of Spray Equipment

Application equipment must be calibrated properly. The following method is recommended for calibration of spray equipment. It can be used for boom, band, drop-nozzle, and directed application spraying. Once you learn this method, calibration can be checked quickly and easily.

Step 1. Select and determine an appropriate ground speed. Measure a distance of 176 feet under existing field conditions and determine the time in seconds to travel 176 feet.

$$\text{Speed (MPH)} = \frac{120}{\text{Time (seconds) to travel 176 feet}}$$

If it takes 24 seconds to travel 176 feet, your ground speed is 120 ÷ 24 = 5 miles per hour.

Step 2. Determine the suggested sprayer application volume in gallons per acre (GPA) from the herbicide label or printed recommendations. (Application volume is the gallons of water plus herbicide applied per treated acre.)

Step 3. Use the following formula to determine the nozzle flow rate required:

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W}}{5{,}940^{1}}$$

GPA = gallons per acre (Step 2)
GPM = gallons per minute of nozzle flow rate
MPH = miles per hour (Step 1)
W = width (inches) of nozzle pattern
boom spraying: W = nozzle spacing
band spraying: W = band width
drop-nozzles: W = width sprayed per nozzle[2]

Example: To broadcast apply 20 gallons per acre at a speed of 5 miles per hour with a nozzle spacing on the boom of 20 inches will require a nozzle flow rate of 0.337 gallon per minute or 43 ounces per minute.

$$\text{GPM} = \frac{20 \times 5 \times 20}{5{,}940} = 0.337$$

Example: To apply a 14-inch band at a speed of 5 miles per hour using an application volume of 10 gallons per treated acre will require a nozzle flow rate of 0.118 gallon per minute.

$$\text{GPM} = \frac{10 \times 5 \times 14}{5{,}940} = 0.118$$

Step 4. Select and install the proper nozzle tips which have the flow rate determined in Step 3 when operating within the recommended pressure range.

Step 5. Partially fill the sprayer tank with water and operate the sprayer at a pressure within the recommended pressure range. Place a container under each nozzle and check if all nozzles are delivering uniform volumes. Replace all nozzle tips that vary more than 5 percent from the mean flow rate for the nozzle size.

Step 6. Measure the nozzle flow rate by collecting the water from a nozzle. Compare the amount collected with that determined in Step 3 (ounces per minute = gallon per minute × 128 ounces per gallon).

Step 7. Adjust the pressure and repeat Step 6 until the amount collected is the same as that required in Step 3. If the pressure required is not within the recommended range, you must recalibrate by selecting a different application volume (Steps 2 and 3), by using a different ground speed (Step 1), or by changing size of nozzles (Step 4). It is important that the final pressure be within the recommended pressure range.

Step 8. Add the correct amount of herbicide needed for each tankful to a partially filled sprayer. Never place herbicide concentrates in an empty spray tank. Finish filling the spray tank with water.

Step 9. Operate the sprayer at the ground speed determined from Step 1 and the pressure determined from Step 7. After spraying a known number of acres, check to verify that the proper application is being disbursed.

Step 10. Periodically recalibrate the sprayer by repeating Steps 6 and 7. If the flow rate has changed over 10 percent, it is probably time to change the nozzle tips.

Additional information related to calibrating herbicide spraying equipment can be found in Illinois Extension Circular 1038, Calibrating and Maintaining Spray Equipment, and Circular 1047, Band Spraying Preemergence Herbicides.

[1] Can be rounded to 6,000 with a 1 percent loss in accuracy.
[2] If two nozzles are directed into one row, then width per nozzle is one-half of spray width.

Herbicide Combinations

Herbicides are often combined to control more weed species, reduce herbicide carryover, or reduce crop injury. Some combinations are sold as a "package mix" while others are tank-mixed. Tank mixing allows you to adjust the ratio to fit local weed and soil conditions. Tank mixes should be registered with the EPA and mixing information should either be on the label of one of the components or appear as supplemental information. If you use a tank mix, you must follow restrictions on all products used in the combination.

Mixing problems sometimes occur when mixing emulsifiable concentrate (EC) formulations with wettable powder (WP) or water dispersible liquid (WDL) formulations. These problems can sometimes be prevented by using proper mixing procedures. Wettable powders should be added to the tank before EC's. Preemulsify EC's by mixing with equal volumes of water before adding them to the tank. Empty and clean spray tanks often to prevent an accumulation of material on the sides and in the bottom of the tank.

Herbicide combinations currently registered are listed below. The herbicide listed first is the one which carries label or supplemental instructions on mixing. The other herbicide's label may also carry mixing instructions.

Corn

AAtrex + Princep (PPI, Pre)[1]
Amiben + AAtrex (Pre)
Banvel + AAtrex (Post)
Banvel + Lasso (Pre)
Banvel + 2,4-D (Post)
Bladex + AAtrex (Pre)
Bromex + Lasso (Pre)
Dowpon + 2,4-D (Post)

Lasso + AAtrex (PPI, Pre)
Lasso + Bladex (Pre)
Lorox + AAtrex (Pre)
Lorox + Lasso (Pre)
Lorox + Ramrod (Pre)
Paraquat + AAtrex (NT)
Paraquat + AAtrex + Lasso (NT)
Ramrod + AAtrex (Pre)

Soybeans

Amiben + Lorox (Pre)[1]
Bromex + Lasso (Pre)
Dyanap + Lasso (Pre)
Furloe + Lasso (Pre)
Lasso + Lorox (Pre)
Lasso + Sencor (Pre)
Lorox + Lasso (Pre)
Maloran + Lasso (Pre)
Paraquat + Lorox (NT)
Premerge + Amiben (Pre)
Premerge + Lasso (Pre)
Solo + Lasso (Pre)
Vernam + Treflan (PPI)

The U.S. Environmental Protection Agency policy on tank-mix and serial applications (combinations in times of application) is as follows.

1. All tank mixes and serial applications registered with the EPA and stated on EPA-approved labels are legal.

2. Intra-state registrations are still legal until 1976. However, Illinois law does not allow Illinois registration without federal registration.

3. Various tank mixes and serial applications which have been tested and are common agricultural practices are considered consistent with the label (do not constitute a violation) if: they are not applied at a rate exceeding the label instructions for each herbicide, the label of one of the products does not explicitly prohibit such a mixture, and if the use is consistent with the label.

The relaxed policy on the third group of combinations, those which are not registered with the EPA, does not indicate EPA approval for the mixtures. The user and applicator assume the risks involved with adverse effects such as crop injury, personal injury, mixing and application problems, and environmental effects.

Herbicide Incorporation

Some herbicides must be incorporated to reduce surface loss caused by volatilization or photodecomposition. Those which are highly volatile need immediate incorporation. Incorporation of some herbicides may improve their performance by placing them in sufficient moisture to be absorbed by weeds, thus overcoming some of the dependence upon rainfall.

Depth and thoroughness of incorporation depend upon type of equipment, depth of operation, speed, soil texture, and soil moisture. It is important to obtain uniform distribution, both horizontal and vertical, to prevent areas of high and low concentrations which may result in injury, residue, or poor control.

The majority of most annual weed seeds germinate in the top 1 or 2 inches of soil, so that is where you want to place most of the herbicide. The tandem disk is the most common implement for herbicide incorporation. The disk tends to incorporate herbicides at about half the depth at which the disk is operated. Disking twice may result in more uniform distribution than disking once. The field cultivator has been used for incorporation, but streaking often results unless you use a drag-harrow behind the field cultivator. A disk with less than 22-inch blades used twice, or disking followed by field cultivating has usually given better herbicide distribution than using the field cultivator twice.

Speed and depth are important in obtaining satisfactory results with all equipment. Keep in mind that if the herbicide is incorporated too deep, its effectiveness may be reduced because of dilution.

Corn Herbicides

Preplant Incorporation

Some herbicides are applied before planting to facilitate incorporation, but this necessitates broadcast application. You can apply preplant herbicides before the busy planting season. You can sometimes mix herbicide, insecticide, and fertilizer together and apply at the same time, if the chemicals are compatible and the incorporation provides the proper placement for each chemical.

AAtrex (atrazine) can be applied within two weeks before planting corn. The reason for preplant incorporation of atrazine is to overcome some of the dependence upon rainfall. Incorporation should not be too deep.

AAtrex is very effective for control of many broadleaf weeds. Control of annual grass weeds is often satisfactory. However, AAtrex may not adequately control some annual grasses such as fall panicum, crabgrass, and giant foxtail. See further details under the discussion of preemergence applications on page 59.

Sutan+ (butylate) needs immediate incorporation and where possible application and incorporation should be done in the same operation. Sutan+ is a new formulation of Sutan plus a safening agent to reduce the risk of corn injury. Apply and incorporate Sutan+ accurately to minimize injury.

Sutan+ is cleared for field, sweet, and silage corn, but not for seed corn production. Sutan+ is primarily for control of annual grass seedlings, but will also suppress yellow nutsedge. Most broadleaf weeds are not controlled by Sutan+ (see selectivity table on back cover). Broadleaf weed control can be improved by a combination of Sutan+ with atrazine or with a postemergence application of 2,4-D.

[1] PPI = preplant incorporated, Pre = preemergence, Post = postemergence, NT = no-till.

Sutan+ is used alone at the rate of two-thirds of a gallon per acre. It is also available as a 10-percent granule which is used at 40 pounds per acre. The granular formulation also requires immediate incorporation.

Sutan (butylate) plus atrazine is available as a premixed wettable powder or can be tank-mixed. The premixed wettable powder contains 36 percent butylate and 12 percent atrazine. The suggested rate is 8½ to 11⅓ pounds per acre, depending upon soil and weed problems. A combination of one-half to two-thirds gallon of Sutan+ 6E plus 1¼ to 2 pounds of AAtrex 80W can be tank-mixed. Use the higher rates on soils with over 5 percent organic matter. Use the higher rate of Sutan on heavy infestations of wild cane or nutsedge.

Eptam (EPTC) is chemically related to Sutan, but is more active on yellow nutsedge, wild cane, and johnsongrass seedlings. Because of the degree of corn injury sometimes caused by Eptam, its use on corn has been limited. However, the development of chemical "safening agents" may revive the usage of Eptam for these problem weeds. Eptam is a six-pound-per-gallon formulation and the rate for corn is one-half to two-thirds gallon per acre. Eptam must be incorporated immediately.

Protect (1,8 naphthalic anhydride) is a seed treatment to protect corn from Eptam injury. Use one 2-ounce package of Protect for each one-half bushel of seed corn. It must be thoroughly mixed so that each kernel is completely coated. Do not use a planter box treatment.

Eradicane is a mixture of EPTC (Eptam) plus a safener for use in field and silage corn where wild cane, johnsongrass, yellow nutsedge, and quackgrass are weed problems. Because of less risk of corn injury, Eradicane should usually be considered in preference to Eptam. Perennial grasses must be turned under and thoroughly chopped prior to treatment so that rhizomes contain four or less nodes. Apply two-thirds gallon Eradicane 6E per broadcast acre prior to planting and incorporate immediately. Tandem disks should be set to cut to a depth of 4 to 6 inches when operated at 4 to 6 miles per hour, followed by a leveling device (harrow or drag) which extends beyond the ends of the disk. Disking in two different directions (cross-disking) is recommended for control of perennial grasses and on heavier soils to provide more thorough mixing. Incorporation with a field cultivator is recommended only on lighter soils in good tilth. See the label for instructions. Do not overdose. Plant corn no deeper than two inches within two weeks after treatment. Do not use on corn seed stock.

Prefox (ethiolate + cyprazine) is a preplant herbicide combination for corn which had an experimental permit in 1972 and 1973. The 1973 formulation was three-quarters pound of cyprazine and 4 pounds of ethiolate per gallon, and the rate was one gallon per acre on all soils. The 1974 formulation may contain a different ratio and specify varying the rate on different soil types. Prefox controls a fairly broad spectrum of weeds, but corn is sometimes injured. Immediate incorporation is necessary because ethiolate is quite volatile.

Lasso (alachlor) or Lasso plus atrazine may be used preplant within seven days before planting corn. A surface application is usually preferred for control of annual grasses, but incorporation may improve nutsedge control. Consider using the higher rates of Lasso indicated on the label if Lasso is to be incorporated. See further details in the preemergence section.

Preemergence Herbicides for Corn

AAtrex (atrazine) will be available in 1974 under several private brand names. They are all the same as AAtrex 80W.

Atrazine controls both annual grasses and broadleaf weeds, but is especially effective on many annual broadleaf weeds. Fall panicum and crabgrass have sometimes become problems where atrazine has been used several years in succession. AAtrex usually controls weeds for most of the season, but may sometimes remain in the soil to damage certain crops the following season. If you use AAtrex in the spring, do not plant small grains, small seeded legumes, or vegetables the next fall or spring. If you use AAtrex 80W at over 3.75 pounds per acre (or an equivalent rate of AAtrex 4L) or if you apply after June 10, plant only corn or sorghum the next year.

Soybeans planted the year following AAtrex may be injured if you use more than recommended amounts or if you overlap when broadcasting or overdose when turning at the ends of fields. Carryover injury can be minimized by accurate mixing and application, by use of the lowest rates consistent with good weed control, and by thorough tillage of the soil prior to planting subsequent crops.

Corn tolerance is very good with AAtrex. You can use AAtrex on field corn, sweet corn, silage corn, popcorn, and seed production fields. AAtrex is available as an 80-percent wettable powder and a four-pound-per-gallon liquid suspension. Rates vary with soil organic matter (see Table 47), with about 1 pound of AAtrex 80W needed for each percent organic matter to control most annual grasses.

Mix properly, provide adequate agitation, and follow other precautions on the label.

Princep (simazine) used alone or in combination with AAtrex usually gives better control of fall panicum and crabgrass than AAtrex alone. Princep is less soluble than AAtrex and may have more residual activity, so follow label precautions to minimize carryover. Princep is available as 80-percent wettable powder and a four-pound-per-gallon formulation. The major use of Princep is a combination with AAtrex on soils with less than 3 to 4 percent organic matter. Princep and AAtrex are used in a 1:1 combination, each at half rates of its use alone.

Bladex (cyanazine) is chemically related to atrazine. Corn tolerance is not quite as good as with atrazine, but soil persistence is less. Bladex may control giant foxtail and fall panicum better than atrazine does, but control of some broadleaf weeds may not be as good (see Table 49).

Bladex is available as an 80-percent wettable powder, a 4-pound-per-gallon formulation, and a 15-percent granule. Use 1½ to 5 pounds of Bladex 80W, 1¼ to 4 quarts of Bladex 4-WDS, or 8 to 27 pounds of Bladex 15G per acre on a broadcast basis. Rates should be adjusted carefully to soil conditions to avoid corn injury (Tables 47 and 48), *especially on sandy soils.*

Tank mix combinations of Bladex with AAtrex or Lasso are registered for preemergence use. The Bladex: AAtrex ratios are 1:1 or 2:1 depending upon severity of grass infestation expected. The individual rates vary greatly with soil texture and organic matter, so refer to the Bladex label for exact rate information. The Bladex-Lasso combination specifies 2 quarts of Lasso with 1¼ to 2¾ pounds of Bladex depending upon soil texture and organic matter. See either the Bladex or Lasso label for rates for specific soils.

Ramrod (propachlor) controls annual grasses and pigweed and is usually used on soils above 3 percent organic matter. Most other broadleaf weeds are not controlled. Many farmers band Ramrod granules at planting time to control annual grass weeds and follow with an early postemergence application of 2,4-D.

Corn tolerance to Ramrod is good. Ramrod is cleared on field corn, silage corn, sweet corn, and corn seed fields. Ramrod is irritating to the skin and eyes, so observe label precautions. Some individuals are more sensitive than others.

The broadcast rate is 6 to 9 pounds per acre of Ramrod 65W or 20 to 30 pounds per acre of Ramrod 20G (granules). Use proportionately less for band application.

Lasso (alachlor) is similar to Ramrod in many respects, but it performs better than Ramrod on soils with less than 3 percent organic matter. Lasso may require more moisture initially, but weed control may last longer. Lasso is not as irritating to handle as Ramrod. However, some individuals may be sensitive, so observe label precautions.

Lasso controls annual grasses, pigweed, and lambsquarter. Most other broadleaf weeds can be controlled with a postemergence followup with 2,4-D. AAtrex, Banvel, or Lorox are also cleared for preemergence combinations with Lasso to help control broadleaf weeds in corn, but Banvel or Lorox may increase the likelihood of crop injury.

The broadcast rate is 1½ to 3 quarts of Lasso 4E or 16 to 26 pounds of Lasso II 15G (the 1973 granular formulation was Lasso 10G). Adjust rate for soil texture and organic matter. Corn tolerance to Lasso is relatively good. However, slight injury has occasionally occurred to certain hybrids. Lasso may be used on field corn, sweet corn, and silage corn. Do not graze or harvest for forage for 21 days after treatment with Lasso.

Ramrod-atrazine is a combination best adapted to soils over 3 percent organic matter. The mixture controls broadleaf weeds better than Ramrod alone and controls annual grasses better than AAtrex alone. However, velvetleaf may not be controlled. It reduces the AAtrex residue problem and often gives more consistent control on the darker soils with limited rainfall than AAtrex alone.

Ramrod-atrazine is a wettable powder used at the rate of 6 to 8 pounds per acre. For tank mixing, use 4½ pounds of Ramrod 65W and 2 pounds of AAtrex 80W on soils with over 3 percent organic matter.

AAtram 20G is a granular combination containing 1 part atrazine and 2 parts propachlor. The rates to use on most Illinois soils are 22.5 to 30 pounds on a broadcast basis. Use proportionately less for band applications.

Lasso-atrazine is preferable to Ramrod-atrazine on soils with less than 3 percent organic matter. Lasso-atrazine is less irritating to handle and controls fall panicum better than Ramrod atrazine. Suggested rates for tank mixing are 1½ to 2 quarts of Lasso and 1¼ to 2 pounds of AAtrex 80W, depending upon soil organic matter. See the Lasso label for mixing instructions. There have been occasional problems in tank mixing AAtrex 4L with Lasso EC, so check compatibility in small containers before mixing large batches.

2,4-D ester preemergence for corn controls broadleaf weeds and gives some control of grass weeds, but weed control is rather erratic. There is some chance of injury to the corn. Use only the ester form for preemergence, since the amine form is more subject to leaching.

Knoxweed is a combination of Eptam (EPTC) and 2,4-D. Knoxweed has given rather erratic weed control. This herbicide should be applied to a dry soil. Rainfall shortly after application is essential for maximum effectiveness. The possibility of corn injury from Knoxweed has not been a serious problem, but injury can occasionally occur. Do not incorporate Knoxweed or use on peats, mucks, or sands. Do not use Knoxweed on seed production fields. It is available in both liquid and granular forms.

Amiben (chloramben), **Lorox** (linuron), and **Maloran** or **Bromex** (chlorbromuron) have label clearance for preemergence use on corn, but risk of corn injury is considered too great to suggest their use alone for this purpose in Illinois. Reduced rates used in combinations reduce but do not eliminate the possibility of corn injury.

Postemergence Herbicides for Corn

AAtrex (atrazine) can be applied early postemergence to corn up to three weeks after planting, but before weeds are more than 1½ inches high. Most annual broadleaf seedlings are more susceptible than grass weeds. Results on larger grasses have been somewhat erratic.

The addition of nonphytotoxic oils, oil-surfactant mixes, or surfactants has generally increased the effectiveness of postemergence AAtrex. The special nonphytotoxic spray oil is used at 1 to 2 gallons per acre. Formulations of 80 percent oil and 20 percent surfactant are used at the rate of 1 to 2 quarts per acre. Some surfactant-spreaders are also marketed for use with postemergence atrazine. These are usually added at 0.5 percent of the total spray volume or about 1 pint per acre. Results with the oils and oil-surfactant mixes have generally been better than with the surfactants.

Corn tolerance to atrazine-oil has been relatively good, but corn has sometimes been damaged. There have been a few cases of fairly severe injury where corn has been under stress from prolonged cold, wet weather or other factors.

Do not use over 2½ pounds of AAtrex 80W or 2 quarts of AAtrex 4L per acre if you mix with oil. Do not add 2,4-D to the atrazine-oil treatment or severe injury may result. Mix the atrazine with water first and add the oil last. If AAtrex is applied after June 10, do not plant any crop except corn or sorghum the next year because of risk of herbicide carryover. Refer to the label for other precautions.

Bladex (cyanazine) is cleared for postemergence use through the four-leaf stage of growth of corn, but before annual grasses exceed 1½ inches in height. The rate is 1½ to 2½ pounds of Bladex 80W in 15 to 30 gallons of spray per acre. The low rate is for sandy soils and the high rate is for drouthy conditions. Temporary yellowing of the corn may occur under cold, adverse growing conditions. Corn should not be treated after the four-leaf stage. *Do not add any wetting agent (surfactant) or oil* to the postemergence use of Bladex because serious corn injury may result.

Outfox (cyprazine) is a postemergence corn herbicide which is formulated as a 1-pound-per-gallon suspension in oil. This suggested rate is 3 quarts per acre when grasses are less than 2 inches high. Do not apply after corn is 10 inches tall. Corn injury has occurred, but has not generally been severe. At the rates used, carryover should not be a serious problem.

2,4-D provides one of the most economical and effective treatments for controlling many broadleaf weeds in corn. Use drop nozzles if corn is over eight inches high to help keep 2,4-D out of the corn whorl and decrease the possibility of injury. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn.

If you wish to control late-germinating weeds, you can use high-clearance equipment, but do not apply 2,4-D to corn from tasseling to dough stage.

Some corn injury may result from 2,4-D application. Corn is often brittle for 7 to 10 days after application and thus is susceptible to stalk breakage from high winds or cultivation. Other symptoms of 2,4-D injury are stalk bending or lodging, abnormal brace roots, and failure of leaves to unroll, sometimes called "onion leafing."

Spraying when corn is under stress (cool, wet weather) or when corn is growing very rapidly may increase the possibility of corn injury. Some corn inbreds are more susceptible than others. Corn hybrids vary in their sensitivity to 2,4-D, depending upon their genetic makeup.

Apply no more than the recommended rate of 2,4-D to help avoid corn injury. The suggested broadcast rates of acid equivalent per acre are one-sixth to one-fourth pound of ester formulations or one-half pound of amine. This would be one-third to one-half pint of ester or 1 pint of amine for formulations with 4 pounds of 2,4-D acid equivalent per gallon.

The ester forms of 2,4-D can volatilize and the vapors can move to nearby susceptible plants and cause injury. This vapor movement is more likely with high-volatile esters than with low-volatile esters. Amine formulations are relatively nonvolatile, so they are less likely to injure nearby susceptible plants. However, when spraying either the ester or amine forms, spray particles can drift to nearby susceptible plants and cause injury.

Dacamine and Emulsamine are oil-soluble amines of 2,4-D. Since they are formulated in oil like the esters they are said to have the effectiveness of the esters, but to retain the low-volatile safety features of the amines.

The active ingredient in the various formulations of 2,4-D is still 2,4-D and when you adjust rates appropriately to provide equivalent weed control and crop safety the various formulations are usually similar in their effectiveness.

Banvel (dicamba) is similar to 2,4-D in some respects, but controls smartweed better than 2,4-D. However, *Banvel has presented a much more serious problem of injury to soybeans than 2,4-D.* Soybean yields may not be reduced where slight injury occurs early. Thus, Banvel should be applied before soybeans in the area are 10 inches high. However, yields can be reduced when severe injury occurs when soybeans are blooming. Banvel can also affect other susceptible plants such as vegetables and ornamentals. Use extreme caution to avoid injury to desirable plants from either contaminated sprayers or movement of Banvel from treated areas. Also use caution to minimize drift. Spray thickeners and foam additives have reduced, but not eliminated, problems with movement of Banvel.

Banvel may be applied over the top until corn is three feet high or up to 10 days before tassel. However, drop nozzles may be used during this period to give better weed coverage and reduce drift. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn. Corn tolerance is relatively good with Banvel, however corn injury can occur. Broadcast rates are one-quarter to one-half pint per acre. Use the higher rate for taller weeds.

Do not use Banvel on sweet corn or popcorn. Do not graze or harvest corn for dairy feed before the ensilage stage (milk stage).

A mixture of one-quarter pint of Banvel plus one-half pint of 2,4-D amine per acre is more economical than a full rate of Banvel and presents less risk of corn injury than 2,4-D alone. Use drop nozzles on corn over eight inches high when using the Banvel-2,4-D mixture.

Directed Postemergence Herbicides for Corn

Directed sprays are sometimes considered for emergency situations, especially when grass weeds become too tall for control with cultivation. However, weeds are often too large for directed sprays to be very practical when help is sought. Place primary emphasis on early control measures such as use of preemergence herbicides, rotary hoeing, and timely cultivation.

Directed sprays cannot be used on small corn and a height difference between corn and weeds is usually needed to keep the spray off of the corn. Corn leaves that are contacted can be killed and injury may be sufficient to affect yields.

Lorox (linuron) may be applied as a directed spray after corn is at least 15 inches high (to the top of the free standing plant), but before weeds are eight inches tall (preferably not over five inches). This height difference doesn't occur in many fields and when it does it usually lasts only for a few days. Lorox can control both grass and broadleaf weeds.

Use 1¼ to 3 pounds of Lorox 50W on a broadcast basis, with the lower rates used on small weeds, lighter soil types, and soils low in organic matter. Add Surfactant WK at the rate of 1 pint per 25 gallons of spray mixture. Cover the weeds with the spray, but keep it off the corn as much as possible. Refer to the label for other precautions. *Consider this an emergency treatment.*

Evik 80W (ametryne) is cleared for directed use when corn is over 12 inches tall and weeds are less than four inches tall. The rate is 2 to 2½ pounds Evik 80W per acre (broadcast basis) plus 2 quarts of surfactant per 100 gallons of spray mixture. Extreme care is necessary to keep the spray from contacting the leaves. *Use only as an emergency treatment.*

No-Till Corn

No-till (zero-till) corn puts chemical weed control to a real test. You must control both vegetation existing at planting and weed seedlings which germinate after planting. Existing vegetation may be a perennial grass sod, a legume or legume-grass sod, an annual cover crop, or weeds which germinated before planting.

Paraquat (1 to 2 pints per acre) plus AAtrex 80W (2.5 to 3.75 pounds per acre) are the most common herbicides used in a program for no-till corn. The Paraquat has a contact action, while the AAtrex provides a postemergence plus a preemergence effect on vegetation. Use 40 to 60 gallons of spray per acre and add a non-ionic surfactant at one-half pint per 100 gallons of diluted spray.

A pretreatment with 2,4-D or Banvel can improve control of alfalfa considerably. Fall panicum and crabgrass may not be controlled by the AAtrex. A mixture of AAtrex-Lasso or AAtrex-Princep will usually effectively control these grasses. The AAtrex-Lasso mixture is 1½ to 2 quarts of Lasso plus 1½ to 2 pounds of AAtrex 80W per acre. The AAtrex-Princep mixture is 1¼ to 2 pounds of AAtrex 80W plus 1¼ to 2 pounds of Princep 80W per acre.

Soybean Herbicides

You must consider the kinds of weeds likely to be present when you select preplant and preemergence herbicides for soybeans. The herbicide selectivity table (Table 49) lists the various herbicides and the relative control of various weeds.

Soybeans may occasionally be injured by the herbicides which are registered for use. Fortunately, soybeans usually have the ability to outgrow modest amounts of early injury without reducing yields. Use high-quality seed of disease-resistant varieties and do not plant too deep. Soybeans that are injured by a herbicide are likely to be more subject to disease.

Preplant Herbicides for Soybeans

Treflan (trifluralin) can be applied anytime in the spring before planting, but should be incorporated into the soil within 8 hours of application. Immediate incorporation is preferred, especially if soil is moist or winds are over 10 miles per hour.

Incorporation can be performed with several implements listed on the label, but the most common in Illinois is the tandem disk.

See the section on herbicide incorporation on page 58 and the Treflan label for further information on incorporation.

Treflan controls annual grasses including wild cane and johnsongrass seedlings. It also controls pigweed and lambsquarter, but doesn't control most other broadleaf weeds. There is interest in applying certain preemergence herbicides after preplant application of Treflan to control some of the uncontrolled broadleaf weeds. Several preemergence herbicides are cleared for this overlay or "piggyback" application. A tank mix of Treflan plus Sencor may also be cleared to improve broadleaf control.

Soybeans are sometimes injured by Treflan. Injury symptoms are stunted plants with swollen crowns and lateral root inhibition. Injury from Treflan on a statewide basis is not a serious problem, but may be significant in fields where cool wet conditions exist.

There have been a few cases of injury to corn or small grains grown after Treflan was applied to soybeans. In many of these fields the soybean stubble was not plowed. Excessive applications were also the cause in some fields. Use no more than recommended rates. Apply carefully to avoid overlapping application.

The rate of Treflan is 1 to 2 pints per acre. Use 2 pints per acre on silty clay loam or clay loam soils with over 4 percent organic matter. Use 1 to 1½ pints on soils coarser in texture and lower in organic matter. Treflan is also available as a 5-percent granule. Granules are not as popular as the liquid, but have been comparable in performance.

Cobex (dinitramine) controls the same weeds as Treflan, but soybean tolerance is not quite as good. Soybeans under stress from disease, deep planting, or cold wet weather may be more susceptible to injury. The suggested rates are ⅔ to 1⅓ quarts of Cobex per acre, depending upon soil texture and organic matter. Cobex needs thorough incorporation into the soil within 24 hours after application. Shallow incorporation may reduce risk of soybean injury, but may also make weed control more variable.

Tolban (profluralin) is a dinitroaniline herbicide similar to Treflan. It had an experimental permit in 1973. It controls the same weeds as Treflan. Soybean tolerance is also similar to Treflan. However, slightly higher rates of Tolban are required for most soil types. Tolban is a 4-pound-per-gallon formulation and rates are 1 to 3 pints per acre, depending on soil texture. It should be incorporated within 4 hours after application.

Planavin (nitralin) controls the same weeds as Treflan, but requires higher rates for comparable performance in Illinois. Planavin is best adapted to the soils of southern Illinois which contain less than 3-percent organic matter. On most of these soils a rate of 1 pound of active ingredient per acre (1 quart of Planavin 4L or 1⅓ pounds of Planavin 75W) is appropriate. Higher rates are needed as organic matter increases. Planavin is not well adapted to the darker soils of northern Illinois. Planavin can be applied within six weeks of planting. Incorporate soon after application into the top 1 or 1½ inches of soil with a disk operated shallow or with other suitable equipment (see label). Incorporation can be delayed up to two days.

Vernam (vernolate) controls annual grasses and pigweed. Control of morningglory and velvetleaf is sometimes fair. Vernam may also suppress nutsedge. *Some soybean injury occurs* in the form of delayed emergence, stunting, and leaf crinkling. The injury is usually temporary and is usually not reflected in final yields. A tank-mix combination of Vernam with Treflan is cleared. The reduced rate of Vernam used in the combination may decrease the risk of soybean injury, but may also decrease control of velvetleaf and yellow nutsedge. Vernam can be applied up to 10 days prior to planting. Incorporate immediately to prevent surface loss. The broadcast rate is 1⅓ to 2 quarts of Vernam 6E or 20 to 30 pounds of Vernam 10G per acre. Vernam granules are sometimes banded on the surface at planting, but weed control is much more variable without incorporation.

Lasso (alachlor) is sometimes applied preplant for nutsedge suppression at rates of 2½ to 4 quarts per acre. Apply preplant within seven days of planting. Preemergence application is usually preferred for control of annual grasses (see preemergence section on page 64).

Preemergence Herbicides for Soybeans

Amiben (chloramben) controls many annual grass and broadleaf weeds in soybeans. It does not control morningglory. Control of cocklebur and jimsonweed is erratic. Amiben occasionally injures soybeans, but damage is usually not severe. Injury appears as malformed roots and stunted plants. A six-pound-per-gallon formulation will be trial marketed in some sections of Illinois in 1974.

The recommended broadcast rate is 1½ gallons of Amiben liquid (2S) or 30 pounds of Amiben 10G per acre. The 1-gallon or 20-pound rate sometimes used on lighter soils provides significantly less weed control, but may be adequate under some situations.

If rainfall doesn't occur within three to five days, you should rotary hoe or harrow to control the small weeds.

Lorox (linuron) is best adapted to the silt loam soils of southern Illinois which contain less than 2 to 3 percent organic matter. On these soils, a rate of 1 to 1½ pounds per acre of Lorox 50W frequently controls most weeds. *The margin of selectivity between dependable weed control and crop damage is rather narrow.* Careful rate selection and accurate and uniform application will reduce the possibility of crop injury.

The rate of Lorox should be adjusted for soil texture and organic matter (see Table 47 and Lorox label). Lorox is generally not recommended alone on soils with over 4 percent organic matter.

Lorox controls a broad spectrum of weeds, but grass weeds are not usually controlled as well as broadleaf a serious annual grass problem, you should add 1½ to 2 quarts of Lasso.

If weeds are over one inch tall at spraying, the addition of 1 to 2 pints of Paraquat will improve the control of existing weeds. If weeds are over 6 inches, use the higher volumes of water suggested on the Paraquat label. Use a non-ionic surfactant such as Ortho X-77 at 8 ounces per 100 gallons of diluted spray. Fall panicum control has sometimes been erratic with Paraquat.

Additional Information

Not all herbicides and herbicide combinations available for corn and soybeans are mentioned in this publication. Some are relatively new and still being tested. Some are not considered to be very well adapted to Illinois or are not used very extensively. For information on other herbicides refer to the most recent Illinois Custom Spray Operator's Training School Manual available from Entomology Extension, Natural History Survey, Champaign, Illinois 61820.

For information on weed control in small grains, forage crops, and minor crops, refer to "Agronomy Facts" available through your county extension adviser or from the Agronomy Department, University of Illinois, Urbana, Illinois 61801. Information on control of specific weed species is available in the following publications and in Agronomy Facts.

For a list of related publications write the Office of Publications, College of Agriculture, University of Illinois, Urbana, Illinois 61801, or see your county extension adviser.

Table 49. — Relative Effectiveness of Herbicides on Major Weeds

This chart gives a general comparative rating. Under unfavorable conditions some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions control may be better than indicated. Type of soil is also a very important factor to consider when selecting herbicides. Rate of herbicide used will also influence results. G = good, F = fair or variable, and P = poor.

Control for Soybeans

	PREEMERGENCE Amiben	Lasso	Lasso + Lorox	Lorox, Maloran, Bromex	Preforan, Norex	Sencor, Lexone	Solo	Treflan, Tolban, Cobex	Vernam	POSTEMERGENCE Basagran	Tenoran, Soyex	2,4-DB
Soybean tolerance	F-G	G	F	F	F-G	F	F	F-G	F	F-G	F	F
GRASSES												
Giant foxtail	G	G	G	F-G	G	F	F	G	G	P	P	P
Green foxtail	G	G	G	F-G	G	F	F	G	G	P	P	P
Yellow foxtail	G	G	G	F-G	G	F	F	G	G	P	P	P
Barnyard grass	F-G	G	G	F-G	F	F	F	G	G	P	P	P
Crabgrass	F-G	G	G	F-G	G	F	F	G	G	P	P	P
Johnsongrass seedlings	F	P-F	P	P	P	P	P	G	G	P	P	P
Wild cane	F	P-F	P	P	P	P	P	G	G	P	P	P
Yellow nutsedge	P	F	P-F	P	P	P-F	P	P	F	F	P	P
BROADLEAVES												
Annual morningglory	P	P	P	P	P	P	F	F	F	P	F	F
Cocklebur	P-F	P	F	F	P	F	F	P	P	G	F	G
Jimsonweed	P-F	P	F	F	F	F-G	F	P	P	G	F	P
Lambsquarter	G	F	G	G	F	G	F	G	F	F	F	P
Pigweed	G	G	G	G	G	G	G	G	G	F	F	P
Ragweed, common	G	P	G	G	F	G	G	P	P	G	F	F
Smartweed	F-G	P	G	G	G	G	G	P-F	P	G	F	P
Velvetleaf	F	P	F	F-G	P	G	F	P	F	F	P	P

Control for Corn

	PREEMERGENCE AAtrex, atrazine	Bladex	Lasso	Lasso + atrazine	Princep	Ramrod	Ramrod + atrazine	Sutan	Sutan + atrazine	POSTEMERGENCE AAtrex + oil	Banvel	2,4-D	Bladex
Corn tolerance	G	G	G	G	G	G	G	F-G	F-G	F-G	G	F-G	F-G
GRASSES													
Giant foxtail	F	F-G	G	G	F	G	G	G	G	F	P	P	G
Green foxtail	G	G	G	G	G	G	G	G	G	G	P	P	G
Yellow foxtail	G	G	G	G	G	G	G	G	G	G	P	P	G
Barnyard grass	G	F-G	G	G	F	F	F	G	G	G	P	P	G
Crabgrass	P	F-G	G	G	F	G	G	G	G	P	P	P	F
Fall panicum	P	G	G	G	F	F	F	G	G	P	P	P	F
Johnsongrass seedlings	P	P	P-F	P	P	P	P	F	F	P	P	P	P
Wild cane	P	P	P-F	P	F	P	P	F	F	P	P	P	P
Yellow nutsedge	F	P	F	F	P	P-F	P-F	F	F	F	P	P	F
BROADLEAVES													
Annual morningglory	G	F	P	F-G	F-G	P	F-G	P	F-G	G	G	G	G
Cocklebur	F-G	F	P	F-G	F	P	F-G	P	F-G	G	G	G	F
Jimsonweed	G	G	P	G	G	P	G	P	G	G	G	F	G
Lambsquarter	G	G	F	G	G	F	G	P	G	G	G	G	G
Pigweed	G	F	G	G	G	G	G	G	G	G	G	G	F
Ragweed, common	G	G	P	G	G	P	G	P	G	G	G	G	G
Smartweed	G	G	P	G	G	P	G	P	G	G	G	P-F	G
Velvetleaf	F-G	F	P	F	F	P	F	F	F-G	F	F	F	F

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