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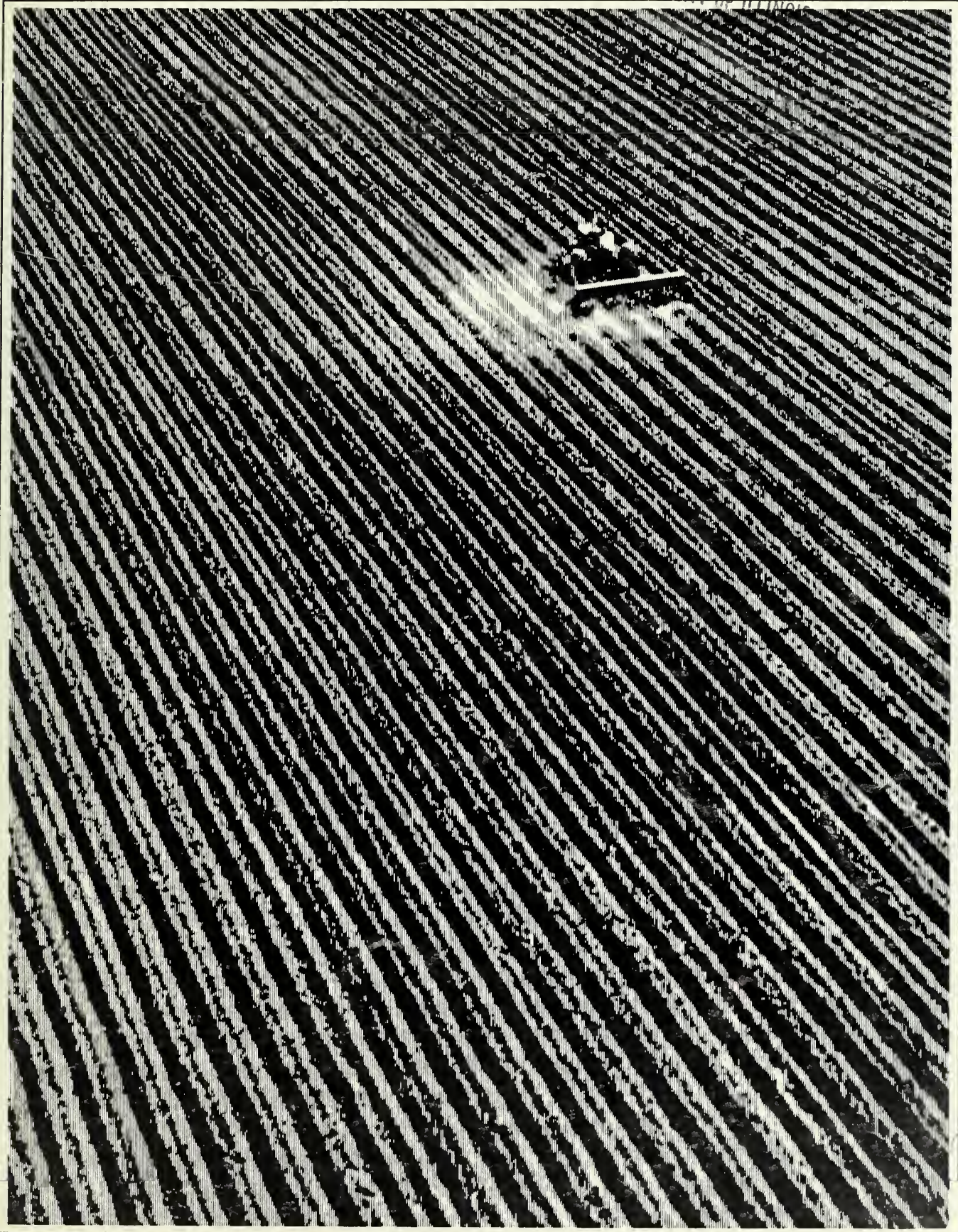
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# Illinois Agronomy Handbook



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Urbana, Illinois

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December, 1978

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# 1980 SUPPLEMENT: Illinois Agronomy Handbook

THE INFORMATION in the *Illinois Agronomy Handbook 1979-80* (Illinois Cooperative Extension Service Circular 1165, published December, 1978) is still current with a few exceptions:

1. The 1979 *Field Crops Weed Control Guide* has been superseded by the 1980 guide, which has been published separately and is available at county Extension offices or the Agricultural Publications Office, Urbana.

2. Several of the yield tables have been updated or revised. The new tables appear in this supplement with the same numbers as in the Handbook. They replace entirely the comparable old tables.

3. Descriptions of several new crop varieties are included.

## NEW VARIETIES

### Spring oats

Benson, Lancer, Marathon, and Moore were tested for the first time in Illinois in 1979. Benson and Moore are white and were developed at the University of Minnesota. Both varieties mature rather late, about the same time as do Wright and Froker. Both are resistant to smut and moderately susceptible to crown rust.

Marathon was developed at the University of Wisconsin. It is light tan and matures about as late as Dal. Marathon is a little shorter and stands better than Dal. It has good smut and crown rust resistance. Lancer was developed at South Dakota State University. It matures a day or two later than Garland. Its kernels are white and high in protein content. Lancer is moderately resistant to crown rust.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE

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Urbana, Illinois

December, 1979

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. JOHN B. CLAR, Director, Cooperative Extension Service, University of Illinois at Urbana-Champaign. The Illinois Cooperative Extension Service provides equal opportunities in programs and employment.

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## UPDATED TABLES

Table 18. — Soybean Variety Descriptions

Maturity group and variety	Relative maturity date	Lodg- ing	Plant height	Seed quality	Seeds per pound <sup>a</sup>	Seed content	
						Protein	Oil
<b>I</b>		<i>score<sup>b</sup></i>	<i>inches</i>	<i>score<sup>c</sup></i>	<i>number</i>	<i>percent</i>	<i>percent</i>
Chippewa 64.....	0 <sup>d</sup>	1.3	33	2.4	2,900	41.5	22.1
Harlon.....	0	1.3	34	1.7	2,650	38.9	22.9
Hodgson <sup>e</sup> .....	+3	1.3	33	1.6	2,700	39.2	22.7
Hark.....	+7	1.3	35	1.6	2,700	41.8	22.5
<b>II</b>							
Wells <sup>e</sup> .....	+8	1.3	39	2.1	2,850	40.7	22.6
Wells II <sup>e</sup> .....	+8	1.3	39	2.1	2,850	40.7	22.6
Corsoy.....	+8	2.3	40	1.9	2,900	40.2	22.8
Vickery.....	+8	2.4	40	2.0	2,950	40.2	22.8
Sloan.....	+8	2.2	40	2.1	2,700	39.5	23.4
Harcor.....	+9	2.4	40	2.0	2,900	40.2	22.8
Amsoy 71 <sup>e</sup> .....	+11	1.8	42	2.2	2,700	39.1	23.4
Beeson.....	+13	1.6	41	2.2	2,400	40.3	22.3
<b>III</b>							
Wayne.....	+20	2.3	43	2.4	2,700	41.8	21.8
Woodworth.....	+20	1.5	43	2.0	2,900	40.3	21.2
Calland.....	+22	2.1	43	2.9	2,600	40.1	21.4
Cumberland.....	+22	1.8	41	2.1	2,450	39.5	23.4
Oakland.....	+23	1.4	43	2.1	2,500	39.8	22.1
Elf.....	+24	1.2	23	2.0	2,700	40.6	22.0
Williams.....	+24	1.5	43	2.0	2,600	40.6	22.6
<b>IV</b>							
Bonus.....	+28	2.3	48	2.1	2,600	43.1	21.7
Union.....	+29	2.4	46	2.1	2,400	41.1	21.6
Cutler.....	+31	1.6	44	2.1	2,400	40.7	21.9
Cutler 71 <sup>e</sup> .....	+31	1.8	46	2.3	2,400	40.1	22.2
Franklin.....	+35	2.3	48	2.4	3,100	39.1	21.9
Kent.....	+37	1.9	43	2.3	2,500	39.8	22.4
Pomona.....	+37	1.9	43	2.3	2,500	40.8	21.3
Crawford <sup>e</sup> .....	+41	2.5	46	2.1	2,700	40.1	21.7

<sup>a</sup> USDA Regional Uniform Test average.

<sup>b</sup> Lodging score: 1 = erect, 5 = prostrate.

<sup>c</sup> Seed quality score: 1 = excellent, 5 = very poor (wrinkled, shriveled, green, moldy, imperfect seed coat, or other defects).

<sup>d</sup> Days to maturity following Chippewa 64.

<sup>e</sup> U.S. Protected Variety.



Table 20. — Yield Record of Wheat Varieties in University of Illinois and Southern Illinois University Tests

	DeKalb <sup>a</sup>				Urbana				Brownstown			
	1977		1977-79 Avg.		1977		1977-79 Avg.		1977		1977-79 Avg.	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
SOFT RED WINTER												
Abe <sup>b</sup> .....	66	60	67	58	87	61	81	60	57	61	55	59
Argee <sup>b</sup> .....	77	59	80	59	78	53	73	55	46	53	..	..
Arthur .....	62	61	62	59	88	61	80	60	63	62	57	60
Arthur 71 <sup>b</sup> .....	62	60	61	58	86	60	76	60	58	61	55	60
Beau <sup>b</sup> .....	63	60	61	59	92	62	80	60	55	60	53	60
Double Crop .....	53	60	54	59	84	60	71	60	61	64	51	61
Hart .....	71	59	61	57	94	61	86	59	61	62	60	59
Oasis <sup>b</sup> .....	61	61	60	59	78	60	73	59	59	61	55	59
Roland .....	75	59	67	57	92	58	83	57	54	57	56	56
Stoddard .....	65	60	64	59	79	60	73	60	61	61	54	59
Sullivan <sup>b</sup> .....	55	61	58	59	86	61	76	60	67	63	55	60
Titan <sup>b</sup> .....	..	..	..	..	80	58	..	..	60	52	..	..
HARD RED WINTER												
Bennett <sup>b</sup> .....	..	..	..	..	82	59	78	58	..	..	..	..
Centurk <sup>b</sup> .....	66	61	69	59	79	59	73	59	..	..	..	..
Centurk 78 <sup>b</sup> .....	68	61	..	..	77	60	74	60	..	..	..	..
Newton <sup>b</sup> .....	66	61	..	..	84	60	72	59	..	..	..	..
Parker .....	61	62	66	60	72	61	68	61	..	..	..	..

<sup>a</sup> Test abandoned in 1978 because of winter injury.

<sup>b</sup> U.S. Protected Variety.

Table 23. — Oat Variety Yields in University of Illinois Tests

	DeKalb <sup>a</sup>				Urbana			
	1978		Listed from earliest to latest 1976-78		1979		1977-79	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
Jaycee .....	44	27	79	31	75	35	86	34
Lang .....	60	30	92	31	95	33	101	32
Otee .....	58	28	87	31	90	36	83	34
Clintford .....	45	28	78	32	84	38	78	35
Noble <sup>b</sup> .....	53	27	85	31	92	35	89	33
Garland .....	41	26	73	29	87	34	68	32
Lancer .....	..	..	..	..	99	34	..	..
Holden .....	46	28	77	30	95	34	72	31
Benson <sup>b</sup> .....	..	..	..	..	103	33	..	..
Wright <sup>b</sup> .....	48	28	77	32	105	37	84	35
Moore <sup>b</sup> .....	..	..	..	..	112	34	..	..
Froker .....	49	27	76	29	100	35	81	32
Marathon <sup>b</sup> .....	..	..	..	..	94	32	..	..
Dal <sup>b</sup> .....	41	28	75	30	95	35	85	32

<sup>a</sup> 1979 Variety test was abandoned.

<sup>b</sup> U.S. Protected Variety.

Table 27. — Leading Alfalfa Varieties Tested  
Three Years or More in Illinois

Variety	Bacterial wilt	Percentage of yield of check varieties		
		No. Ill.	Cen. Ill.	So. Ill.
Anchor .....	R <sup>a</sup>	110	101	99
Answer .....	R	..	109	..
Apollo .....	R	105	106	101
Aquaris .....	R	102	106	104
Arc .....	MR <sup>b</sup>	103	105	102
Atlas .....	R	111	109	..
A-53 .....	MR	104	101	104
A-54 .....	R	..	108	..
Baker .....	R	96	108	99
Blazer .....	R	116	108	..
Cayuga .....	R	105	104	99
Citation .....	R	113	98	..
DeKalb Brand 120 .....	R	120	114	..
Deminor .....	R	105	102	111
Longmeiler .....	S <sup>c</sup>	97	100	106
Gladiator .....	R	101	106	..
Honeoye .....	R	106	102	103
Iroquois .....	R	106	98	100
Marathon .....	R	112	102	105
Milleaves .....	S	93	101	108
Olympic .....	R	108	110	..
Pacer .....	R	110	106	..
Peak .....	R	119	..	..
Polar I .....	R	107	104	105
Primal .....	R	110	103	..
Saranac .....	R	106	103	103
Saranac AR .....	R	108	109	105
Sunrise .....	R	102	106	..
Tempo .....	R	107	99	105
Vanguard .....	MR	107	108	100
Voris A-77 .....	R	111	109	109
Weevlchek .....	R	106	102	103
WL 215 .....	R	108	104	102
WL 219 .....	R	110	105	106
WL 311 .....	R	110	109	105
WL 318 .....	R	102	107	102
520 .....	R	108	105	..
524 .....	R	113	108	103
531 .....	R	105	107	110

<sup>a</sup> R = resistant.  
<sup>b</sup> MR = moderate resistant.  
<sup>c</sup> Susceptible.

Table 28. — Red Clover Variety Average Yields, 1976-77

Variety	Anthracnose resistance	Tons dry matter per acre		
		DeKalb	Urbana	Brownstown
Arlington .....	Northern	4.15	4.28	2.43
Clovage .....	Northern	3.36	3.70	1.97
E-688 .....	Southern	3.63	4.22	2.35
Florex .....	Northern	4.34	4.10	2.09
Florie .....	Northern, Southern	3.98	4.42	2.45
Joy .....	Northern	3.99	4.46	2.34
Kenland .....	Southern	3.32	4.26	2.32
Kenstar .....	Southern	3.60	4.32	2.08
Lakeland .....	Northern	3.81	3.88	2.15
Redland .....	Northern, Southern	3.68	4.32	2.38
Redman .....	Northern	4.29	4.23	2.18

Table 28a. — Birdsfoot Trefoil Variety Average Yields,  
1977-79

Variety	Tons dry matter per acre	
	DeKalb	Urbana
Carroll .....	3.79	3.69
Dawn .....	3.74	3.63
Empire .....	3.58	3.10
Leo .....	4.27	3.84
Mackinaw .....	3.69	3.57
Maitland .....	3.93	3.63
Viking .....	3.97	3.52

# CORN

## Hybrid Selection

When selecting a hybrid for your farm, you should know the hybrid's characteristics, several of which contribute to the amount of corn you will have after harvest is completed.

First, you will want a hybrid that makes use of most of the growing season. The later-maturing hybrids usually outyield the earlier hybrids. On the other hand, trying to grow corn that is too late for your area will not pay. You will want your latest hybrid to reach physiological maturity (30 to 35 percent kernel moisture) by at least two weeks before the average date of the first killing freeze (32°F.) in your community. When corn reaches this stage, the "black layer," an abscission layer near the tip of the kernel, has formed and the corn has reached its maximum yield because there can be no more dry matter translocated into the kernel. At this stage all that stands between you and harvest is the loss of some water from the kernels. How rapidly this occurs depends to some degree on the hybrid but mostly on the weather. Warm temperatures, low humidity, and good air movement favor rapid loss. Before the first freeze the rule of thumb for loss of moisture is about one-half percent per day. After the arrival of cool weather this rule does not hold.

Other characteristics that may make a hybrid desirable or undesirable for your conditions include tolerance to stress, disease resistance, lodging resistance, and whether it tends to drop its ears.

Information concerning hybrids is available from several sources. For instance, the Department of Agronomy conducts hybrid tests each year at eleven locations in the state. The results of these tests are published annually in an Illinois Cooperative Extension Service circular entitled *Performance of Commercial Corn Hybrids in Illinois*. The eleven locations represent the major soil and climatic areas of Illinois. More than 500 hybrids are normally included in the tests. Other sources of information include the results of your own tests and those conducted by seed corn companies, neighbors, county extension personnel, or vocational agriculture classes.

Some of these tests will be "strip tests" — just one strip of each hybrid in the test. You should not base your decision on the results of just one strip test; the difference between two hybrids may be because of their location in the field rather than because of an actual superiority of one over the other.

Look at the results of as many tests as possible before making a decision on a hybrid. Good performance for more than one year is an important criterion of a good hybrid. If a hybrid performs well over a period of years, it probably tolerates stress.

It is a good idea to plant hybrids that will mature at more than one time. This will stretch the work load in the fall and serve as a hedge against drought at pollination time.

Comparing hybrids with respect to maturity is sometimes difficult. Physiological maturity is reached when the maximum amount of dry matter has been accumulated in the kernels. Corn usually is considered mature when the kernel moisture is 30 to 35 percent. Therefore, grain moisture at harvest time as reported in *Performance of Commercial Corn Hybrids in Illinois* can help you determine the relative maturity of different hybrids.

Also, seed companies provide information regarding maturity of the hybrids they sell. However, some companies label their hybrids using a number-of-days-to-maturity system; others indicate maturity in terms of growing degree units or days; still others use both systems. To calculate growing degree units or days per day, add the maximum temperature and the minimum temperature, divide that sum by 2, then subtract 50. If the maximum temperature is higher than 86°F., substitute 86° for the actual temperature. If the minimum temperature is below 50°F., use 50° as the minimum. According to this system, corn should be mature when the total number of growing degree units accumulated after planting equals the number of growing degree units specified by the seed company as necessary for the hybrid to reach maturity.

A quick and easy way to identify physiological maturity is to look at the black layer, which can be seen by splitting the kernel from top to bottom or by removing the tip that was attached to the cob. When using the black layer as an indication of physiological maturity, look for it in the kernels in the middle of the ear. The layer forms first in the kernels at the tip of the ear and last in the kernels at the butt of the ear.

## Planting Date

Your goal in planting corn should be to have all or most of the crop planted by the date beyond which decreased yields will normally result if planting is delayed. This date is often called the "optimum date." The optimum date for planting is earlier in southern Illinois than in central or northern Illinois and probably ranges from late April in southern Illinois to as late as May 10 in northern Illinois.

In order to reach this goal, you may need to start planting — weather and soil conditions permitting — at least two weeks before the average date of the last killing frost in your area. There are relatively few days in April and early May when weather and soil conditions favor field operations (Table 1). Corn that is planted two or three weeks before the optimum date may not yield as much as that planted on or near the optimum date; however, it normally will yield considerably more than that planted two weeks or more after the optimum date (Table 2).

Some possible hazards associated with early planting include: (1) germination and emergence are delayed because of a cool, wet soil; (2) weeds may be more of a

**Table 1. — Days Available and Percent of Calendar Days Available for Field Operations in Illinois<sup>a</sup>**

Period	Northern Illinois		Central Illinois		Southern Illinois	
	Days	Pct.	Days	Pct.	Days	Pct.
April 1-20 <sup>b</sup> .....	5.8	(29)	4.2	(21)	2.6	(13)
April 21-30 <sup>c</sup> .....	3.5	(35)	3.1	(31)	2.6	(26)
May 1-10 <sup>c</sup> .....	5.8	(58)	4.3	(43)	3.5	(35)
May 11-20 <sup>c</sup> .....	5.5	(55)	5.0	(50)	4.4	(44)
May 21-30 <sup>c</sup> .....	7.4	(74)	5.8	(58)	5.4	(54)
May 31-June 9 <sup>c</sup> ...	6.0	(60)	5.4	(54)	5.6	(56)
June 10-19 <sup>c</sup> .....	6.0	(60)	5.4	(54)	5.8	(58)

<sup>a</sup> Summary prepared by R. A. Hinton, Department of Agricultural Economics of the University of Illinois Cooperative Crop Reporting Service, unpublished official estimates of Favorable Work Day, 1955-1975. The summary is the mean of favorable days omitting Sundays, less one standard error, representing the days available 5 years out of 6.

<sup>b</sup> 20 days.  
<sup>c</sup> 10 days.

**Table 2. — Effect of Planting Date on Yield<sup>a</sup>**

	Northern Illinois	Central Illinois	Southern Illinois
Late April.....		156	102
Early May.....	151	162	105
Mid May.....	150		82
Early June.....	100	133	58

<sup>a</sup> 3-year average at each location.

problem when emergence is slow; (3) insects and diseases have a longer period in which to attack and destroy the seed or seedling; and (4) the danger of loss of stand due to frost is greater. Modern seed treatment and herbicides and pesticides have greatly reduced the first three hazards, and frost injury usually is minimal unless the frost is followed by an extended period of poor growing weather.

The effect of frost usually is small because frost kills only a few leaves on the young corn plants. Those leaves, though the upper ones at the time of the frost, would have become the lower leaves on fully grown plants; they were destined to become ineffective as soon as they were shaded by leaves further up the stalk. In fact, most of those leaves break off before the plant is full grown. In addition, the growing point of corn is seldom killed by frost because it is below ground level until the plant is about knee high or has six fully expanded leaves. Researchers at the Michigan Agricultural Experiment Station have started planting corn about April 15 for more than fifteen consecutive years. The corn often has frosted once and sometimes it has frosted twice, but there has been little effect on yield.

We recognize that there is some risk with early planting, but we feel that the advantages far outweigh the risks.

The advantages of early planting include (1) higher yield, (2) drier corn in the fall, (3) more control of your planting date, and (4) greater choice of hybrids of differing maturity. If replanting becomes necessary, the decision often can be made early enough to allow the use of your first-choice hybrid.

The lowest temperature at which corn will germinate is about 50°F. Therefore, planting may begin when the soil temperature at planting depth is 50°F. or higher. The five-day weather forecast also should be favorable. You probably will need to determine soil temperature on your own because soil temperatures reported by weather bureaus usually are taken under sod. The mid-day temperature at 2 to 4 inches under sod often is 8 to 12 degrees lower than it is under bare ground.

The following guides may be helpful:

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

2. Plant when the temperature at 1 p.m. reaches 55°F. at the 4-inch level. The 4-inch level is suggested for the 1 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 1, plant if the soil is dry enough even if the soil temperature is below the suggested guidelines. Perhaps a simple way to say it is plant according to soil temperature early in the season, later on plant by the calendar.

Some areas, such as river bottoms and low-lying flatlands, tend to warm up slowly and are subject to late freezes. These areas should be the last to be planted.

When planting in April, plant the full-season hybrids first and be sure of your weed control program. You also may consider increasing your planting rate 1,000 to 2,000 kernels per acre because the early planted corn is normally shorter and is less likely to be under moisture stress when pollinating.

## Planting Depth

Ideal planting depth varies with soil and weather conditions. Emergence will be more rapid from relatively shallow-planted corn; therefore, early planting should not be as deep as later planting. An ideal depth for normal conditions is about 2 inches. Early planted corn should not be any deeper than that; up to ½ inch shallower is preferred. Later in the season when temperatures are higher and evaporation is greater, planting 1 inch deeper to reach moist soil may be advantageous.

Depth-of-planting studies show that not only do fewer plants emerge when planted deep, but also that those that do emerge often take longer to reach the pollinating stage and may have higher moisture in the fall.

## Plant Population

Your goal at planting time is the highest population per acre that can be supported with normal rainfall without excessive lodging, barren plants, or pollination problems. How do you know when you have found the ideal or optimum population for a particular field? Check the field after the crop is mature for average ear weight.

**Table 3. — Effect of Crowding on Corn Yield, Urbana**

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

**Table 4. — Effect of Row Width on Corn Yield, Urbana**

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

**Table 5. — Planting Rate That Allows for a 15 Percent Loss From Planting to Harvest**

Plants per acre at harvest	Seeds per acre at planting time
16,000	18,800
18,000	21,200
20,000	23,500
22,000	25,900
24,000	28,200
26,000	30,600
28,000	33,000
30,000	35,300

Most studies in Illinois show that there is a very close relationship between half-pound ears and optimum population. A half-pound ear should shell out 0.4 of a pound of grain at 15.5 percent moisture. The optimum population for a particular field is influenced by several factors, some of which you can control and some over which you have little or no control. Concentrate on those factors that you can control. For instance, there is little that you can do to affect the amount of water available to the crop during the growing season. This variable is determined by the soil type and the total amount and distribution of the rainfall between the time the crop is planted and when it is mature. But there is much that you can do about how efficiently this water is used. The more efficient its use, the higher the population that can be supported with the water that is available. Remember that ear number is generally more important than ear size, and that the most practical way to increase ear number with today's hybrids is through population control.

Two very important factors influencing the efficiency of water use that you can control are soil fertility and weeds. Keep the fertility level of your soil high and the weed population low.

Other factors that are important include:

**1. Hybrid selection.** Hybrids differ in their tolerance to the stress of high populations (Table 3).

**2. Planting late.** Early planting enables the plant to produce more of its vegetative growth during the long days of summer and to finish pollinating before the normal hot, dry weather in late July and early August.

**3. Row width** (Table 4).

**4. Insect and disease control.**

The harvest population is always less than the number of seeds planted. Insects, diseases, adverse soil conditions, and other hazards take their toll. You can expect from 10 to 20 percent less plants at harvest than seeds planted (Table 5).

## White Corn

Most of the white corn grown in the United States is used to make corn flakes and cornmeal. It often sells at a higher price than yellow corn, sometimes as much as 1½ to 2 times the price of yellow corn.

The cultural practices for producing white corn are the same as those for yellow corn except that there are relatively few white hybrids available in maturities adapted to Illinois. Choice of hybrid is therefore important. In addition, kernels developed from ovaries pollinated by pollen from yellow hybrids will be light yellow. These yellowish kernels are undesirable. The official standards for corn specify that white corn not contain more than 2 percent of corn of other colors. Therefore, white corn probably should not be planted on land that produced yellow corn the year before. It also may be desirable to harvest the outside ten or twelve rows separate from the rest of the field. Most of the pollen from adjacent yellow corn will be trapped in those outer rows.

## High-Lysine Corn

Lysine is one of the amino acids essential to animal life. Livestock producers need not be concerned whether the protein ruminant animals eat contains this amino acid because the microflora in rumen can synthesize lysine from lysine-deficient protein. Nonruminants cannot do this, however, 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 called 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 substantially less soybean meal was required when high lysine corn was fed to swine.

Agronomic research with high-lysine corn indicates that it is slightly lower in yield and higher in moisture than its normal counterpart. Furthermore, the kernel is softer and more susceptible to damage. Current research with more sophisticated hybrids, however, indicates that the differentials in yield may be overcome; continued work probably will solve the other problems.

The Opaque 2 gene is recessive: high-lysine corn pollinated by normal pollen produces normal low-lysine grain. Although isolation from normal corn is not essential, regular hybrids, for example, should not be strip planted in high-lysine corn, nor should high-lysine be planted in a field where volunteering normal corn is expected to be high.

Lysine content may be reported as percent of dry weight or on a No. 2 yellow corn basis. No. 2 yellow corn may contain up to 15.5 percent moisture; thus it is 84.5 percent dry weight. Lysine content reported as percent of dry weight only thus is 15.5 percent higher than the same lysine content reported on a No. 2 yellow corn basis. To convert from a dry matter basis to percent of No. 2 yellow corn, multiply by 84.5 percent.

With the aid of county agricultural extension advisers, 136 high-lysine samples were obtained from 35 Illinois counties during the 1973-74 winter. The percent of lysine, percent of total protein, and percent of contamination from normal corn were determined on a dry-matter basis for each sample. The samples ranged from a low of 0.29 percent lysine to a high of 0.54 percent lysine. The average lysine content of all 136 samples was 0.37 percent. Seventy-seven percent of the variation in lysine content could be accounted for by variation in total protein content and the amount of contamination from normal corn. The sample with the lowest lysine content also had the lowest protein content (7.3 percent). The sample with the highest lysine content had the highest protein content (12.2 percent).

### Other Types of Corn

**Liguleless or upright-leaved corn.** Development and research indicate that these types are more tolerant of high populations. One form of the upright leaf angle is controlled by a gene known as liguleless, thus the term liguleless corn.

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

Until recently, yields were disappointing for varieties

with higher oil content than normal dent corn. However, recent research involving new gene pools of high-oil material unrelated to the original Illinois High Oil indicates that varieties containing 7 to 8 percent oil may be produced with little or no sacrifice in yield. Experimental higher oil hybrids will probably be marketed soon on a limited scale.

Since oil is higher in energy per pound than starch, a livestock ration containing high-oil corn should have some advantage over one containing normal corn. Feeding trials involving high-oil corn have generally confirmed this assumption. The corn-milling industry's 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. 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 the 75 percent typical for ordinary dent hybrids. Amylopectin starch is used in many food and industrial products.

Our chief source of amylopectin starch prior to World War II was tapioca imported from eastern Asia. The Japanese occupation of what was then the Dutch East Indies essentially cut off our supply of tapioca. 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 waxy characteristic is controlled by a recessive gene. Therefore, waxy corn pollinated by pollen from normal corn will develop into normal dent corn. Waxy corn, like high-lysine corn, should not be planted in fields where dent corn is likely to volunteer. The outside six to ten rows also may need to be kept segregated from the rest of the field to keep the amount of contamination from normal corn to an acceptable level.

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

The amylose starch content also 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.

## PLANT VARIETY PROTECTION ACT

Congress passed the Plant Variety Protection Act in 1970. This law provides the inventor or owner of a new variety of certain seed-propagated crops the right to exclude others from selling, offering for sale, reproducing, exporting, or using the variety to produce a hybrid, different variety, or blend.

These rights are not automatic. The owner must apply for a certificate of protection. If the owner does not choose to protect the variety, it is public property and anyone may legally reproduce it and sell seed of it.

Essentially all varieties of the self-pollinated crops commonly grown in Illinois—such as soybeans and wheat—developed by private industry since 1970 are protected varieties. Many of the varieties developed at state experiment stations also are protected under the act.

The law allows you, if you desire, to save your own production of a protected variety for seed. However, it does place certain restrictions on the sale of seed of a protected variety.

Under one provision of the act, the owner may stipulate that the variety be sold by variety name only as a class of certified seed. Seed of varieties protected under this provision of the act cannot be sold by variety name

unless it is produced according to the standards and procedures of one of the official seed certification agencies in the United States. In Illinois, this is the Illinois Crop Improvement Association. The sale of uncertified seed of varieties protected in this manner also is a violation of the Federal Seed Act.

If the owner of a protected variety does not subscribe to the certified seed provision of the act, a farmer whose primary occupation is producing food or feed may sell seed of the protected variety to another farmer whose primary occupation is producing crops for food or feed. However, the second farmer may not sell as seed any of the crop that he produces.

Even if the protected variety is not covered by the certified seed provision of the act, anything advertising the sale of seed of that variety—including farm sale bills—usually is considered an infringement of the owner's rights. Therefore, any person desiring to sell seed of a protected variety must first obtain permission from the owner of the variety.

The container in which seed of a protected variety is sold should carry a label identifying the seed as that of a protected variety.

## 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 compared with the penalty for planting corn late. Therefore, the practice of planting soybeans after the corn acreage has been planted is accepted and wise.

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 (Tables 6 and 7).

Table 6. — Yields of Soybeans Planted on Four Dates, Urbana

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

Table 7. — Yields of Soybeans Planted on Four Dates, Carbondale

Variety	Date of planting			
	May 3	May 17	June 7	July 1
	<i>Bushels per acre</i>			
Corsoy.....	27	38	43	28
Cutler.....	62	46	54	27
Dare.....	72	45	37	32

Table 8. — Days to Maturity for Three Planting Dates, Columbia, Missouri (Six-Year Average)

Variety	Date of planting		
	May 1	June 1	June 12
	<i>Days to maturity</i>		
Hawkeye.....	122	104	98
Clark.....	149	115	105

Table 9. — Days to Maturity for Four Planting Dates, Carbondale

Variety	Date of planting			
	May 3	May 17	June 7	July 1
	<i>Days to maturity</i>			
Corsoy.....	118	103	107	101
Wayne.....	131	117	117	105
Cutler.....	145	133	117	108
Dare.....	159	153	138	122

**Effect on maturity.** The vegetative stage (planting to the beginning of flowering) is 45 to 60 days for full-season varieties planted at the normal time. This period is shortened as planting is delayed and may be only 25 to 26 days when these varieties are planted in late June or early July.

Soybeans are photoperiod responsive and the length of the night or dark period is the main factor in determining when flowering begins. The vegetative period also is influenced by temperatures — high temperatures shorten and low temperatures lengthen it — but the main effect remains that of the length of the dark period.

The length of the flowering period and that of pod filling also are shortened as planting is delayed. However, the effect of planting time on these periods is minor compared to that on the vegetative period.

As the length of the vegetative period grows shorter, the number of days it takes soybean plants to mature becomes fewer (Tables 8 and 9).

### 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.

### Planting Depth

Emergence will be more rapid and stands will be more uniform if soybeans are planted only 1½ to 2 inches deep. Deeper planting often results in disappointing stands.

Varieties differ in their ability to emerge when planted more than 2 inches deep, as the following table shows. Therefore, special attention should be given to planting depth of these varieties.

	<i>Planting depth (in.)</i>	<i>Percent emergence</i>
Beeson.....	2	71
	4	39
Hawkeye.....	2	80
	4	60

### Row Width

If weeds are controlled, soybeans will yield more in narrow rows than in the traditional 38- to 40-inch rows (Table 10).

Since late-planted soybeans normally are not as tall as those planted in early May, the advantage of using narrow rows increases as planting is delayed past early June. Double-crop soybeans planted after the small-grain harvest should be planted in rows at least as narrow as 20 inches (Table 11).



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

Variety	40 inches	30 inches	20 inches	10 inches
	<i>Bushels per acre</i>			
Wayne.....	47.0	51.2	52.4	53.6
Harosoy.....	38.8	42.0	45.0	48.0

Table 11. — Yield of Double-Crop Soybeans When Planted in 20- and 30-Inch Rows in 1972

	20-inch rows	30-inch rows
	<i>Bushels per acre</i>	
Dixon Springs.....	53	43
Brownstown.....	37	32
Urbana.....	33	24

Table 12. — Ability of Soybeans To Compensate for Loss of Stand, Urbana

Treatment, 20-foot rows	Percent of original stand	Yield (Bu./A.)
Six plants per foot of row.....	100	50
Three plants per foot of row.....	50	50
Three 40-inch gaps.....	50	41
Five 24-inch gaps.....	50	44
Four plants per foot of row.....	66	51
Two 40-inch gaps.....	66	43
Five 16-inch gaps.....	66	47
Five plants per foot of row.....	80	50
Two 24-inch gaps.....	80	47
Five 9.6-inch gaps.....	80	47

For many years some Illinois farmers have planted their soybeans with a small grain drill. Interest in this method is increasing, primarily because of the availability of herbicides that greatly reduce the probability of the need to cultivate. If weeds can be kept under control, the small grain drill is a practical narrow-row planting machine for soybeans. Research results do not always show an advantage for 7- or 8-inch rows over 15- or 20-inch rows, but the drilled beans usually yield 10 to 20 percent more than those planted in 40-inch rows. The key to the success of planting soybeans with a grain drill is good weed control. However, depth of planting is more difficult to control and you may wish to try the method on a relatively small acreage first.

See Illinois Cooperative Extension Service Circular 1161, *Narrow-Row Soybeans: What to Consider*.

### When To Replant

An experiment at Urbana in 1969 demonstrated the ability of soybeans to compensate for loss of stand. The soybeans were planted in 30-inch rows at a rate of six plants per foot of row. They were thinned when in the second-leaf stage to stands of 50, 66, and 80 percent of the original stand. 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 40-inch gaps

a 20-foot row equal 50 percent of the original stand. The results of this experiment are shown in Table 12 and may be valuable when the question of whether to replant must be answered.

### Double Cropping

See Illinois Cooperative Extension Service Circular 1106, *Double Cropping in Illinois*.

### Seed Source

In order to ensure 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 diseased and damaged kernels.

Samples of soybean seed taken from the planter box as farmers were planting showed that homegrown seed was inferior to seed from other sources (Tables 13 and 14). The number of seeds that germinate and the pure seed content of homegrown seeds were lower. Weed seed content, percent inert material (hulls, straw, dirt, and stones), and presence of other crop seeds (particularly corn) in homegrown seed were higher.

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

This evidence indicates the Illinois farmer could improve the potential of his soybean production by using higher quality seed. Homegrown 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

Table 13. — Uncertified Soybean Seed Analysis by Seed Source

	Germination	Pure seed	Weed seed	Inert matter	Other crops
	<i>Percent</i>				
Homegrown.....	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 14. — Certified and Uncertified Soybean Seed Analysis

	Sam- ples	Germination	Pure seed	Weed seed	Inert matter	Other crops
	<i>Percent</i>					
Uncertified.....	363	80.2	95.5	.02	2.6	2.0
Certified.....	56	84.2	98.7	.001	1.2	.2

nonprofit 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 higher quality seed than others. It pays to read the tag.

## Varieties

Soybean varieties are divided into maturity groups according to their relative time of maturity (Table 15). Varieties of Maturity Group I are nearly full season in northern Illinois but are 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 resists Phytophthora root rot. Chippewa and Chippewa 64 account for about two-thirds of the soybean acreage in Wisconsin and Minnesota. Grow them only in northern Illinois and only when you want earliness; 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 and slightly less lodging resistant. Rampage is susceptible to Phytophthora root rot but resistant to shattering.

**Hark** is a variety adapted to northern Illinois. It has yielded as well there as most Group II varieties, but not as well as Amsoy and Corsoy. 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 (yellowing of leaves) when planted on soils of high pH (7 or higher).

**Harlon** was developed at the Harrow Research Station in Ontario, Canada, and released in 1976. It matures 4 days earlier than Hodgson and is about 1 inch taller than Hark. It is equal to Hark in lodging resistance and is resistant to Phytophthora rot.

**Hodgson** was released by the University of Minnesota and the USDA in 1974. It matures 4 days earlier than Hark and is about 2 inches shorter. Hodgson is similar to Hark in lodging resistance and is susceptible to Phytophthora rot.

### Maturity Group II

**Harosoy** and **Harosoy 63** are similar except that Harosoy 63 is resistant to Phytophthora root rot. This can be of great importance on low ground or in wet springs when Phytophthora can kill or cause severe stunting of susceptible Harosoy. Harosoys were the top-yielding varieties in northern Illinois before the release of Corsoy. Continue to use Harosoy 63 on land subject to flooding or where Phytophthora root rot is a problem, since Corsoy is very susceptible. Both varieties have a ten-

dency to shatter when conditions are overly dry at harvest time.

**Wells** was developed at Purdue University and released in 1973. It is similar to Corsoy in plant height and seed size but matures 1 to 2 days earlier. Wells is superior to Amsoy 71, Beeson, and Corsoy in lodging resistance. It is resistant to Phytophthora root rot and frogeye leaf spot race 2.

**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 matures 1 to 3 days earlier. Corsoy is slightly less resistant to lodging than Amsoy. Corsoy and Amsoy should replace the older Group II varieties except where Phytophthora root rot is present.

**Amsoy** is a high-yielding variety, second only to Corsoy among the Group II varieties, and is very popular. 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 that of 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.

**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 that of Amsoy or Corsoy. It is similar in height to Corsoy and 1 to 3 inches shorter than Amsoy. It has a spreading leaf canopy.

**Harcor**, developed at the Harrow Research Station in Ontario, Canada, was released in 1976. It is comparable to Corsoy in height and lodging resistance and matures 1 to 2 days later. It is resistant to Phytophthora rot.

**Wells II** has a maturity identical to that of Wells. The main advantage of Wells II is its resistance to five additional races of Phytophthora. Like Wells, it has very good yield and excellent lodging resistance. Seed will be available for planting in 1980.

**Vickery** was released by Iowa in 1978. It matures one day before Corsoy but lodges slightly worse. Vickery has resistance to races 1, 2, 3, 5, 6, 7, 8, and 9 of Phytophthora. Yields have been slightly better for Vickery than for Corsoy. Plant height is very similar to that of Corsoy, which was used as a parental line in its development.

**Sloan** was released by Iowa in 1978. It has a maturity of 2 to 3 days after Amsoy 71. Plant height is slightly less than that of Corsoy or Amsoy 71. Lodging tends to be equal to that of Corsoy, but yields have not been affected by this trait. Generally Sloan has yielded better than Cor-

Table 15. — Characteristics and Parentage of Soybean Varieties

Maturity group and variety	Parentage and year released <sup>a</sup>	Flower color	Pubescence color	Pod color	Seed luster	Hilum color <sup>b</sup>
<b>I</b>						
Chippewa 64.....	Chippewa <sup>8</sup> X Blackhawk (1964)	purple	brown	brown	shiny	black
Rampage.....	Clark X Chippewa	purple	brown	brown	shiny	black
Hark.....	Hawkeye X Harosoy (1966)	purple	gray	brown	dull	yellow
Harlon.....	Blackhawk X Harosoy 63 (1976)	white	gray	brown	dull	yellow
Hodgson <sup>c</sup> .....	Corsoy X M372 (1974)	purple	gray	brown	dull	buff
<b>II</b>						
Harosoy 63.....	Harosoy <sup>8</sup> X Blackhawk (1963)	purple	gray	brown	dull	yellow
Corsoy.....	Harosoy X Capital (1967)	purple	gray	brown	dull	yellow
Amsoy.....	Adams X Harosoy (1965)	purple	gray	tan	shiny	yellow
Amsoy 71 <sup>c</sup> .....	Amsoy <sup>8</sup> X C1253 (Blackhawk X Harosoy) (1971)	purple	gray	tan	shiny	yellow
Hawkeye 63.....	Hawkeye <sup>7</sup> X Blackhawk (1963)	purple	gray	brown	dull	imp. black
Beeson.....	(Blackhawk X Harosoy) X Kent (1968)	purple	gray	brown	shiny	imp. black
Wells <sup>c</sup> .....	(Harosoy X C1079) X C1253 (1973)	purple	gray	brown	dull	imp. black
Wells II <sup>c</sup> .....	Wells X Mack (1979)	purple	gray	brown	dull	imp. black
Harcor.....	Corsoy X 0X383 (1976)	purple	gray	brown	shiny	yellow
Sloan.....	M59-120 X IVR Ex4731 (1978)	white	tawny	brown	shiny	brown
Vickery.....	Corsoy X Mack XL65-1342 or Anoka (1978)	purple	gray	brown	dull	yellow
Marion <sup>c</sup> .....	Amsoy X [Provar X (Magna X Disoy)] (1976)	purple	gray	tan	shiny	buff
<b>III</b>						
Wayne.....	(Lincoln, Richland, CNS) X Clark (1964)	white	brown	brown	shiny	black
Calland.....	(Blackhawk X Harosoy) X Kent (1968)	purple	brown	brown	dull	black
Williams.....	Wayne X L57-0034 (1972)	white	brown	tan	shiny	black
Woodworth.....	Wayne X L57-0034 (1975)	white	tawny	tan	dull	black
Cumberland.....	Corsoy X Williams (1978)	purple	gray	brown	shiny	imp. black
Oakland.....	L66L-137 X Calland (1978)	purple	tawny	brown	dull	black
Elf.....	Williams X Ransom dt <sub>1</sub> (1978)	purple	tawny	tan	shiny	black
<b>IV</b>						
Columbus.....	C1069 (Lincoln X Ogden) X Clark	purple	brown	brown	shiny	black
Bonus <sup>c</sup> .....	C1266R X C1253 (1972)	purple	gray	brown	dull	imp. black
Clark 63.....	(Clark <sup>7</sup> X CNS) X (Clark <sup>8</sup> X Blackhawk) (1963)	purple	brown	brown	dull	black
Cutler 71 <sup>c</sup> .....	Cutler <sup>4</sup> X Kent — Rpo rpx — 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	intermediate	black
Pomona.....	C1266 X C1265 (1975)	purple	tawny	brown	dull	black
Union.....	Williams X SL11 (Wayne RpmRps) (1977)	white	tawny	tan	shiny	black
Franklin.....	L12 X Custer (1978)	purple	gray	brown	dull	imp. black
Crawford <sup>c</sup> .....	Williams X Columbus (1978)	purple	tawny	brown	shiny	black
Miles.....	Clark X D64-4731 (1978)	purple	tawny	tan	dull	black
<b>V</b>						
Dare.....	Hill X Roanoke X Ogden (1965)	white	gray	tan	shiny	buff
Essex.....	Lee X 55-7075 (1973)	purple	gray	brown		buff
Forrest <sup>c</sup> .....	Dyer X Bragg (1973)	white	brown		shiny	black
Oksoy.....	Scott <sup>6</sup> X Blackhawk (1971)	purple	gray			buff
York.....	Dorman X Hood (1967)	purple	gray	tan	shiny	buff
Bedford.....	Forrest (2) X (D68-18 X PI88788) (1978)	white	tawny	tan	shiny	black
<b>VI</b>						
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
Centennial <sup>c</sup> .....	D64-4636 X tawny pubescence. Pickett 71 type (1978)	purple	tawny	tan		black

<sup>a</sup> Superscript indicates the number of crosses in a backcrossing program. <sup>b</sup> imp. = imperfect. <sup>c</sup> U.S. Protected Variety.

soy and Amsoy 71. Because it is susceptible to *Phytophthora* this variety may not be adapted to low or poorly drained soils.

#### 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 or higher). It is susceptible to pod and stem blight, so at times it will have poor seed quality. Its advantages are resistance to bacterial pustule and high yields. Wayne is classed as susceptible to *Phytophthora* root rot but appears to have some tolerance to this disease.

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.

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

Table 16. — Soybean Yields, 1976-78 Average, Bushels per Acre

Variety	DeKalb <sup>a</sup>	Urbana <sup>a</sup>	Girard	Brownstown	Belleville	Eldorado
Hark.....	41	..	..	..	..	..
Wells <sup>b</sup> .....	39	..	..	..	..	..
Corsoy.....	48	51	42	..	..	..
Harcor.....	46	52	41	..	..	..
Amsoy 71 <sup>b</sup> .....	44	47	42	..	..	..
Beeson.....	41	47	38	..	..	..
Woodworth.....	43	47	46	33	51	42
Cumberland.....	..	46	46	36	52	46
Oakland.....	..	47	46	36	49	44
Williams.....	..	49	47	36	48	47
Elf.....	..	50	44	31	51	48
Union.....	..	..	..	37	51	47

<sup>a</sup> Average of 1976 and 1978 only.  
<sup>b</sup> U.S. Protected Variety.

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.

Woodworth is a selection from the same cross as Williams. It was released by the USDA and the University of Illinois in 1975. It is similar to Williams in height, lodging resistance, and seed quality but matures 3 to 4 days earlier. It is classed as susceptible to *Phytophthora* rot but appears to have some tolerance to the disease. Woodworth is resistant to bacterial pustule and superior to Wayne and Calland in shattering resistance.

Cumberland was released by Iowa with Illinois participating. This new variety was selected from the cross of Corsoy and Williams. Maturity of Cumberland is about 2 days before Williams, but yields have been better than those of Williams. Plant size is similar to both Woodworth and Williams with lodging to a degree similar to Williams. Cumberland is susceptible to *Phytophthora*.

Oakland is a 1978 Iowa release in which Illinois is participating. It has resistance to *Phytophthora* root rot. It is similar in size to Williams but matures about 2½ days earlier. Lodging of Oakland is less than Williams but Oakland generally will yield no better.

Elf is a considerably shorter soybean than most others available. It matures the same time as Williams but may be only half as tall, greatly reducing its lodging tendency. The small canopy of Elf makes it adapted to narrow rows. Production in rows wider than 30 inches will result in relatively poor performance because of its inability to fill in row middles with its smaller canopy. The determinate growth habit of Elf also contrasts with the indeterminate growth habit of virtually all other Group III varieties. Combined with environmental stress early in the growing season, the determinate growth of Elf will result in an even more compact short plant. Such a plant tends to be less productive and more difficult to harvest. Therefore, an environment conducive to high yields in which Elf can be seeded in narrow rows

will be where maximum yields would be expected from this variety.

#### Maturity Group IV

Pomona was developed at Kansas State University and released in 1975. It is similar to Kent in maturity, lodging resistance, and height. Pomona is superior to Kent and Bonus in resistance to shattering. It is susceptible to *Phytophthora* rot.

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 that of 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 but susceptible to frogeye leaf spot, bacterial pustule, and downy mildew. It tends to shatter more than Cutler 71. Bonus is similar to other varieties in oil content but is 1 to 2 percent higher in protein content.

Clark and Clark 63 are similar except that 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 in that area *Phytophthora* root rot can cause severe damage. Neither disease will develop on Clark 63, so this is the preferred variety. The high yield and excellent lodging resistance of these two varieties make them the leading varieties in southern Illinois.

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 per acre more than Clark 63 and 1 bushel per acre more than Kent. Cutler is 2 to 3 days later maturing than Clark 63 and 5 days earlier than Kent.

Cutler 71, developed at Purdue University, is similar to Cutler except that it is resistant to *Phytophthora*.

Kent is a late-maturing 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.

**Columbus** was developed at Kansas State University and released to certified seed growers in 1971. It matures about 4 days later than Kent and 7 to 9 days later than Cutler 71. It is similar to Cutler 71 in plant height and lodging resistance. Unlike most Group IV varieties, Columbus has the determinate type of growth.

**Union** has resistance to Phytophthora and downy mildew. It is also resistant to bacterial pustule. Union matures about 2 days earlier than Cutler 71. Union is comparable to Cutler 71 in plant height and lodging resistance. Seed quality is better than for Cutler 71 but not quite equal to that of Williams.

**Franklin** is an Illinois and Missouri developed variety released in 1978. Resistance to race 3 of soybean cyst nematode and good yields are outstanding features of this

new variety. Maturity of Franklin is very similar to Custer, a variety which Franklin will likely replace. Lodging and seed shattering of Franklin is less than that of Custer too. Yields of Franklin have consistently been better than those of Custer, which also has resistance to race 3 of the cyst nematode.

**Crawford** was developed from the cross Williams X Columbus and released in 1978. Maturity is later than Cutler 71 and Kent, but earlier than Columbus. The chief advantage of Crawford is that it yields more than other varieties of similar maturity. Lodging and plant height of Crawford are greater than Cutler 71 or Kent.

#### Maturity Group V

**York** was released in 1967. It is similar to Dare in maturity and plant height but is superior to Dare in lodging resistance. It is moderately resistant to Phytophthora rot and susceptible to the soybean cyst nematode.

**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

Table 17. — Disease Resistance of Soybean Varieties

Maturity group and variety	Phytophthora root rot	Bacterial pustule	Bacterial blight	Downy mildew	Frogeye leaf spot race 2
<b>I</b>					
Chippewa 64.....	++	-	+	-	-
Rampage.....	--	-	-	-	-
Hark.....	--	-	-	-	-
Harlon.....	++	-	-	-	--
Hodgson <sup>a</sup> .....	--	-	-	-	--
<b>II</b>					
Wells <sup>a</sup> .....	++	-	-	+	+
Wells II <sup>a</sup> .....	++	-	-	+	+
Corsoy.....	--	-	-	+	-
Amsoy.....	--	-	-	+	-
Amsoy 71 <sup>a</sup> .....	++	-	-	+	-
Beeson.....	++	-	-	+	+
Harcor.....	++	-	-	-	--
Sloan.....	-	-	-	+	++
Vickery.....	++	-	-	+	--
<b>III</b>					
Wayne.....	+	++	-	--	+
Calland.....	++	-	-	+	-
Williams.....	+	++	-	--	-
Woodworth.....	+	++	-	--	-
Cumberland.....	-	-	-	+	-
Oakland.....	+	-	-	+	-
Elf.....	-	-	-	+	++
<b>IV</b>					
Bonus.....	++	-	-	--	--
Clark 63.....	++	++	-	--	-
Cutler.....	+	-	-	-	+
Cutler 71 <sup>a</sup> .....	++	-	-	-	++
Kent.....	-	-	-	+	++
Columbus.....	-	-	-	-	-
Pomona.....	--	--	-	-	++
Union.....	+	+	-	+	-
Franklin.....	+	+	-	-	-
<b>V</b>					
Dare.....	+	++	-	+	-
Forrest <sup>a</sup> .....	++	++	-	+	-
Mack.....	++	++	-	+	-
Essex.....	++	++	-	+	-
York.....	+	-	-	-	-
Bedford.....	+	++	-	-	-

++ = resistant; + = slightly susceptible; - = susceptible; -- = very susceptible.  
<sup>a</sup> U.S. Protected Variety.

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 yielded more than 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.

Essex was developed at the Virginia Agricultural Experiment Station. It matures about 2 days earlier than Dare, grows about 4 to 6 inches shorter, and is more resistant to lodging. It is resistant to bacterial pustule, several races of downy mildew, and frogeye leaf spot and moderately resistant to *Phytophthora* rot. It is susceptible to the soybean cyst nematode.

Forrest was developed at the Delta Branch Agricultural Experiment Station, Mississippi. It is similar to Dare in maturity. It is resistant to races 1 and 3 of the soybean cyst nematode, bacterial pustule, wild fire, and target spot and moderately resistant to *Phytophthora* rot. It has excellent resistance to shattering.

Bedford was jointly developed by Mississippi and Tennessee and released in 1978. The major advantage of Bedford is its resistance to races 3 and 4 of the soybean cyst nematode. Where race 4 of the cyst nematode is a problem Bedford will be useful by replacing Forrest which is susceptible to the pest. When race 4 is not a problem, Bedford and Forrest have similar yields. Heavy

seeding rates for Bedford cannot be used because of severe lodging tendencies of the variety.

#### Private Varieties and Blends

So many private soybean varieties now are available that they no longer will be listed in this book.

More than 200 different varieties, blends, and experimental strains were entered in the 1978 Commercial Soybean Performance Tests. The results of these annual tests are published soon after January 1 of each year. The publication can be obtained at your county extension office or from the College of Agriculture Office of Publications. The tests are conducted at seven locations. Data collected for each entry include yield, moisture content at harvest, resistance to lodging, maturity date, and average height.

Several of the entries in the test are blends. They are identified as such at the front of the publication. A blend is a mixture of the seed of two or more varieties and is sold as "soybeans, variety not stated." Blends usually are identified by a brand, such as "John Doe 200 Brand." Most blends are reconstituted with the same varieties in the same proportions each year; however, neither the Illinois nor the Federal Seed Law requires this. Thus, you have only the assurance of your seed dealer that the brand or blend has been reconstituted with the same proportions of the same varieties.

Table 18. — Soybean Variety Descriptions

Maturity group and variety	Relative maturity date	Lodg- ing	Plant height	Seed quality	Seeds per pound <sup>a</sup>	Seed content	
						Protein	Oil
I		<i>score<sup>b</sup></i>	<i>inches</i>	<i>score<sup>c</sup></i>	<i>number</i>	<i>percent</i>	<i>percent</i>
Chippewa 64.....	0 <sup>d</sup>	1.3	33	2.4	2,900	41.5	22.1
Harlon.....	0	1.3	34	1.7	2,650	38.9	22.9
Hodgson <sup>e</sup> .....	+3	1.3	33	1.6	2,700	39.2	22.7
Hark.....	+7	1.3	35	1.6	2,700	41.8	22.5
II							
Wells <sup>e</sup> .....	+8	1.3	39	2.1	2,850	40.7	22.6
Wells II <sup>e</sup> .....	+8	1.3	39	2.1	2,850	40.7	22.6
Corsoy.....	+8	2.3	40	1.9	2,900	40.2	22.8
Vickery.....	+8	2.4	40	2.0	2,950	40.2	22.8
Sloan.....	+8	2.2	40	2.1	2,700	39.5	23.4
Amsoy 71 <sup>e</sup> .....	+11	1.8	42	2.2	2,700	39.1	23.4
Beeson.....	+13	1.6	41	2.2	2,400	40.3	22.3
Harcor.....	+19	2.4	40	2.0		40.2	22.8
III							
Wayne.....	+20	2.3	43	2.4	2,700	41.8	21.8
Woodworth.....	+20	1.5	43	2.0	2,900	40.3	21.2
Calland.....	+22	2.1	43	2.9	2,600	40.1	21.4
Cumberland.....	+22	1.8	41	2.1	2,450	39.5	23.4
Oakland.....	+23	1.4	43	2.1	2,500	39.8	22.1
Elf.....	+24	1.2	23	2.0	2,700	40.6	22.0
Williams.....	+24	1.5	43	2.0	2,600	40.6	22.6
IV							
Bonus.....	+28	2.3	48	2.1	2,600	43.1	21.7
Union.....	+29	2.4	46	2.1	2,400	41.1	21.6
Cutler.....	+31	1.6	44	2.1	2,400	40.7	21.9
Cutler 71 <sup>e</sup> .....	+31	1.8	46	2.3	2,400	40.1	22.2
Franklin.....	+35	2.3	48	2.4	3,100	39.1	21.9
Kent.....	+37	1.9	43	2.3	2,500	39.8	22.4
Pomona.....	+37	1.9	43	2.3	2,500	40.8	21.3
Crawford <sup>e</sup> .....	+41	2.5	46	2.1	2,700	40.1	21.7

<sup>a</sup> USDA Regional Uniform Test average.

<sup>b</sup> Lodging score: 1 = erect, 5 = prostrate.

<sup>c</sup> Seed quality score: 1 = excellent, 5 = very poor (wrinkled, shriveled, green, moldy, imperfect seed coat, or other defects).

<sup>d</sup> Days to maturity following Chippewa 64.

<sup>e</sup> U.S. Protected Variety.

# WHEAT

## Time of Seeding

See Table 19 for the average date of seeding wheat for highest yields. Wheat planted much earlier is subject to attack by Hessian fly unless the variety is resistant to this insect. In addition, disease infection in the fall will be reduced. Healthy non-diseased plants are more winter hardy and more vigorous the following spring.

Early planted wheat is more likely to be infected by several diseases. For instance, Septoria leaf spot is favored by the rank fall growth that is usually associated with early planting. The barley yellow dwarf (BYD)

**Table 19. — 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-	
Cass	Sept. 30-Oct. 2	Putnam	Sept. 23-26
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

virus is transmitted by an aphid. Since the aphids are killed by freezing temperatures, wheat planted shortly before the first killing freeze is likely to escape being injected with the disease in the fall. The effects of spring infection by BYD are usually much less severe than those of fall infection.

## Seed Treatment

Treating wheat seeds with the proper fungicide or mixture of fungicides is a cheap way to help insure improved stands and better grain quality. In addition, the yield from treated seed usually will be higher than that from untreated seed.

The Department of Plant Pathology suggests several fungicides for treating seeds, including captan, maneb, HBC, thiram, and Vitavax. Vitavax controls loose smut in wheat and barley and should be used if this disease was present in the field where the seed was produced. Since Vitavax is not effective on some of the other seed-borne diseases that cause seedling blight (such as Septoria), another fungicide should be used along with Vitavax. Should you desire additional information concerning wheat diseases or seed treatment methods and materials, contact the University of Illinois Department of Plant Pathology or your county extension adviser.

## Rate of Seeding

Rate-of-seeding trials involving several different wheat varieties have been conducted in Illinois. The results of these trials indicate that 1½ bushels (90 pounds) of good seed per acre 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 semidwarf 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 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 (in.)	Two-year average yield (bu./A.)
8	37.8
16	31.6
24	27.2

Table 20. — Yield Record of Wheat Varieties in University of Illinois and Southern Illinois University Tests

Variety	DeKalb†				Urbana				Brownstown				Dixon Springs			
	1977		1976-77		1978		1977-78		1978		1977-78		1978		1977-78	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
<b>SOFT RED WINTER</b>																
Abe*	68	56	66	58	75	59	79	60	55	58	54	58	35	59	45	60
Argee*	83	58			68	54	70	55								
Arthur	62	56	63	58	75	60	75	60	52	58	53	59	36	60	47	60
Arthur 71*	61	56	61	58	66	60	71	60	52	58	54	59	32	59	45	60
Beau*	58	57			73	60	74	60	50	60	51	60	34	59	44	60
Blueboy II*													36	55	49	56
Double Crop	55	57			67	61	65	60	44	60	46	60	25	59	37	59
Hart	51	55	62	57	78	59	81	59	63	58	60	58	36	59	50	59
Oasis*	60	56	61	58	68	57	71	58	54	58	52	59				
Roland	59	55			75	55	79	56	54	56	57	55	37	58		
Stoddard	63	57	61	58	70	58	71	59	43	57	50	58	37	59	44	60
Sullivan*	61	57			69	60	71	60	54	58	50	58				
<b>HARD RED WINTER</b>																
Centurk*	71	56	71	58	66	59	70	59								
Newton					61	57										
Parker	71	59	67	60	64	61	68	61								

† Test abandoned in 1978 because of winter injury.  
\* U.S. Protected Variety.

## Varieties

### Hard Red Winter

**Centurk** is a bearded white-chaff variety that 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 centennial of the introduction of Turkey wheat into the United States in 1873-74. Centurk matures 1 to 2 days later than Parker and is not as resistant to lodging. It possesses good rust resistance and has yielded better in Illinois than other hard wheats. Centurk is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Gage**, a bearded white-chaff variety, was released by Nebraska in 1963. It is similar to Centurk in maturity and straw strength, and has improved resistance to rust and soil-borne mosaic. Gage has performed well in Illinois trials.

**Parker** is a bearded white-chaff variety released in Kansas in 1966. It matures earlier than Gage or Pawnee but slightly later than Triumph 64. Parker has shorter straw than other hard wheat varieties grown in Illinois. Its straw strength is excellent. Although resistant to leaf rust and races A and B of Hessian fly, Parker 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 64** is a bearded white-chaff wheat developed in Oklahoma. It matures 2 to 3 days earlier than Parker and is not as resistant to lodging. It is susceptible to mosaic, leaf and stem rust, and bunt; however, it has a good test weight and yield record in Illinois.

**Homestead** is bearded and has white chaff. It was developed at the University of Nebraska and released in 1972. Homestead is similar to Parker in maturity. It is 4

to 5 inches shorter than Parker. Straw strength is similar to Parker. Homestead is resistant to soil-borne mosaic and stem rust but susceptible to leaf rust. Homestead is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Sentinel** is a bearded white-chaff variety developed at the University of Nebraska and released in 1973. Sentinel is about one day later than Homestead and grows slightly taller. It tends to lodge slightly more than Homestead. Sentinel is resistant to stem rust, but susceptible to leaf rust and Hessian fly, and moderately susceptible to soil-borne mosaic. Sentinel is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Trison** is a bearded white-chaff variety developed at Kansas State University. It matures 2 to 3 days earlier than Parker. It is similar in plant height, but slightly more susceptible to lodging. Trison is resistant to bunt, but susceptible to the rusts, soil-borne mosaic, and Hessian fly.

### Soft Red Winter

**Abe** is a beardless white-chaff 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. Abe is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Arthur** is a beardless white-chaff variety released in 1967 by the Purdue Agricultural Experiment Station and the USDA. It has been a high-yielding variety in Illinois tests with excellent test weight. As winter hardy as Monon, it is 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 similar to Arthur except that it is resistant to races A and B of the Hessian fly and is more resistant to leaf rust. Arthur 71 is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Argee** was released in 1976 by the University of Wisconsin. It is a bearded white-chaff variety. Argee is 2 to 4 inches taller than Abe, less lodging resistant, and matures 6 to 8 days later. It is resistant to leaf rust, stem rust, and loose smut. Argee is protected under the Plant Variety Protection Act and may be sold only as a class of certified seed.

**Beau** is a beardless white-chaff variety developed at Purdue University and released in 1976. It is similar to Abe in maturity, grows about 2 inches shorter in height, and is slightly more resistant to lodging. Beau is resistant to Hessian fly and soil-borne mosaic, and has some resistance to Septoria and powdery mildew. Beau is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Blueboy II** is a beardless white-chaff variety developed at North Carolina State University. It is less winter hardy than Arthur 71 and Abe. Blueboy II matures 6 to 8 days later than Abe. Although resistant to soil-borne mosaic and moderately resistant to downy mildew, it is susceptible to Hessian fly. This variety is 2 to 3 pounds lower in test weight than Abe. Blueboy II is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Double Crop** is a beardless white-chaff variety selected out of Arthur at the University of Arkansas. It matures 2 to 4 days earlier than Arthur and is slightly shorter in height. Double Crop has good lodging resistance, but tends to shatter.

**Hart**, a bearded white-chaff variety, was released jointly by the University of Missouri and Pennsylvania State University. It matures 2 to 3 days later than Abe, grows to about the same height, and is slightly more lodging resistant. It has some tolerance to Septoria, loose smut, barley yellow dwarf, and the rusts.

**Oasis** is a beardless white-chaff variety developed by Purdue University and released in 1973. It is similar to Arthur 71 in maturity, plant height, and lodging resistance. Oasis is resistant to leaf rust, powdery mildew, loose smut, Hessian fly, and soil-borne mosaic. It has good resistance to Septoria leaf spot, but is susceptible to stem rust. Oasis is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Roland**, beardless and white chaffed, was developed at the University of Illinois and released in 1977. Roland matures about 2 days later than Abe, grows 2 to 4 inches shorter in height, and is more resistant to lodging. The test weight of Roland will average one or two pounds less than Abe. It is moderately resistant to the barley yellow dwarf disease.

**Ruler** is a beardless white-chaff variety developed at Ohio State University and released in 1974. It matures 4 to 5 days later than Arthur and grows about 2 inches taller. It is resistant to Hessian fly, moderately resistant to soil-borne mosaic, and susceptible to the rusts and powdery mildew. Ruler is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Stoddard**, beardless and white chaffed, was developed at the University of Missouri and released in 1973. Stoddard is about 2 days later than Arthur in maturity and 3 to 4 inches taller. It is comparable to Arthur in lodging resistance. Stoddard has good resistance to leaf rust, is moderately susceptible to soil-borne mosaic, and is susceptible to stem rust, Hessian fly, and Septoria.

**Sullivan**, released in 1977, is a beardless white-chaff variety developed at Purdue University. It matures 1 to 2 days earlier than Abe, is slightly taller, and is similar in lodging resistance and test weight. Sullivan is resistant to Hessian fly, and the common races of leaf rust, powdery mildew, Septoria, loose smut, and some races of stem rust. It is the first variety of soft red winter wheat to have moderate resistance to the take-all-root rot disease that has been a problem in some wheat fields in recent years. Sullivan is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

Table 21. — 1978 Soft Wheat Variety Demonstration Yields

Location	Abe*		Arthur		Arthur 71*		Beau*		Blueboy 11*		Double Crop		Hart		Oasis*		Roland		Sullivan*	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
Ewing Dem Center. . . . .	56.8	61	43.8	61	55.1	61	56.7	59	55.1	56	32.3	61	48.1	60	49.8	61	59.4	59	57.7	61
Gallatin Co. . . . .	61.6	60	61.1	59.5	62.6	59	60.4	57	66.1	49	62	60.5	58.0	59	57.6	59.5	68	54	64.7	59.5
Jackson Co. . . . .			37	57			33.4	55.5	43.6	53	40.1	59	35.7	54	33.5	55	46.4	54	35.8	55.5
Macoupin Co. . . . .	60.6	56	53.9	57	55.1	56	63.1	58	53	54	55.6	58	63.1	56	60.5	57	58.9	52	60.1	56
Monroe. . . . .	50.6	56	51.9	54	50.5	54	47.6	55	43.4	54	41.9	56	55.2	56	49.7	55	47.2	54	62.6	56
Richland. . . . .	67	60	58.2	61	57.5	60	61.9	61	58.2	57	58	60	56.4	58	59.9	59.5	65.2	57.5	61	61
Shelby. . . . .	43.3	57			45.3	57	37.2	57					34.7	56	39.6	57	42.7	54	37.1	59
St. Clair. . . . .	62	60	63.4	61	65.8	61	63.8	60	82.7	58	27.9	58	70.5	60	55.5	60	69.5	59	54.5	60
Washington. . . . .	77.3		76.2		73		86.9		77.3		64.9		87.4		73.5		84.7		76.7	
White Co. #1. . . . .	66.9	60	63.7	60	57.8	60	51	61	77.5	56	60.6	61	71.7	60	71.3	60	75.6	59	69.4	61
#2. . . . .	35.4	59	42.3	61	48.6	59	44	59	58.8	55	39.8	59	57.7	60	45.7	60	59.2	60	44	61
One of 8 locations. . . . .	57.6	59	54.8	59	56.6	58.7	56	58.7	61.8	54.8	47.3	59.2	60.1	58.6	56.25	59	62.9	56.8	59.2	59.4

\* U.S. Protected Variety.

Table 22. — Hard Red Spring Wheat Performance, DeKalb

Variety <sup>a</sup>	1978		1976-78	
	Bu./A.	T.W.	Bu./A.	T.W.
Ellar . . . . .	31	58	42	58
Eureka . . . . .	34	52		
Selkirk . . . . .	37	58	42	57
Tioga . . . . .	38	58	44	59
Olaf . . . . .	30	55	42	57
Era . . . . .	33	56	44	57
Fletcher . . . . .	32	56	39	56

<sup>a</sup> Listed with earliest at top and latest at bottom of table.

*Hard Red Spring*

**Olaf** is an awned, semidwarf variety of medium maturity with good lodging resistance. It is resistant to stem and leaf rust, but susceptible to loose smut. Test weight is medium.

**Era** is an awned, midseason to late semidwarf with good lodging resistance. It is resistant to stem and leaf rust, and tolerant to Septoria, bunt, loose smut, and ergot. Test weight is high.

**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 not well adapted to Illinois and are usually deficient in some characteristic such as winter hardiness, seed set, or seed quality. 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 at Urbana and in DeKalb County indicates that the crop is generally lower yielding than winter wheat and spring oats. Both spring and winter types of triticale are available.

## OATS

### Spring 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 compared with broadcasting. The normal seeding rate when planted by drilling is 2 to 2½ bushels per acre. The seed should be treated with a fungicide before planting.

### Varieties

**Chief**, released by the South Dakota Agricultural Station in 1972, 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 similar in lodging resistance and kernel weight. It is resistant to leaf rust.

**Clintford** was developed at Purdue from the cross of 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.

**Dal**, released by the Wisconsin Agricultural Experiment Station in 1972, is similar to Froker in height and maturity. It is resistant to the rusts and smut. Straw strength is about equal to that of Froker. Dal kernels, which have a whitish color, contain about 2.5 percent more protein than other commonly grown varieties. Dal is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**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 that of Portal but has 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.

**Goodland**, released by Wisconsin in 1974, is similar to Garland in maturity. It grows to about the same height

as Otter and has excellent resistance to lodging. Goodland is moderately resistant to stem rust, resistant to leaf rust, and susceptible to barley yellow dwarf. Like Dal and Otee, it has high protein content. Protected under the Plant Variety Protection Act, Goodland can be sold only as a class of certified seed.

**Grundy**, a yellow oat variety released by the Iowa Agricultural Experiment Station in 1972, is similar to Jaycee in maturity, lodging resistance, and plant height. Although resistant to some, but not all, races of leaf rust, it is susceptible to stem rust and barley yellow dwarf virus. Protected under the Plant Variety Protection Act, Grundy can be sold only as a class of certified seed.

**Holden** was released by the Wisconsin Agricultural Experiment Station in 1967. The variety matures slightly later than Garland. It has yielded 5 to 8 percent more per acre than Garland in northern Illinois, but slightly less than 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 that of Garland. Holden is resistant to older races of leaf rust and moderately 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 and is similar to Newton in groat percentage and test weight. 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 as possible after maturity in order to avoid high field losses. It has barley 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.

**Lang** is a yellow oat released by the University of Illinois and the USDA in 1977. It matures about one day earlier than Otee and is similar in height. Lang is resistant to the barley yellow dwarf disease, but susceptible to smut and the rusts. Since it has a beard that is difficult to thresh, Lang often produces a slightly lower weight per bushel than Otee.

**Noble** was released to certified seed producers for planting in 1974. It was developed by the Purdue University Agricultural Experiment Station and the Agriculture Research Service, USDA. Noble is an improved Tippecanoe type. It is resistant to races of loose smut currently prevalent in Illinois and is moderately resistant to barley yellow dwarf. It has limited resistance to the rusts, being susceptible to current predominant races. Performance tests have shown it to have excellent yielding ability, resistance to lodging, and good test weight. Protected under the Plant Variety Protection Act, Noble can be sold only as a class of certified seed.

Table 23. — Oat Variety Yields in University of Illinois Tests

	DeKalb				Urbana			
	1978		1976-78		1978		1976-78	
	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
	Listed from earliest to latest							
Jaycee	44	27	79	31	99.0	31.0	93.0	32.0
Lang	60	30	92	31	87.0	29.0	102.9	31.0
Otee	58	28	87	31	68.0	31.0	83.0	33.0
Clintford	45	28	78	32	54.0	31.0	75.0	33.0
Noble*	53	27	85	31	84.0	30.0	81.0	31.0
Garland	41	26	73	29	50.0	28.0	53.0	30.0
Holden	46	28	77	30	48.0	28.0	55.0	29.0
Wright*	48	28	77	32	65.0	32.0	74.0	34.0
Froker	49	27	76	29	51.0	28.0	63.3	30.0
Dal*	41	28	75	30	52.0	28.0	76.0	30.0

\* U.S. Protected Variety.

Otee is a variety developed in Illinois and released jointly by the Illinois Agricultural Experiment Station and the USDA for planting by certified seed producers in 1973. The grain color is yellow. Otee is the result of a cross of Albion X Newton 2 X Minhafer 3 X Jaycee. The final selection was made in the fifth generation following the final cross. Yields have been similar to the Jaycee variety in Illinois. The grain of Otee is higher in percent protein than other varieties currently grown in Illinois. Otee is early in maturity and has short straw and good lodging resistance. It is definitely superior to Jaycee in after-ripening standability. Otee is resistant to many of the races of leaf and stem rust and has good resistance to barley yellow dwarf disease.

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. Its test weight has been slightly below that of most varieties, but the groat percentage has been high.

Wright is a yellow oat released in 1975 by the University of Wisconsin. It matures one day earlier than Dal and is about 2 to 3 inches taller. Wright is not quite as resistant to lodging as Dal. It is resistant to crown rust and moderately resistant to stem rust. The protein content is average. Wright is protected under the Plant

Variety Protection Act and can be sold only as a class of certified seed.

### Winter Oats

Winter oats are not as winter hardy as wheat and are adapted to only the southern third or 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 similar to that for spring oats. Seeding rate is 2 to 3 bushels per acre when drilled.

Norline, Compact, and Walker are sufficiently winter hardy to survive most winters in the southern third of the state.

Norline was released by Purdue University in 1960. It tends to lodge more than Walker and Compact. Compact was released by the University of Kentucky in 1968. It is short and more lodging resistant than Norline. Walker was released by the University of Kentucky in 1970. It is more lodging resistant than Norline and Compact but grows a little taller than those varieties.

## GRAIN SORGHUM

While grain sorghum can be grown successfully throughout Illinois, its greatest potential is in the southern third of the state. It is adapted to almost all soils, from sand to heavy clay. Its greatest advantage over corn is tolerance of moisture extremes. Grain sorghum usually yields more than corn when moisture is a problem, though it seldom yields as much as corn under optimum conditions.

**Fertilization.** Nutrient requirements for sorghum are similar to those of corn. Since the response to nitrogen has been erratic, maximum rate of nitrogen suggested is about 125 pounds. Sorghum is sensitive to salt, and seeds should not be placed in direct contact with starter fertilizer.

**Planting.** Sorghum should not be planted until soil temperature is 65°F. or above. In the southern half of the state mid-May is considered the starting date; late May to June 1 is the planting date in the northern half.

Sorghum emerges more slowly than corn and requires a relatively fine and firm seedbed. Planting depth should not exceed 1½ inches, and ¾ to 1 inch is considered best.

**Population and row spacing.** Row spacing experiments have shown that 20- to 30-inch rows produce far better than 40-inch rows. Narrow rows are suggested if

weeds can be controlled without mechanical cultivation. Four to 6 plants per foot of row in 30-inch rows at harvest and 2 to 4 plants per foot in 20-inch rows are adequate. Plant 30 to 50 percent more seeds per foot of row than the intended stand.

**Weed control.** Since emergence of sorghum is slow, controlling weeds presents special problems. Suggestions for chemical control of weeds are given in the back of this handbook. As with corn, a rotary hoe is useful before weeds become permanently established.

**Harvesting and storage.** Timely harvest is important. Rainy weather after sorghum grain reaches physiological maturity may cause sprouting in the head or weathering (soft and mealy grain), or both.

**Marketing.** Before planting, check on local markets. Because of limited acreage in Illinois, many elevators do not purchase grain sorghum.

**Grazing.** After harvest, sorghum stubble can be used for pasture. Livestock should not be allowed to graze for one week after frost, since the danger of prussic acid or hydrocyanic acid (HCN) poisoning is especially high. Newly frosted plants sometimes develop tillers high in prussic acid.

## BARLEY

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

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

### Spring Barley

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

#### Varieties

Except for Burk, all varieties included in Tables 24 and 25 are approved for malting.

Burk is a six-row, smooth-awn variety developed at the University of Wisconsin. It is a nonmalting variety and is used only for feed.

**Table 24. — Spring Barley Performance, DeKalb**

Variety <sup>a</sup>	1978		1977-78	
	Bu./A.	T.W.	Bu./A.	T.W.
Beacon.....	58	45	65	45
Larker.....	50	49	57	48
Conquest.....	56	45	65	46
Manker.....	58	47	64	47
Burk.....	58	49	69	49
Morex.....	51	45		
Bonanza.....	57	45	67	46
Karl.....	55	45	65	45

<sup>a</sup> Listed with earliest at top and latest at bottom of table.

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

### Winter Barley

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

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

#### Varieties

Paoli is a new six-row winter barley from Purdue University. It is early maturing, very winter hardy, short, and stiff strawed. It has short rough awns that are persistent, making it 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. Paoli is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

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. It has rough awns.

Pike was released by Purdue University in 1975. It is short and matures about three days before Barsoy and Paoli. Pike is similar to Paoli in height and lodging resistance. It has rough awns. Pike is protected under the Plant Variety Protection Act and can be sold only as a class of certified seed.

**Table 25. — Winter Barley Performance**

Variety <sup>a</sup>	Brownstown			Urbana				
	1978		Pct. winter survival	1977-78		Pct. winter survival		
	Bu./A.	T.W.		Bu./A.	T.W.			
						1978 <sup>b</sup>	1976-77	
						Pct. winter survival	Bu./A.	T.W.
Pike <sup>c</sup> .....	42	48	75	58	46	4	86	49
Barsoy.....	14	49	5	50	48	0	75	47
Paoli <sup>c</sup> .....	56	51	98	56	44	78	91	45
Perry.....	67	53	83	64	46	25	84	48
Harrison.....	53	51	80	54	45	3	83	47
Maury.....	54	47	50	66	43	42	100	45
Monroe.....	33	47	33	54	42	2	81	45
Schuyler.....	77	49	90	63	42	58	96	41

<sup>a</sup> Listed with earliest at top and latest at bottom of table.

<sup>b</sup> 1978 test was not harvested.

<sup>c</sup> U.S. Protected Variety.

## 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 (1) is it too late to replant with corn or soybeans? (2) if it is not too late, how early a variety should be used? and (3) 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) rainfall and temperatures will favor normal growth and development, and (3) 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.

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 third), you can move the planting date proportionally later into June because temperatures will be higher during the remainder of the growing season.

In central Illinois, where the average killing frost occurs on October 15, early varieties of corn planted as late as July 5 have a 50-percent chance of maturing before frost. In southern Illinois, corn planted later in July usually will mature. However, planting later than July 5 to 10 is of questionable merit unless the need for grain or silage is especially great.

When corn planting is delayed past June 1 to 10, consider soybeans or sorghum as alternatives. These crops usually yield better than late-planted corn.

The vegetative period of soybeans is shortened as planting is delayed. Thus, soybeans can 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 end of June. The later varieties, such as Harcor and Corsoy, may be used until the middle of June.

In north central Illinois, you can plant Harcor and Corsoy until early July and you can use varieties of the maturity of Beeson until mid-June. In central Illinois, Wayne and varieties of similar maturity will mature when planted by mid-June. Use Amsoy 71, Corsoy, and Harcor 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 with low podding. Dry weather aggravates this problem.

Other grain crops that mature in a short time and can 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 as 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 before planting. Some elevators prefer not to handle sorghum. Local livestock feeders or feed mills may be interested in the crop. Drying the grain is another problem often associated with sorghum. 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.

## HAY, PASTURE, SILAGE, AND SEED POLLINATION

### 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 in the seeding year, 10 plants per square foot the second year, and 5 plants per square foot for succeeding years.

Vigorous stands are created and maintained by choosing disease- and insect-resistant varieties that grow and recover quickly after harvest, fertilizing adequately, harvesting at the optimum time, and protecting the stand from insects.

### Establishment

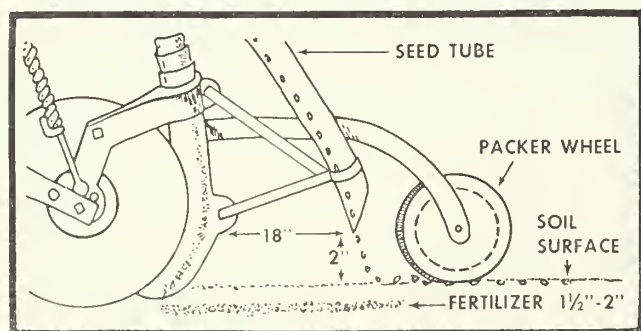
Spring seeding date for hay and pasture species in Illinois is late March or early April as soon as a seedbed can be prepared. An exception is when seedings are made in a fall-seeded winter annual companion crop. In winter annual companion crops, hay and pasture species should be seeded about the time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

Spring seedings in spring 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 quarter of Illinois.

Late-summer seeding date is August 10 in the northern quarter 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 33 on page 27. These rates are for average conditions and when seeded with a companion crop in the spring or without a companion crop in late summer.



Placement of high-phosphate fertilizer with grain drill. (Fig. 1)

Table 26. — Seeding Method of Alfalfa in Illinois

Years	Bands <sup>a</sup>	Broadcast <sup>a</sup>
	Average tons dry matter per acre per year	Average tons dry matter per acre per year
1959, Urbana .....	6.44	5.73
1967-70, Urbana .....	5.38	5.56
1967-70, DeKalb .....	4.57	4.48
1967-68, Brownstown .....	3.11	2.92

<sup>a</sup> Seeding rate of 12 pounds per acre.

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 33 have proven economical in northern and central Illinois when alfalfa was seeded as a pure stand in early spring and two or three harvests in the seeding year were taken. Seeding alfalfa at 18 pounds per acre has produced 0.2 to 0.4 ton higher yield than seeding at 12 pounds per acre in northern and central Illinois, but not in south-central Illinois.

The two basic methods of seeding are band seeding and broadcast seeding. Band seeding is placing a band of phosphate fertilizer (0-45-0) about two inches deep in the soil with a grain drill, then placing the forage seed on the soil surface directly above the fertilizer band. The fertilizer should be covered with soil before the forage seeds are dropped. This process occurs naturally when soils are in good working condition. A press-wheel should roll over the forage seed to firm the seed into the soil surface. Many seeds will be placed one-fourth to one-half inch deep with this seeding method (Fig. 1).

Broadcast seeding is spreading the seed uniformly over the prepared soil surface, then pressing the seed into the soil surface with a corrugated roller. The fertilizer is applied at the early stages of seedbed preparation. The seedbed is usually disked and smoothed with a harrow. Most soil conditions are too loose after these tillage operations and should be firmed with a corrugated roller before seeding. The best seeding tool for broadcast seeding is the double corrugated roller-seeder.

Which is the better seeding method? Illinois studies have shown that band seeding resulted in higher alfalfa yields than broadcast seedings for August and spring seedings at most locations (Table 26). Seedings on a low phosphorus-supplying soil had a higher yield from band seeding than broadcast seeding (Brownstown). Early seeding on a cold, wet soil was favored by banded phosphorus fertilization (DeKalb). The greater yield from band seeding may be a response to abundant, readily available phosphorus from the banded fertilizer. Broadcast seedings were higher yielding at Urbana in one trial, probably because the silt loam soils were medium in phosphorus-supplying capacity and are better drained and warmer than the silty clay loam at the DeKalb field.



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. The double corrugated roller-seeder and the band seeder with press wheels roll the seed into contact with the soil and are the best known methods of seeding forages.

## Fertilizing and Liming Before or at Seeding

**Lime.** Apply lime at rates suggested in Figure 5, page 31. 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 should be applied for legume seedings on 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. In the seedings of a pure grass stand, 50 to 100 pounds nitrogen 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 (Tables 46 and 48) 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.

**Potassium.** Fertilize before or at seeding. Broadcast application of potassium is preferred (Tables 44 and 45). 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 600 pounds of  $K_2O$  per acre in the seedbed without damaging seedlings if the fertilizer is incorporated.

## Fertilization

**Nitrogen.** See pages 37 and 38.

**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 and nutrient content of the forage harvested (Table 48). Grasses, legumes, and grass-legume mixtures contain about 12 pounds of  $P_2O_5$  (4.8 pounds of P) per ton of dry matter. Total annual fertilization needs include any needed build-up rate (Table 46) and the maintenance rate (Table 48).

**Potassium.** Grasses need large amounts of potassium to balance high rates of nitrogen fertilization, since potassium helps the plant convert nitrogen to protein. As

nitrogen rates are increased, the percent nitrogen in the plant tissue also increases. However, if potassium is deficient, some nitrogen may remain in the plant as non-protein nitrogen.

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

Annual potassium needs are determined from yield, nutrient content in the forage that is harvested, and nutrient build-up requirements of a particular soil (Tables 47 and 48). Grasses, legumes, and grass-legume mixtures contain about 50 pounds of  $K_2O$  (41.5 pounds of K) per ton of dry matter.

**Boron.** Symptoms of boron deficiency appear on second and third cuttings of alfalfa during drought 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 that there is a boron deficiency, topdress strip in your alfalfa fields with 30 pounds per acre of household borax (3.3 pounds of actual boron). For general application, have boron added to the phosphorus-potassium fertilizer.

## Management

**Seeding year.** Hay crops and pastures spring-seeded 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 and occasionally two harvests 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 very likely will need to be controlled about 30 days after seeding unless a preemergence herbicide was used. A postemergence herbicide, 2,4-DB, is effective against most broadleaf 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 harvesting 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.

Table 27. — Leading Alfalfa Varieties Tested Three Years or More in Illinois

	Bacterial wilt	Percentage of yield of check varieties		
		No. Ill.	Cen. Ill.	So. Ill.
Agate.....	R <sup>a</sup>	99	102	
Anchor.....	R	110	101	99
Apalachee.....	S <sup>b</sup>			105
Apollo.....	R	102	105	99
Arc.....	MR <sup>c</sup>	103	105	102
Atlas.....	R	111	108	
A-53.....	MR	104	101	104
Baker.....	R		110	
Cayuga.....	R	105	104	99
Citation.....	R	113	98	
Dominor.....	R	105	102	111
Gladiator.....	R		106	
Honeoye.....	R	104	99	104
Iroquois.....	R	105	97	101
Marathon.....	R	112	102	105
Maris Phoenix.....	R	104	98	
Olympic.....	R	107	109	
Pacer.....	R	109	106	
Polar I.....	R	105	104	105
Riley.....	R		104	
Saranac.....	R	106	103	104
Saranac AR.....	R	106	105	103
Tempo.....	R	107	99	104
Thor.....	R	108	100	102
Valor.....	R	104	106	
Vanguard.....	R	106	108	98 <sup>d</sup>
Weevlchek.....	R	106	102	102
WL 210.....	R	110	103	114 <sup>d</sup>
WL 215.....	R	109	105	
WL 219.....	R	111	107	
WL 311.....	R	110	111	
WL 318.....	R	101	108	
Yukon.....	R	105	101	104
131.....	R	105	102	98
520.....	R	107	105	
521.....	R	104	104	
524.....	R	112	108	

<sup>a</sup> R = resistant.  
<sup>b</sup> S = susceptible.  
<sup>c</sup> MR = moderate resistant.  
<sup>d</sup> 2 years' data only.

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. After the September harvest, alfalfa needs a recovery period lasting until late October to restore root reserves. On well-drained soils in central and southern Illinois, a "late" harvest may be taken after plants have become dormant in late October.

### Species and Varieties

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 often is associated with alfalfa pastures. Balancing 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. Some have been privately developed; some have been developed at public institutions. Private varieties usually are marketed through a few specific dealers. Not all varieties are available in Illinois.

An extensive testing program has been under way at the University of Illinois for many years. The listing of alfalfa variety performance in Table 27 is based on test data information compiled since 1961. Some varieties have been tested every year since 1961; others have been tested only recently. However, each variety appearing in this list has been in test at least two years.

Bacterial wilt is one of the major diseases of alfalfa in Illinois. Stands of susceptible varieties usually decline severely in the third year of production and may die out in the second year under intensive harvesting schedules. Moderate resistance to bacterial wilt enables alfalfa to persist up to four or five years. Varieties listed as resistant usually persist beyond five years.

Other diseases and insects are problems and some varieties have particular resistance to these problems. You should question your seed supplier 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. New varieties, including Arlington, Kenstar, and Redland, have increased resistance to root and crown diseases and are expected to be productive for at least three years. See Table 28.

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

Table 28. — Red Clover Variety Yields, 1976

Variety	Anthracnose resistance	Tons dry matter per acre		
		DeKalb	Urbana	Brownstown
Arlington.....	Northern	5.00	5.93	2.02
Clovene.....	Northern	4.57	5.16	1.86
E-684.....	Southern	4.20	5.99	2.00
E-685.....	Southern	4.50	6.01	2.02
E-688.....	Southern,			
	Northern	4.79	5.94	2.19
Florie.....	Southern	5.02	6.07	2.29
Florex.....	Northern	5.24	5.75	1.50
Joy.....	Northern	5.01	6.16	1.95
Kenland.....	Southern	4.04	5.88	1.91
Kenstar.....	Southern	4.63	6.17	1.84
Lakeland.....	Northern	5.13	5.46	2.09
Redland.....	Southern,			
	Northern	4.78	6.10	2.24
Redman.....	Northern	5.61	5.96	1.95

There are fewer varieties of red clover than of alfalfa. Most are from the U.S. Department of Agriculture and state experiment stations. Private breeders now are becoming active in red clover variety development.

Mammoth red clover has increased in use during the last two or three years. Yields of mammoth red clover have been lower than yields of most of the improved varieties of medium red clover (Table 28).

Ladino clover is an important legume in pastures, but it 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 frequently are experienced.

Ladino lacks drought tolerance because its root system is rarely as deep as that of 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 that of 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.

Rooting depth of birdsfoot trefoil is shallower than alfalfa. Thus birdsfoot trefoil is not as productive during drought.

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 that of 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 the 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 that sainfoin has a slow growth and recovery growth rate 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 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 brome grass. There are promising new varieties (Table 29).

Smooth brome grass is probably the most widely adapted, high-yielding grass species for northern and central Illinois. Smooth brome grass combines well with alfalfa or red clover. It is productive, but it has limited summer production when moisture is lacking and temperatures are high. It produces well in spring and fall

Table 29. — Timothy Variety Yields, 1974-76

Variety	Tons dry matter per acre		
	DeKalb	Urbana	Brownstown
Clair.....	3.87	3.56	3.35
Climax.....	3.73	3.46	3.75
Itasca.....	3.37	3.59	....
N7-126.....	3.63	3.61	3.22
Timfor.....	3.58	3.71	3.50
Toro.....	3.73	3.60	....
Verdant.....	3.38	3.88	....

Table 30. — Smooth Brome grass Variety Yields, 1974-76

Variety	Tons dry matter per acre		
	DeKalb	Urbana	Brownstown
Barton.....	4.20	3.31	3.37
Baylor.....	3.55	3.49	3.09
Beacon.....	3.59	3.64	2.86
Blair.....	3.96	3.69	2.83
Lincoln.....	3.62	3.24	2.81
Sac.....	3.40	2.96	2.75

Table 31. — Orchardgrass Variety Yields, 1974-76

Variety	Tons dry matter per acre		
	DeKalb	Urbana	Brownstown
Able.....	3.50	3.43	3.32
Boone.....	3.32	3.15	3.53
Dart.....	3.62	3.36	3.59
Dayton.....	3.73	3.12	3.07
Hallmark.....	3.73	3.43	3.10
Ina.....	3.24	3.15	3.40
Jackson.....	3.63	3.28	3.35
Napier.....	3.62	3.31	3.40
Potomac.....	3.41	3.44	3.02
Virginia 70.....	3.37	3.32	3.27

Table 32. — Other Hay, Pasture, and Silage Crop Varieties

Crop	Variety	Origin	Use	Relative maturity (days) <sup>a</sup>
Ladino clover	Merit	Iowa	Pasture	
Birdsfoot trefoil	Carroll	Iowa	Hay and pasture	
	Empire	New York	Pasture	
	Dawn	Missouri	Pasture	
	Viking	New York	Hay and pasture	
	Leo	Canada	Hay and pasture	
	Maitland	Europe	Hay and pasture	
Crownvetch	Penngift	Pennsylvania	Erosion and pasture	
	Chemung	New York	Erosion and pasture	
	Emerald	Iowa	Erosion and pasture	
Smooth brome	Achenbach	Kansas	Hay and pasture	
	Barton	Land O' Lakes, Inc.	Hay and pasture	
	Baylor	Rudy Patrick Co.	Hay and pasture	
	Beacon	Research Seeds, Inc.	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	Able	Farm Forage Research Coop.	Hay and pasture	late
	Boone	Kentucky	Hay and pasture	0
	Danish	Denmark	Hay and pasture	+10
	Dart	Land O' Lakes, Inc.	Hay and pasture	+2
	Dayton	Rudy Patrick Co.	Hay and pasture	+1
	Dolcea	Holland	Hay and pasture	late
	Hallmark	Farm Forage Research Coop.	Hay and pasture	+3
	Ina	Northrup, King & Co.	Hay and pasture	+8
	Jackson	Virginia	Hay and pasture	+7
	Napier	Rudy Patrick Co.	Hay and pasture	+3
	Pennlate	Pennsylvania	Hay and pasture	+11
	Pennmead	Pennsylvania	Hay and pasture	+8
	Potomac	Maryland	Hay and pasture	0
	Sterling	Iowa	Hay and pasture	+2
	Virginia 70	Virginia	Hay and pasture	-1
Tall fescue	Alta	Oregon	Pasture	
	Aronde	Holland	Pasture	early
	Fawn	Oregon	Pasture	
	Goar	California	Pasture	
	Kenmont	Kentucky	Pasture	
	Kenwell	Kentucky	Pasture (more palatable)	
	Ky-31	Kentucky	Pasture	
	Mo-96	Missouri	Pasture (more digestible)	
	Pastuca	Holland	Pasture	late
	Timothy	Clair	Kentucky	Hay
Climax		Indiana	Hay	+15
Itasca		Minnesota	Hay	0
Pronto		Pride Co., Inc.	Hay	
Timfor		Northrup, King & Co.	Hay	0
Toro		Rudy Patrick Co.	Hay	
Verdant		Wisconsin	Hay	+20

<sup>a</sup> Maturity relative to a popular variety within the species.

and can utilize high-fertility programs. There are a few improved varieties, and breeding work continues (Table 30).

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 quarter of the state. Orchardgrass heads out relatively early in the spring and 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 (Table 31).

Reed canarygrass is not widely used, but it has growth attributes that deserve 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 drought-resistant grasses and can utilize high fertility. It is coarser than orchardgrass or brome but not as coarse as tall fescue. Grazing studies indicate that reed canarygrass will produce good gains equal to those of brome, 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 growth and induce dormancy earlier



than with tall fescue, smooth brome grass, or orchard-grass.

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 quarter 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 from these grasses may be less than that 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 and thus will dry more rapidly; they should be chosen for hay purposes over the sorghum-sudan hybrids. Crushing the stems with a hay conditioner will help speed drying.

Millets are warm season annual grasses that are drought tolerant. Four commonly known millets are pearl millet (*Pennisetum typhoides*), browntop millet (*Panicum ramosum*), foxtail or Italian millet (*Setaria italica*), and Japanese millet (*Echinochloa crusgalli*). Pearlmillet has been evaluated in grazing trials and is a suitable alternative for summer annual pastures.

Pearlmillet requires a warmer soil for rapid establishment than does sudangrass. Seedings should be delayed until the soil temperature in the seedbed averages 70°F.

Pearlmillet does not have a prussic acid potential as does sudangrass, nor is pearl millet as susceptible to leaf diseases. Pearlmillet is more drought tolerant than sudangrass, thus producing more pasture during hot dry periods of late summer than does sudangrass.

### Forage Mixtures

Mixtures (Table 33) of legumes and grasses usually are desired. Yields tend to be greater with mixtures than with 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 the 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 in which some of the species are not particularly well suited to the soil, climate, or use.

### Pollination of Legume Seeds

Illinois always has been an important producer of legume seeds, particularly red clover. In both acreage and seed produced, Illinois leads the nation. Yet per acre yields generally are low, in part because of inadequate pollination by bees. Only during the second bloom

do honey bees visit red clover in high enough numbers to pollinate it while they collect pollen and nectar. In experiments on the Agronomy Farm at Urbana, honey bees collected 54 to 99 percent of their daily pollen intake from red clover between July 12 and August 3.

Bumblebees also pollinate red clover, but they cannot be relied on because they are not always present and their numbers are unpredictable. Even the presence of honey bees in the vicinity of red clover fields can no longer be assured, because hive numbers in Illinois are now estimated at only 44,000 compared with about 76,000 hives in 1970 and 140,000 in 1958.

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. Do not rely on bees present in the neighborhood, because pollination and seed set decrease rapidly as distance between the hives and the crop becomes greater than 800 feet. Bring a sufficient number of hives to the field as soon as it comes into bloom. When all factors for seed production are favorable, proper pollination of red clover by honey bees has the potential of doubling or tripling seed yields.

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

Crownvetch does not attract 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 8 to 10 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.

Many legumes grown in Illinois for pasture or for purposes other than seed production are visited by honey bees and other bee pollinators. Alfalfa and birdsfoot trefoil as well as 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 at Urbana in July and August during their bloom. The beans are a major source of honey in the state. In tests at Urbana, honey bee visits to Clark soybeans did not increase seed yield over that of plants caged to exclude bees. Other studies showed, however, that honey bees can cross-pollinate some soybean varieties. Yields of Corsoy and Hark varieties were increased 14 percent and 16 percent, respectively, by honey bee visits in recent experiments in Wisconsin. Honey bees had no effect on yields of Chip-pewa 64 in the same study. It seems likely that other varieties also are benefited by visits of honey bees to their blossoms.

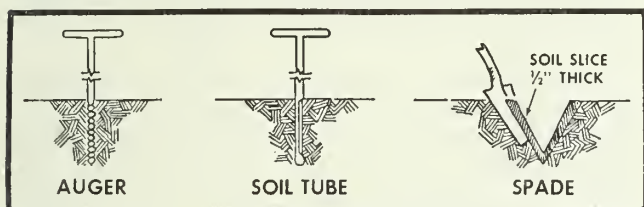
# SOIL TESTING AND FERTILITY

## Soil Testing

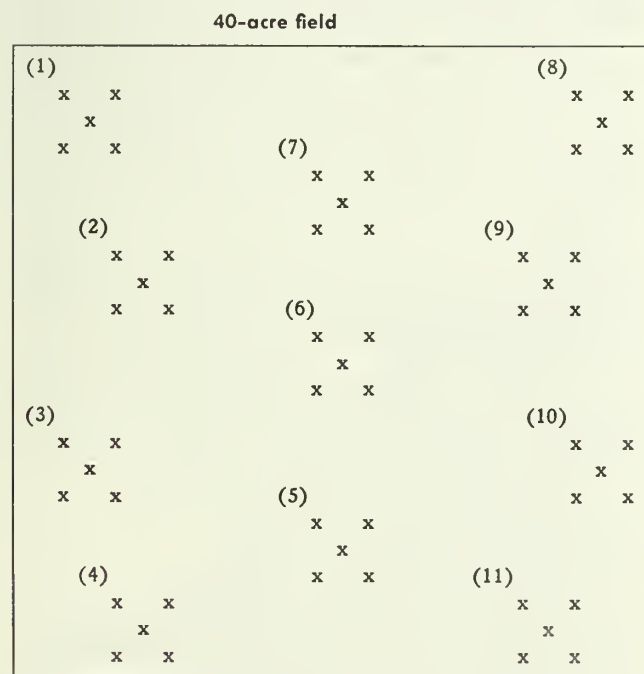
Soil testing is the most important single guide to the profitable application of fertilizer and lime. When soil test results are combined with information about the nutrients that are available to the various crops from the soil profile the farmer has a reliable basis for planning his fertility program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

Traditionally, soil testing has been used to decide how much lime and fertilizer to apply. Today, with increased emphasis on the environment, soil tests are also a logical tool to determine areas where adequate or excessive fertilization has taken place. It is just as important to determine where fertilizers should not be used.

**How to sample.** A soil tube is the best implement to use for taking soil samples, but a spade or auger also can be used (Fig. 2). One composite sample from every 3 to 4 acres is suggested. Five soil cores taken with a tube will give a satisfactory composite sample of approximately



How to take soil samples with an auger, soil tube, and spade. (Fig. 2)



Soil-sampling patterns for a 40-acre field. For a 20-acre field, eliminate 8 through 11. (Fig. 3)

1 to 2 cups in size. You may follow a regular pattern as indicated in Figure 3.

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

**When to sample.** Sampling every four years is strongly suggested. Late summer and fall are the best seasons to collect soil samples from the field. Potassium test results are most reliable during these times. Sampling frozen soil or within two weeks after the soil is frozen should be avoided.

**Where to have soil tested.** Illinois has about 65 commercial soil-testing services. If you do not know of any, your county extension adviser or fertilizer dealer can advise you of availability of soil testing in your area.

**Information to accompany soil samples.** The best fertilizer recommendations made are those that are based both on soil test results and a knowledge of the field conditions that will affect nutrient availability. Since the person making the recommendation does not know the conditions of each field, it is important that you provide adequate information with each sample.

This necessary information includes cropping intention for the next four years; the nature of the soil (clay, silty, or sandy; light or dark colored; level or hilly; erodes; well drained or wet; tiled or not; deep or shallow); fertilizer you have been using (amount and grade); whether the field was limed in the past two years; and yield goals for all proposed crops.

**What tests to have made.** Illinois soil-testing laboratories are equipped to test soils for pH (soil acidity), P<sub>1</sub> (available phosphorus), and K (potassium). No test for nitrogen has proven successful enough to justify a recommendation by University of Illinois agronomists. The reserve phosphorus soil test (P<sub>2</sub>) has been discontinued in most laboratories. Rock phosphate usage has decreased, so the need for the test has diminished.

Soil tests for certain secondary and micronutrients may warrant consideration under particular circumstances. These 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. However, soil tests are of 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.

Tests may be made for most of the secondary and micronutrients, but their interpretation is less reliable than

interpretation of tests for lime, phosphorus, or potassium. Complete field history and soil information are especially important in interpreting the results of tests for micro-nutrients.

## Lime

A growing amount of Illinois farmland is being short-changed of lime. One of the most serious limitations in crop production is soil acidity. The use of nitrogen fertilizer has increased rapidly, but the tonnage of limestone used has not kept pace. In Illinois, limestone usage ranged from 4.7 to 4.9 million tons from 1963 to 1966, but it declined to 3.7 to 4.1 million tons in 1971 and 1972. The use of nitrogen fertilizer increased from 175,000 tons in 1963 to 596,000 tons in 1972. It requires about 4 pounds of lime to neutralize the acidity resulting from 1 pound of nitrogen applied as ammonia or urea and as much as 9 pounds of lime to neutralize the acidity resulting from 1 pound of nitrogen as ammonium sulfate. A soil test every four years is the best way to keep check on soil acidity levels.

**The effect of soil acidity on plant growth.** There are several ways soil acidity affects plant growth. Whenever soil pH is low (i.e., acidity is high), several situations may exist.

1. The concentration of soluble metals may be toxic. Excess solubility of aluminum and manganese has been established experimentally.

2. Populations and activities of the organisms responsible for transformations involving nitrogen, sulfur, and phosphorus may be altered.

3. Calcium may be deficient. This usually occurs when the cation-exchange capacity of the soil is extremely low.

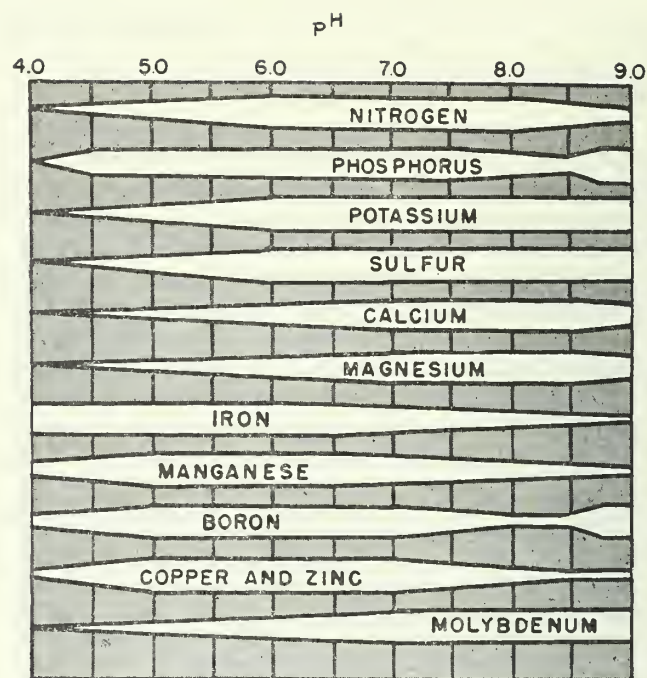
4. Symbiotic nitrogen fixation is impaired greatly on acid soils. The symbiotic relationship requires a narrower range of soil reaction than is necessary for growth of plants not relying on N fixation.

5. Acidic soils are poorly aggregated and have poor tilth. This is particularly true for soils low in organic matter.

6. Availability of mineral elements to plants may be improved. Figure 4 shows the relationship between soil pH and nutrient availability. The wider the white bar, the greater the nutrient availability. For example, phosphorus availability is greatest in the pH range between 6.5 and 7.5, dropping off rapidly below 6.0. Molybdenum availability is increased greatly as soil acidity is decreased. Molybdenum deficiencies usually can be corrected by liming.

**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 probably will 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



Available nutrients in relation to pH. (Fig. 4)

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 it does to maintain 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 raising the pH above 6.5 in cash-grain systems is unlikely.

**Liming treatments based on soil tests.** The limestone requirements in Figure 5 are based on these assumptions:

1. A nine-inch plowing depth. If plowing is less than nine inches deep, reduce the amount of limestone; if more than nine 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 or 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.

Instructions for using Figure 5 are as follows:

1. Use Chart I for grain systems and Chart II for alfalfa, clover, or lespedeza.

2. Decide which soil class fits your soil:

- A. Dark-colored silty clays and silty clay loams.

- B. Light- and medium-colored silty clays and silty clay loams; dark-colored silt and clay loams.

- C. Light- and medium-colored silt and clay loams; dark- and medium-colored loams; dark-colored sandy loams.



D. Light-colored loams; light- and medium-colored sandy loams; sands.

E. Muck and peat.

Color is related to organic matter. Light-colored soils usually have less than 2.5 percent organic matter; medium-colored soils have 2.5 to 4.5 percent organic matter; dark-colored soils have above 4.5 percent organic matter; sands are excluded.

The "typical" limestone on which Figure 5 is based has an effective neutralizing value (ENV) of 46.35. Here are the steps to follow (using the fineness and neutralizing power values) to calculate the ENV of your limestone.

First, determine what percentages of the limestone particles fall into four size groups. Then, multiply these four percentages by the efficiency factors (E.F.) listed in Table 34 to obtain the size fraction efficiency. Total the size fraction efficiencies to obtain the fineness efficiency as illustrated below.

	<i>% × E.F. = Size fraction efficiency</i>
10% of lime particles do not pass 8-mesh	$0.10 \times 5 = 0.5$
30% of particles pass 8-mesh, but do not pass 30-mesh	$0.30 \times 20 = 6.0$
30% of particles pass 30-mesh, but do not pass 60-mesh	$0.30 \times 50 = 15.0$
30% of particles pass 60-mesh	$0.30 \times 100 = 30.0$
Fineness efficiency	51.5

Then, the effective neutralizing value will equal the fineness efficiency multiplied by the calcium carbonate equivalent ( $46.35 = 51.5 \times 90$  percent). Your limestone dealer can tell you what the calcium carbonate equivalent of your limestone is.

Table 34. — Comparative Value of Limestone Particle Sizes

Size fraction	Efficiency factor
Through 60-mesh.....	100
30- to 60-mesh.....	50
8- to 30-mesh.....	20
Over 8-mesh.....	5

**Limestone quality.** You should buy limestone on the basis of quality, and premium limestone should sell for a premium price.

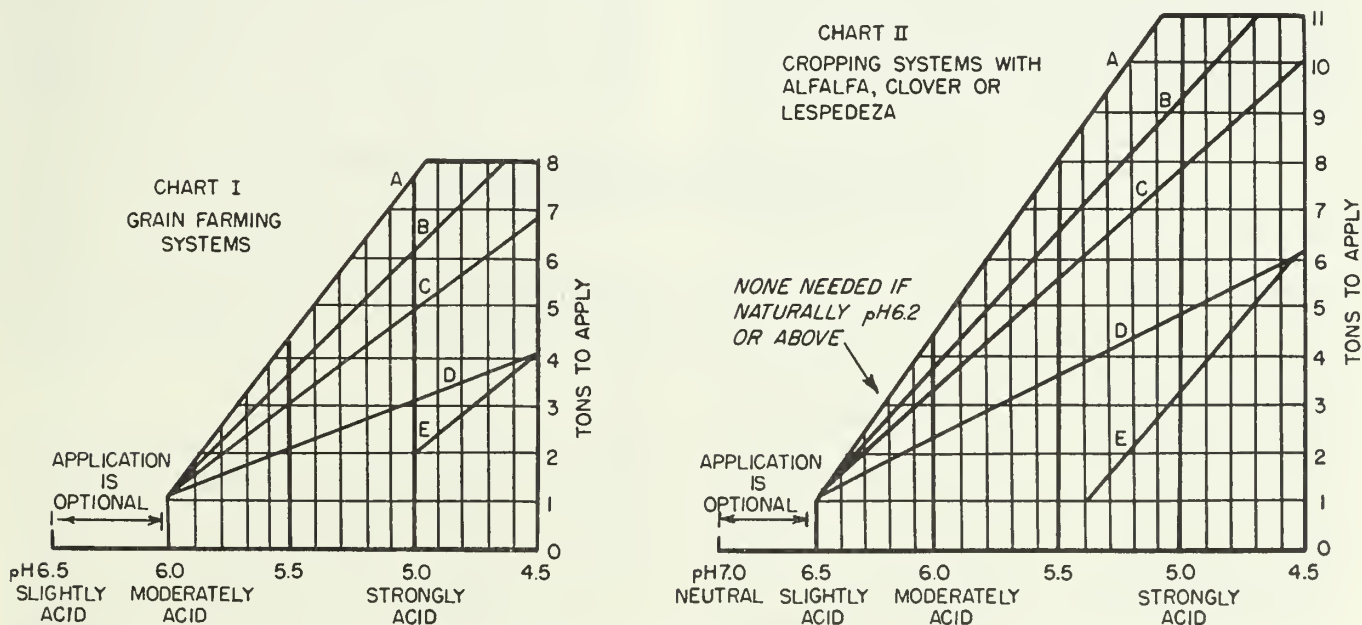
Limestone quality is measured by fineness and neutralizing power. The value of lime in correcting soil acidity problems can be calculated easily using the efficiency factors in Table 34.

To compare different limestones to the typical limestone on which Figure 5 is based, follow this procedure:

1. Calculate the ENV for your limestone as explained above.
2. Divide 46.35 (the ENV for typical limestone) by the calculated ENV value for your limestone.

**ENV greater than that of typical limestone.** If the fineness efficiency value of your limestone is 49.5 to 53.5, you may reduce the amount of lime to use by 1 percent for each 1 percent of calcium carbonate equivalent above 90 percent.

If the ENV of your limestone is greater than 46.35 and the calcium carbonate equivalent is 88 to 92 percent, then the increase in ENV is because of the fineness of the grind, and no adjustment in the amount of lime used per acre is justified. However, the finer materials will react more rapidly to neutralize acid soils than the typical limestone, and this may be of benefit in some situations.



Suggested limestone rates based on soil type, pH, and cropping system. (Fig. 5)

ENV less than that of typical limestone. If your limestone has an ENV less than 46.35, then you should increase the amount to apply per acre. Divide the amount of limestone needed per acre on your land by the value you calculated in step 2 above (for instance, 2 tons per acre divided by a value of 0.9 would equal about 2.22 tons to apply per acre).

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 needed is 6 tons or more per acre, apply it in split applications of about two-thirds the first time and the remainder three or four years later.

**Lime incorporation.** Lime does not react with acid soil very far from the particle. However, special tillage operations to mix lime with soil usually are not necessary; this has been true with conventional tillage that included use of the moldboard plow. Systems of tillage that use a chisel plow or field cultivator rather than a moldboard plow may necessitate a reexamination of soil acidity within the root zone.

### Calcium-Magnesium Balance in Illinois Soils

Soils in northern Illinois usually contain more magnesium than those in central and southern sections because of the high magnesium content in the rock from which the soils developed and because northern soils are geologically younger. This has caused some to wonder whether the magnesium level is too high. There have been reports of suggestions that either gypsum or low-magnesium limestone from southern Illinois quarries should be applied. However, no one operating a soil-testing laboratory or selling fertilizer in Illinois has put forth research to justify concern over too narrow a calcium:magnesium ratio.

On the other hand, there is justifiable concern over a soil magnesium level that is low, because of its relationship with hypomagnesemia, a prime factor in grass tetany or milk fever in cattle. This is more relevant to forage production than to grain production. Very high potas-

sium levels (500+) combined with low soil magnesium levels contribute to low-magnesium forages. Research data to recommend specific magnesium levels are not available. However, levels of magnesium less than 40 pounds per acre on sands and 150 pounds per acre on silt loam are regarded as low.

Calcium and magnesium levels of agricultural limestone vary between different quarries in the state. Dolomite limestone (material with an appreciable magnesium content as high as 21.7 percent MgO or 46.5 percent MgCO<sub>3</sub>) occurs predominantly in the northern three tiers of Illinois counties, including Kankakee County on the east and an additional area in Calhoun County. Limestone in the remainder of the state is dominantly calcitic (high calcium, although it is not uncommon to have 1 to 3 percent MgCO<sub>3</sub>).

For farmers following a grain system of farming, there are no agronomic reasons 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 limestone from southern Illinois or that farmers in southern Illinois order limestone from northern Illinois quarries because of magnesium content.

For farmers with a livestock program or who produce forages in the claypan and fragipan regions of the south where soil magnesium levels may be marginal, it is appropriate to use a soil test to verify the conditions and to use dolomite limestone or supplemental magnesium fertilization.

### Nitrogen

Harvested crops remove more nitrogen than any other nutrient from Illinois soils. Erosion reduces the nitrogen content of soils because the surface soil is richest in nitrogen and erodes first. Further nitrogen losses occur as a result of denitrification and leaching. About 40 percent of the original nitrogen and organic matter content has been lost from typical Illinois soils since farming began.

The use of nitrogen fertilizer is necessary if Illinois

Table 35. — Economic Optimum Nitrogen Rate Experimentally Determined for Eight Locations as Affected by Corn-Nitrogen Price Ratios

Location and rotation	Corn-nitrogen price ratio			
	10:1		20:1	
	Optimum yield (bu./acre)	Optimum N rate (lb./bu.)	Optimum yield (bu./acre)	Optimum N rate (lb./bu.)
Brownstown (continuous corn).....	83	1.30	86	1.47
Carthage (continuous corn).....	144	1.22	147	1.29
DeKalb (continuous corn).....	141	1.28	143	1.31
Urbana (continuous corn).....	171	1.17	173	1.24
Average of continuous corn.....		1.24		1.33
Dixon (corn-soybeans).....	131	1.37	134	1.58
Hartsburg (corn-soybeans).....	156	1.19	157	1.27
Oblong (corn-soybeans).....	123	1.11	126	1.23
Toledo (corn-soybeans).....	123	1.12	124	1.20
Average of corn-soybeans.....		1.20		1.32
Average of all locations.....		1.22		1.32

**Table 36. — Nitrogen Recommendations for Selected Illinois Soils Under High Level of Management**

Soil type	Corn-nitrogen price ratio	
	10:1	20:1
	<i>Nitrogen recommendation (lbs./acre)</i>	
Muscatine silt loam.....	205	220
Ipava silt loam.....	200	215
Sable silty clay loam.....	190	205
Drummer silty clay loam.....	185	200
Plano silt loam.....	185	200
Hartsburg silty clay loam.....	175	190
Fayette silt loam.....	155	170
Clinton silt loam.....	155	170
Cowden silt loam.....	145	160
Cisne silt loam.....	140	150
Bluford silt loam.....	125	135
Grantsburg silt loam.....	115	125
Huey silt loam.....	80	85

agriculture is to continue to provide adequate crop production to aid in meeting the ever-increasing world demand for food. With the world shortage of nitrogen fertilizer and energy, all nitrogen fertilizers should be used in the most efficient manner possible. Factors that influence efficiency of fertilizer use are discussed in the following sections.

**Rate of Application**

**Corn.** Yield goal is one of the major considerations to use in determining the optimum rate of nitrogen application for corn. These goals should be established for each field, taking into account the soil type and management level under which the crop will grow.

For Illinois soils, suggested productivity index values are given in Illinois Cooperative Extension Service Circular 1156, *Soil Productivity in Illinois*. Yield goals are presented for both basic and high levels of management. For fields that will be under exceptionally high management, a 15-to-20-percent increase of the values given for high levels of management would be reasonable. Annual variations in yield of 20 percent above or below the productivity index values are common because of variations in weather conditions. However, applying nitrogen fertilizer for yields possible in the most favorable year will not result in maximum net return when averaged over all years.

The University of Illinois Department of Agronomy has conducted research trials designed to determine the optimum nitrogen rate for corn under varying soil and climatic conditions.

The results of these experiments show that average economic optimum nitrogen rates varied from 1.22 to 1.32 pounds of nitrogen per bushel of corn produced when nitrogen was spring applied (Table 35). The lower rate of application (1.22 pounds) would be recommended at a corn-nitrogen price ratio (corn price per bushel to nitrogen price per pound) of 10:1 and the higher rate (1.32 pounds) at a price ratio of 20:1.

**Table 37. — Soybean Yields at Four Locations as Affected by N Applied to Corn the Preceding Year (Four-Year Average)**

N applied to corn (lb./acre)	Soybean yield (bu./acre)				
	Aledo	Dixon	Elwood	Kewanee	Average
0.....	48	40	37	40	41
80.....	49	40	36	38	41
160.....	48	39	36	40	41
240.....	48	42	36	40	41
320.....	48	42	36	37	41

As would be expected, the nitrogen requirement was lower at those sites having a corn-soybean rotation than at sites with continuous corn because of the nitrogen contribution from soybeans (see nitrogen rate adjustment section).

With the exception of Dixon, which was based on limited data, Brownstown and DeKalb had the highest nitrogen requirement per bushel of corn produced. This higher requirement may be in part the result of the higher denitrification losses that frequently have been observed at Brownstown and DeKalb.

Based on these results, examples of the recommended rate of nitrogen application for selected Illinois soils under a high level of management are indicated in Table 36.

**Soybeans.** Based on average Illinois corn and soybean yields from 1971-73 and average nitrogen content of the grain for these two crops, the total nitrogen removed per acre by soybeans was greater than that removed by corn (soybeans, 132 pounds of nitrogen per acre; corn, 82 pounds of nitrogen per acre). However, recent research results from the University of Illinois indicate that when properly nodulated soybeans were grown at the proper soil pH, symbiotic fixation was equivalent to 63 percent of the nitrogen removed in harvested grain. Thus, net nitrogen removal by soybeans was less than that of corn (corn, 82; soybeans, 49).

This net removal of nitrogen by soybeans in 1973 was equivalent to 39 percent of the amount of fertilizer nitrogen used in Illinois. On the other hand, symbiotic fixation of nitrogen by soybeans in Illinois (367,000 tons of N) was equivalent to 67 percent of the fertilizer nitrogen used in Illinois.

Even though there is a rather large net nitrogen removal from soil by soybeans (49 pounds of nitrogen per acre), research at the University of Illinois has not generally indicated any soybean yield increase caused by either residual nitrogen remaining in the soil or nitrogen applied for the soybean crop.

*A. Residual from nitrogen applied to corn (Table 37).* Soybean yields at four locations were not increased by residual nitrogen remaining in the soil even when nitrogen rates as high as 320 pounds per acre had been applied to corn the previous year.

*B. Nitrogen on continuous soybeans (Table 39).* After 18 years of continuous soybeans at Hartsburg, yields were unaffected by nitrogen rates.

Table 38. — Recommended Nitrogen Application Rates for Wheat, Oats, and Barley

Soil situation	Organic matter content	Fields with alfalfa or clover seeding		Fields with no alfalfa or clover seeding	
		Stiff-strawed varieties	Other adapted wheat and oat varieties and all varieties of barley	Stiff-strawed varieties	Other adapted wheat and oat varieties and all varieties of barley
<i>Nitrogen (lb./acre)</i>					
Soils low in capacity to supply nitrogen: inherently low in organic matter (forested soils) . . . . .	<2%	50-70	40-60	70-90	50-70
Soils medium in capacity to supply nitrogen: moderately dark-colored soils . . . . .	2-3%	30-50	20-40	50-70	30-50
Soils high in capacity to supply nitrogen: all deep, dark-colored soils . . . . .	>3%	20-30	0	40-50	20-30

C. High rates of added nitrogen (Table 40). In 1968 a study was started at Urbana using moderate rates of nitrogen. Rates were increased in 1969 so that the high rates could furnish more than the total nitrogen needs of soybeans. Yields were not affected by nitrogen in 1968, but a tendency toward a yield increase occurred in 1969 and 1970 with 400 pounds per acre of nitrogen. However, this rate of nitrogen would not be economical at current prices.

**Wheat, oats, and barley.** The rate of nitrogen application to be used on wheat, oats, and barley is dependent on soil type, variety to be grown, and future cropping intentions (Table 38). Light-colored (low organic matter) soils require the highest rate of nitrogen application as they have a low capacity to supply nitrogen. Deep, dark-colored soils require relatively low rates of nitrogen application for maximum yields. Estimates of organic matter content for soils of Illinois can be obtained from Agronomy Fact Sheet SP-36, "Average Organic Matter Content in Illinois Soil Types," or by using University of Illinois publication AG-1941, "Color Chart for Estimating Organic Matter in Mineral Soils."

Higher rates of application can be used on the stiff-strawed wheat varieties such as Abe, Arthur, Arthur 71, Blueboy, Blueboy II, and Oasis than on the other varieties, which are more susceptible to lodging. Nearly all recommended oat varieties grown in Illinois have good straw strength; thus, higher nitrogen rates are recommended. Most varieties of barley grown in Illinois are weak strawed and, thus, susceptible to lodging.

Some wheat in Illinois serves as a companion crop for legume or legume-grass seedings. On those fields, it is best to apply nitrogen fertilizer at slightly below the optimum rate, as unusually heavy vegetative growth of wheat competes unfavorably with the young forage seedlings (Table 38).

Nitrogen fertilizer efficiency normally will be at a maximum if no nitrogen is fall applied to the dark-colored soils and only a small amount (15 to 20 pounds per acre) is drill applied at planting time on the light colored soils. The remainder of the nitrogen should be topdressed early in the spring of the year.

Table 39. — Yield of Continuous Soybeans With Rates of Added N at Hartsburg

N (lb./acre/year)	Soybean yield (bu./acre)	
	1968-71	1954-71
0 . . . . .	43	37
40 . . . . .	42	36
120 . . . . .	43	37

Table 40. — Soybean Yields as Affected by High Rates of Nitrogen

Nitrogen (lb./acre)			Soybean yield (bu./acre)		
1968	1969	1970	1968	1969	1970
0	0	0	54	53	40
40	200	200	54	57	41
80	400	400	56	57	45
120	800	800	53	55	42
160	1,600	1,600	55	34	36

Table 41. — Nitrogen Fertilization of Hay and Pasture Grasses

Species	Time of application			
	Early spring	After first harvest	After second harvest	Early September
<i>Nitrogen (lb./acre)</i>				
Kentucky bluegrass . . . . .	60-80			(see text)
Orchardgrass . . . . .	75-125	75-125		
Smooth bromegrass . . . . .	75-125	75-125		50*
Reed canarygrass . . . . .	75-125	75-125		50*
Tall fescue for winter use		100-125	100-125	50*

\* Optional if extra fall growth is needed.

The amount of nitrogen needed for good fall growth is not large because the total uptake in roots and tops prior to cold weather is not likely to exceed 30 to 40 pounds per acre. If all of the recommended nitrogen were fall applied, excessive vegetative growth could occur in the fall and increase the probability of disease occurrence.

**Hay and pasture grasses.** The species grown, period of use, and yield goal determine optimum nitrogen fertilization (Table 41). The lower rate of application is recommended on those fields where an inadequate stand or moisture limits production.

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

Make the first nitrogen 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 can be delayed until after the first harvest or grazing cycle to distribute production more uniformly throughout the summer. However, total produc-

tion likely will be less if nitrogen is applied after first harvest rather than in early spring. The second application of nitrogen usually is made after the first harvest or first grazing cycle. However, this application can 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 on nitrogen.

After the legume has declined to less than 30 percent of the mixture, the object of 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 pounds or more when legumes are less than 20 percent of the mixture.

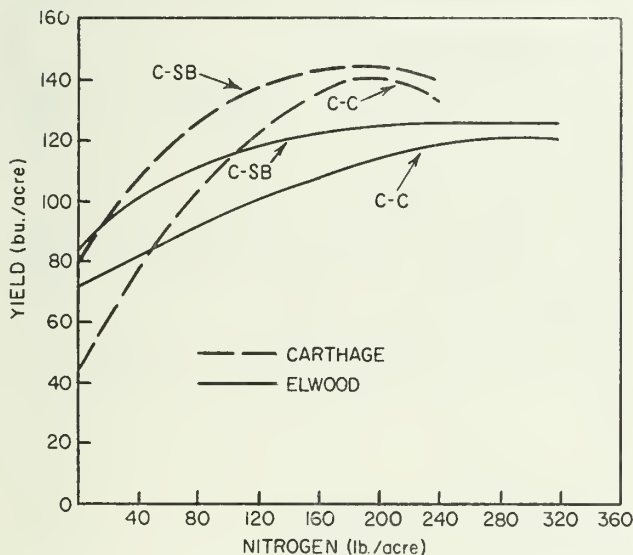
#### Rate Adjustments

In addition to determining nitrogen rates, consideration should be given to other agronomic factors that influence available nitrogen. These adjustments include past cropping history and the use of manure (Table 42), as well as date of planting.

Experiments conducted at the Carthage experimental field comparing nitrogen requirements of continuous corn and corn following soybeans indicate a soil nitrogen contribution of 30 to 40 pounds per acre at the lower rates of applied nitrogen and 20 to 30 pounds per acre at the higher rates of nitrogen application (Fig. 6). At Elwood, the yield differential between continuous corn and corn-soybeans continues to widen at higher rates of nitrogen application. It is doubtful that this yield differential is entirely the result of nitrogen contributions from the soybeans. The contribution of legumes, either soybeans or alfalfa, to wheat will be less than the contribution to corn because the oxidation of the organic nitrogen from these legumes will not be as rapid in early spring, when the nitrogen needs of small grain are greatest, as it is in the summer, when nitrogen needs of corn are greatest.

Manure generally is considered to contain 10 pounds of nitrogen, 5 pounds of phosphorus ( $P_2O_5$ ), and 10 pounds of potassium ( $K_2O$ ) per ton. However, there is some variation in content dependent on source and method of handling (Table 43). Regardless of source, however, only 50 percent of the total nitrogen will be available to the crop during the first year after application.

Research at the Northern Illinois Research Center for several years showed that as planting was delayed, less nitrogen fertilizer was required for most profitable yield. 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 can be reduced 20 pounds per acre down to 80 to 90 pounds per acre as the minimum for very late planting in a corn-soybean cropping system. Suggested reference dates are April 10 to 15 in southern Illinois, April 20 to May 1 in central



Effect of crop rotation and applied nitrogen on corn yield. (Fig. 6)

Table 42. — Adjustments in Nitrogen Recommendations

Crop to be grown	Factors resulting in reduced nitrogen requirement					Ma-nure	
	After soy-beans	1st year after alfalfa or clover			2nd year after alfalfa or clover		
		Plants/sq. ft.	5	2-4	<2		5
		<i>Nitrogen reduction (lb./acre)</i>					
Corn . . . . .	40	100	50	0	30	0	5 <sup>a</sup>
Wheat . . . . .	10	30	10	0	0	0	5 <sup>a</sup>

<sup>a</sup> Nitrogen contribution in pounds per ton of manure.

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 the planting date, farmers are encouraged not to delay planting just to apply nitrogen fertilizer: plant, then sidedress.

#### Reactions in the Soil

Efficient use of nitrogen fertilizer requires an understanding of how nitrogen behaves in the soil. Key points to consider are the change from ammonium ( $\text{NH}_4^+$ ) to nitrate ( $\text{NO}_3^-$ ) and movements and transformations of nitrate.

A high percentage 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 it nitrifies (changes from ammonium to nitrate). In the nitrate form, nitrogen can be lost by either denitrification or leaching.

**Denitrification.** Denitrification is believed to be the main process by which nitrate and nitrite nitrogen are lost, except on sandy soils, where leaching is more important. Denitrification involves only nitrogen in the form of either nitrate ( $\text{NO}_3^-$ ) or nitrite ( $\text{NO}_2^-$ ).

The amount of denitrification depends mainly on (1) how long water stands on the soil surface or how long the surface is saturated; (2) the temperature of the soil and water; (3) the pH of the soil; and (4) the amount of energy material available to denitrifying organisms.

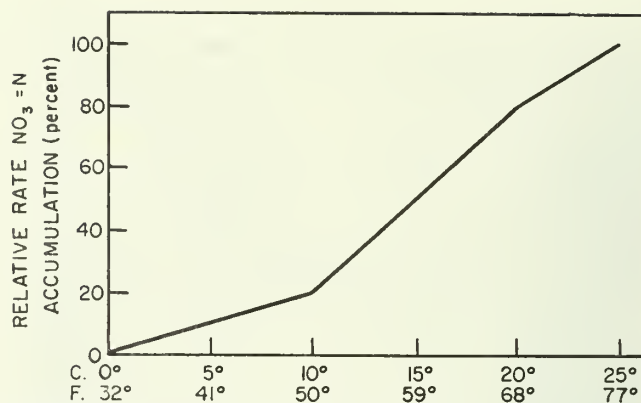
When water stands on the soil or when the surface is completely saturated in fall or early spring, nitrogen loss is likely to be small because (a) much nitrogen is still in the ammonium rather than nitrate form, and (b) the soil is cool and denitrifying organisms are not very active.

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 clay-pan 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.

Table 43. — Average Composition of Manure

Kind of animal	Nutrients (lb./ton)		
	Nitrogen (N)	Phosphorus ( $\text{P}_2\text{O}_5$ )	Potassium ( $\text{K}_2\text{O}$ )
Dairy cattle.....	11	5	11
Beef cattle.....	14	9	11
Hogs.....	10	7	8
Chicken.....	20	16	8
Dairy cattle (liquid).....	5(26) <sup>a</sup>	2(11)	4(23)
Beef cattle (liquid).....	4(21)	1( 7)	3(18)
Hogs (liquid).....	10(56)	5(30)	4(22)
Chicken (liquid).....	13(74)	12(68)	5(27)

<sup>a</sup> Parenthetical numbers are pounds of nutrients per 1,000 gallons.



Influence of soil temperature on the relative rate of  $\text{NO}_3$ -N accumulation in soils. (Fig. 7)

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

**Leaching.** In silt loams and clay loams, one inch of rainfall moves down about five to six 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 is more than six 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 is difficult to predict 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 silt and clay loams 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 already may be saturated. In either of these cases the nitrates will not move down five to six inches as suggested above.

Corn roots usually penetrate to six feet in Illinois soils. Thus, nitrates that leach three to four feet are well within normal rooting depth unless they reach tile lines and are drained from the field.

#### Time of Application

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

The 50° F. level for fall application is believed to be a realistic guideline for farmers. Applying nitrogen earlier involves risking too much loss (Fig. 7). Later application involves risking wet or frozen fields, which would prevent

application and fall plowing. Average dates on which these temperatures are reached are not satisfactory guides because of the great variability from year to year. Soil thermometers should be used 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. 7), the period of time is long during which the soil temperature is between 32° F. and 40° to 45° F.

The results from 18 experiments in central and northern Illinois in four recent years (Fig. 8) 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 8, left, 120 pounds of nitrogen applied 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 of nitrogen to produce as much yield increase in the fall as was produced by 100 pounds in the spring (Fig. 8, right). At higher nitrogen rates, the comparisons become less favorable for fall application because the yield leveled off 6 to 8 bushels below that from spring application.

Unfortunately, no recent 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 might be greater if an all-ammonium form is 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 in susceptibility to denitrification and leaching loss between late-fall and early-spring applications of ammonium sources is probably small. Both are, however, more susceptible to loss than is nitrogen applied at planting time or as a sidedressing.

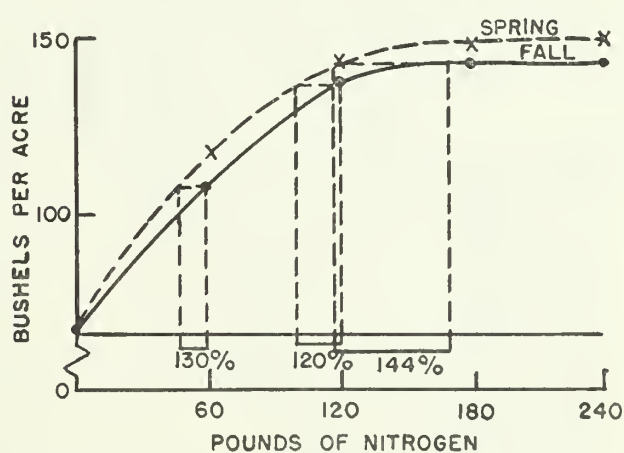
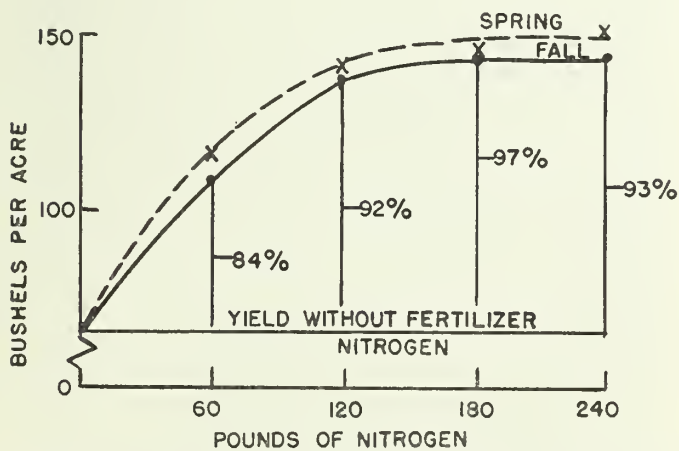
Anhydrous ammonia nitrifies more slowly than other ammonium forms and, therefore, is slightly preferred for fall applications. It is well suited to early spring application, provided the soil is dry enough for good dispersion of ammonia and closure of the applicator slit.

**Aerial application.** Recent research at the University of Illinois has indicated that an aerial application of dry urea will result in increased yield. This practice should not be considered as a replacement for normal nitrogen application, but rather as an emergency treatment in instances where corn is too tall for normal applicator equipment. Aerial application of nitrogen solutions on growing corn is not recommended, as extensive leaf damage will likely result if the rate of application is greater than 10 pounds of nitrogen per acre.

#### Which Nitrogen Fertilizer?

The bulk of the nitrogen fertilizer materials available for use in Illinois provides nitrogen in the combined form of ammonia, ammonium, urea, and nitrate. For many uses on a wide variety of soils, all forms are likely to produce about the same yield provided that they are properly applied.

**Ammonia.** Nitrogen materials that contain free ammonia ( $\text{NH}_3$ ), such as anhydrous ammonia or low-pressure solutions, must be injected into the soil in order to avoid gaseous loss of ammonia. Upon injection into the soil, ammonia quickly reacts with water to form ammonium ( $\text{NH}_4^+$ ). In this positively charged form, the ion is not susceptible to gaseous loss because it is temporarily attached to the negative charges on clay and organic



Comparison of fall- and spring-applied ammonium nitrate, 18 experiments in central and northern Illinois, 1966-1969 (DeKalb, Carthage, Carlinville, and Hartsburg). Figure at left shows increased yield from fall fertilizer application as a percent of yield increases achieved when fertilizer was applied in the spring. Figure at right shows amount of fertilizer you need to apply in the fall to obtain a given yield as a percent of the fertilizer needed to obtain that same yield with spring application. (Fig. 8)

matter. Some of the ammonia reacts with organic matter to become a part of the soil humus.

On silt loam or finer textured soils, ammonia will move approximately 4 inches from the point of injection. On coarser textured soils such as sands, ammonia may move 5 to 6 inches from the point of injection. If the depth of application is shallower than the distance of movement, some ammonia may move slowly to the soil surface and escape as a gas over a period of several days. Therefore, on coarse-textured (sandy) soils, anhydrous ammonia should be placed 8 to 10 inches deep, whereas on silt-loam soils, the depth of application should be 6 to 8 inches. Anhydrous ammonia is lost more easily from shallow placement than ammonia in low-pressure solutions. Nevertheless, these low-pressure solutions do contain free ammonia and thus need to be incorporated into the soil at a depth of 2 to 4 inches. Ammonia should not be applied to soils having a physical condition that would prevent closure of the applicator knife track. Ammonia will escape to the atmosphere whenever there is a direct opening from the point of injection to the soil surface.

Table 44. — Effect of Source of Nitrogen for Zero-Till Corn

Source	Nitrogen			Browns- town 1974-77 avg.	Dixon Springs 1974 1975	
	Date of appli- cation	Method of appli- cation	Rate lbs./ acre			
Control . . . . .	..	..	0	52	50	
Ammonium nitrate . . . . .	early spring	surface	120	96	132	160
Urea . . . . .	early spring	surface	120	80	106	166
Ammonium nitrate . . . . .	early June	surface	120	106	151	187
Urea . . . . .	early June	surface	120	99	125	132

Table 45. — Effect of Source and Rate of Spring-Applied Nitrogen on Corn Yield, DeKalb

Carrier	N (lb./acre)	Year		
		1976	1977	Avg.
		Yield (bu./acre)		
None . . . . .	0	66	61	64
Ammonia . . . . .	80	103	138	120
28 pct. N solution incorporated . . . . .	80	98	132	115
28 pct. N solution unincorporated . . . . .	80	86	126	106
Ammonia . . . . .	160	111	164	138
28 pct. N solution incorporated . . . . .	160	107	157	132
28 pct. N solution unincorporated . . . . .	160	96	155	126
Ammonia . . . . .	240	112	164	138
28 pct. N solution incorporated . . . . .	240	101	164	132
28 pct. N solution unincorporated . . . . .	240	91	153	122
	FLSD.10	9.1	5.2	

**Ammonium nitrate.** Fifty percent of the nitrogen contained in ammonium nitrate is in the ammonium form and 50 percent is in the nitrate form. That present as ammonium attaches to the negative charges on the clay and organic matter particles and remains in that state until it is utilized by the plant or converted to the nitrate ions by microorganisms present in the soil. Since 50 percent of the nitrogen is present in the nitrate form, this product is more susceptible to loss from leaching and denitrification. Thus, ammonium nitrate should not be applied to sandy soils because of the likelihood of leaching, nor should it be applied far in advance of the time the crop needs the nitrogen because of the possibility of loss by denitrification.

**Urea.** The chemical formula for urea is  $\text{CO}(\text{NH}_2)_2$ . In this form, it is very soluble and moves freely up and down with soil moisture. After being applied to the soil, urea is converted to ammonia either chemically or by the enzyme urease. The speed with which this conversion occurs depends largely on temperature. At low temperatures conversion is slow, but at temperatures of 55° F. or higher conversion is rapid.

If the conversion of urea occurs on the soil surface or on the surface of crop residue or leaves, some of the resulting ammonia will be lost as a gas to the atmosphere. The potential for loss is greatest when:

1. Temperatures are greater than 55° F. Loss is less likely with winter or early spring applications.
2. Considerable crop residue remains on the soil surface.
3. Application rates are greater than 100 lbs. N per acre.
4. The soil surface is moist and rapidly drying.
5. Soils have a low cation-exchange capacity.
6. Soils are neutral or alkaline in reaction.

Research conducted at both the Brownstown and Dixon Springs Research Centers have shown that surface application of urea for zero-till corn did not yield as well as ammonium nitrate (Table 44) in most years. In years in which a rain was received within one or two days after application, urea resulted in as good a yield increase as did ammonium nitrate (that is, compared to results from early spring application of ammonium nitrate at Dixon Springs in 1975). In other studies, urea that was incorporated soon after application yielded as well as ammonium nitrate.

**Nitrogen solutions.** The non-pressure nitrogen solutions that contain 28 or 32 percent of nitrogen consist of a mixture of urea and ammonium nitrate. Typically, half of the nitrogen is from urea and the other half is from ammonium nitrate. The constituents of these compounds will undergo the same reactions as described above for the constituents applied alone.

Recent experiments at DeKalb have shown a yield difference between incorporated and unincorporated nitrogen solutions which were spring-applied (Table 45).



This difference in yield associated with method of application is probably caused by the volatilization loss of some nitrogen from the surface-applied solution containing urea.

## Phosphorus and Potassium

### Inherent Availability

Illinois has been divided into three regions in terms of inherent phosphorus-supplying power of the soil below the plow layer in dominant soil types (Fig. 9).

High phosphorus-supplying power means that the soil test for available phosphorus ( $P_1$  test) is relatively high and conditions are favorable for good root penetration and branching throughout the soil profile.

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 branching.
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 phosphorus-supplying power are shown in Figure 9. Parent material and degree of weathering were the primary factors considered in determining the various regions.

The "High" region occurs in western Illinois, where the primary parent material was more than 4 to 5 feet of loess that was high in phosphorus content. The soils are leached of carbonates to a depth of more than 3½ feet, and roots can spread easily in the moderately permeable profiles.

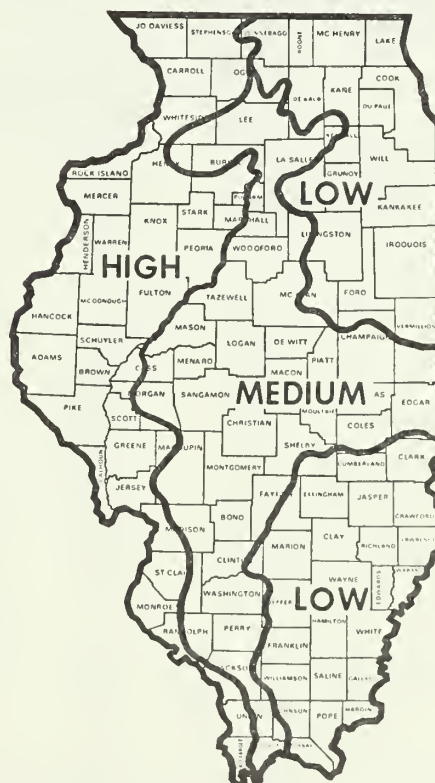
The "Medium" region occurs in central Illinois with an arm extending into northern Illinois and a second arm extending into southern Illinois. The primary parent material was more than 3 feet of loess over glacial till, glacial drift, or outwash. Some sandy areas with low phosphorus-supplying power occur in the region. Compared with the high-phosphorus 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. Phosphorus-supplying power of soils of the region is likely to vary with natural 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, generally low in available phosphorus, ranges in texture from gravelly loam to clay in various soil associations of the region. In addition, shallow carbonates further reduce the phosphorus-supplying power of the soils of the region. High bulk density and slow permeability in the subsoil and substratum restrict rooting in 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 phosphorus-supplying power. It appears, for example, that soils developed under forest cover have more available subsoil phosphorus than those developed under grass.

Illinois is divided into two general regions based on potassium-supplying power (Fig. 10). There are, however, important differences among soils within these general regions because of differences in the seven factors listed below.



Phosphorus-supplying power. (Fig. 9)

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. The amount of calcium and magnesium. Very high calcium and magnesium may reduce K uptake.
6. The parent material from which the soil formed.
7. Compactness or other conditions that influence root growth.

Soils having a cation-exchange capacity less than 12 me./100 g. are classified as having low potassium-supplying power. These include the sandy soils since minerals from which these soils developed are inherently low in K. Sandy soils also have very low cation-exchange capacities and thus do not hold much reserve K.

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

Table 46. — Amount of Phosphorus ( $P_2O_5$ ) Required To Build Up the Soil (based on buildup occurring over a four-year period; 9 pounds of  $P_2O_5$  per acre required to change  $P_1$  soil test 1 pound)

$P_1$ test (lb./acre)	Pounds of $P_2O_5$ to apply per acre each year for soils with supplying power of:		
	Low	Medium	High
4.....	103	92	81
6.....	99	88	76
8.....	94	83	72
10.....	90	79	68
12.....	86	74	63
14.....	81	70	58
16.....	76	65	54
18.....	72	61	50
20.....	68	56	45
22.....	63	52	40
24.....	58	47	36
26.....	54	43	32
28.....	50	38	27
30.....	45	34	22
32.....	40	29	18
34.....	36	25	14
36.....	32	20	9
38.....	27	16	4
40.....	22	11	0
42.....	18	7	0
44.....	14	2	0
45.....	11	0	0
46.....	9	0	0
48.....	4	0	0
50.....	0	0	0

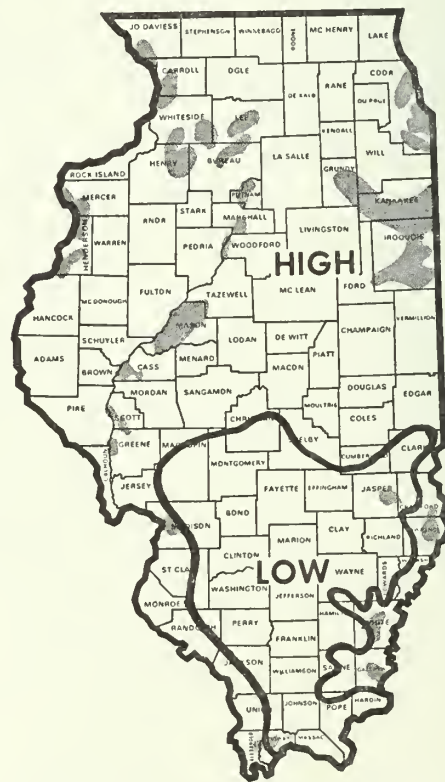
### Rate of Fertilizer Application

**Buildup.** Certain minimum phosphorus and potassium levels are needed in order to produce optimum crop yields.

Near maximum yields of corn and soybeans will be obtained when available phosphorus levels are maintained at 30, 40, and 45 pounds of phosphorus per acre for soils in the high, medium, and low phosphorus-supplying regions, respectively. However, since phosphorus will not be lost from the soil system other than through crop removal or soil erosion and since these are minimum values required for optimum yields, it is recommended that soil-test levels be built up to 40, 45, and 50 pounds per acre for soils in the high, medium, and low phosphorus-supplying regions, respectively. These values ensure that soil phosphorus availability will not limit crop yield.

Research has shown that, as an average for Illinois soils, 9 pounds of  $P_2O_5$  per acre are required to increase the  $P_1$  soil test by 1 pound. Therefore, the recommended rate of buildup phosphorus is equal to nine times the difference between the soil-test goal and the actual soil-test value. The amount of phosphorus recommended for buildup over a four-year period for various soil-test levels is presented in Table 46.

The rate of 9 pounds of  $P_2O_5$  to increase the soil test 1 pound is an average for Illinois soils. As a result, some soils will fail to reach the desired goal in four years



Potassium-supplying power. The shaded areas are sands with low potassium-supplying power. (Fig. 10)

with  $P_2O_5$  applied at this rate and others will exceed the goal. Therefore, it is recommended that each field be retested every four years.

The only significant loss of soil-applied potassium is through crop removal or soil erosion. Therefore, it is recommended that soil-test potassium be built up to values of 260 and 300 pounds of exchangeable potassium, respectively, for soils in the low- and high-cation-exchange capacity region. These values are slightly higher than that required for maximum yield, but as in the phosphorus recommendations this will ensure that potassium availability will not limit crop yields.

Research has shown that 4 pounds of  $K_2O$  are required, on the average, to increase the soil test 1 pound. Therefore, the recommended rate of potassium application for increasing the soil-test value to the desired goal is equal to four times the difference between the soil-test goal and the actual soil-test value. Tests on soil samples that are taken before May 1 or after September 30 should

Table 47. — Amount of Potassium ( $K_2O$ ) Required To Build Up the Soil (based on the buildup occurring over a four-year period; 4 pounds of  $K_2O$  per acre required to change the K test 1 pound)

K test <sup>a</sup> (lb./acre)	Amount of $K_2O$ to apply per acre each year for soils with cation exchange capacity:	
	Low <sup>b</sup>	High <sup>b</sup>
50.....	210	250
60.....	200	240
70.....	190	230
80.....	180	220
90.....	170	210
100.....	160	200
110.....	150	190
120.....	140	180
130.....	130	170
140.....	120	160
150.....	110	150
160.....	100	140
170.....	90	130
180.....	80	120
190.....	70	110
200.....	60	100
210.....	50	90
220.....	40	80
230.....	30	70
240.....	20	60
250.....	10	50
260.....	0	40
270.....	0	30
280.....	0	20
290.....	0	10
300.....	0	0

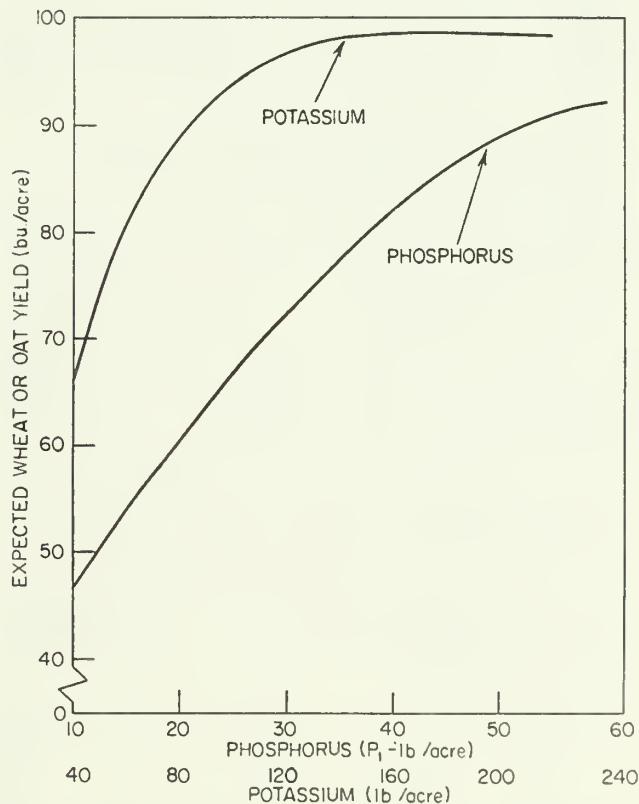
<sup>a</sup> Tests on soil samples that are taken before May 1 or after September 30 should be adjusted downward as follows: subtract 30 pounds for dark-colored soils in central Illinois; 45 pounds for light-colored soils in central and northern Illinois; and 60 pounds for medium- and light-colored soils in southern Illinois.

<sup>b</sup> The low cation-exchange capacity corresponds to soil areas designated low in potassium-supplying power, while high cation-exchange-capacity soils are those formerly designated medium to high in potassium-supplying power. Low cation-exchange-capacity soils would be those with CEC less than 12 me./100 g. soil, and high would be those equal to or greater than 12 me./100 g. soil.

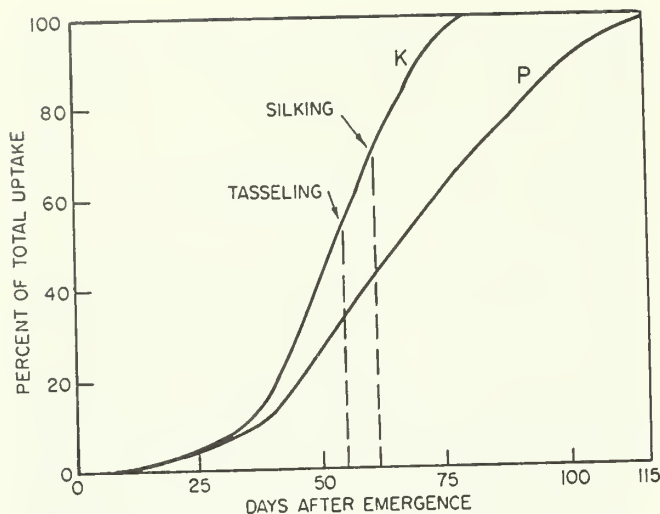
be adjusted downward as follows: subtract 30 for dark-colored soils in central Illinois; subtract 45 for light-colored soils in central and northern Illinois; subtract 60 for medium- and light-colored soils in southern Illinois; subtract 45 for fine-textured bottomland soils. Annual potassium application rates recommended for a four-year period for various soil test values are presented in Table 47.

In addition to the supplying power of the soil, the optimum soil-test value also is influenced by the crop to be grown. For example, the phosphorus soil-test level required for optimum wheat and oat yield is considerably higher than that for corn or soybeans, and the optimum level is the same irrespective of the phosphorus-supplying ability of the soil (Fig. 11). One reason for this difference in requirement is in part the different phosphorus uptake patterns of wheat and corn. Wheat requires a large amount of readily available phosphorus in the fall, when the plant root system is feeding primarily from the upper soil surface. Phosphorus is taken up by corn until the grain is fully developed (Fig. 12), so sub-soil phosphorus is more important in interpreting the phosphorus test for corn than for wheat. To compensate for the higher phosphorus requirements of wheat and oats, it is suggested that 1.5 times the maintenance application be applied prior to seeding them.

Wheat is not very responsive to potassium unless the soil test is less than 100. However, since wheat is usually



Relationship between expected wheat or oat yield and soil-test phosphorus and potassium. (Fig. 11)



Uptake of phosphorus (P) and potassium (K) by corn through the growing season (Hanway, Iowa State University). (Fig. 12)

grown in rotation with corn and soybeans, it is suggested that soils be maintained at the optimum available potassium level for corn and soybeans.

**Maintenance.** In addition to adding fertilizer to build up the soil test, sufficient fertilizer should be added each year to maintain a specified soil-test level. The amount of fertilizer required to maintain the soil-test value is equal to the amount removed by the harvested portion of the crop (Table 48). The only exception to this is that the maintenance value for wheat and oats is equal to 1.5 times the amount of phosphate ( $P_2O_5$ ) removed by the grain. This correction has already been accounted for in the maintenance values given in Table 45.

Although it is recommended that soil-test levels be maintained slightly above the level at which optimum yield would be expected, it would not be economical to attempt to maintain the values at excessively high levels. Therefore, it is suggested that no fertilizer be applied if  $P_1$  soil-test values are higher than 60, 65, or 70, respectively, for soils in the high, medium, and low phosphorus-supplying regions. Similarly, potassium fertilizer should not be applied if available "K" is higher than 360 and 400, respectively, for soils in the low and high cation-exchange-capacity regions, unless crops that remove large amounts of potassium (such as alfalfa) are being grown. When soils test between 400 and 600 pounds per acre of K and alfalfa is being grown, the soil should be tested every two years instead of four, or maintenance levels of potassium should be added to ensure that soil test levels are not depleted below the point where maximum yields will be obtained.

Examples of how to figure phosphorus and potassium fertilizer recommendations are presented below.

**Example 1.** Continuous corn with a yield goal of 140 bushels per acre:

(a) Soil-test results		Soil region
$P_1$	30	high
K	250	high

(b) Fertilizer recommendation, pounds per acre per year		
	$P_2O_5$	$K_2O$
Buildup	22 (Table 43)	50 (Table 44)
Maintenance	60 (Table 45)	39 (Table 45)
Total	82	89

**Example 2.** Corn-soybean rotation with a yield goal for corn of 140 bushels per acre and for soybeans of 40 bushels per acre:

(a) Soil-test results		Soil region
$P_1$	20	low
K	200	low

(b) Fertilizer recommendation, pounds per acre per year		
	$P_2O_5$	$K_2O$
<i>Corn</i>		
Buildup	68	60
Maintenance	60	39
Total	128	99
<i>Soybeans</i>		
Buildup	68	60
Maintenance	34	52
Total	102	112

Note that buildup recommendations are independent of the crop to be grown, but maintenance recommendations are directly related to the crop to be grown and the yield goal for the particular crop.

**Example 3.** Continuous corn with a yield goal of 150 bushels per acre:

(a) Soil-test results		Soil region
$P_1$	90	low
K	420	low

(b) Fertilizer recommendation, pounds per acre per year		
	$P_2O_5$	$K_2O$
Buildup	0	0
Maintenance	0	0
Total	0	0

Note that soil-test values are higher than those suggested; thus, no fertilizer would be recommended. Re-test the soil after four years to determine fertility needs.

For farmers planning to double crop soybeans after wheat, it is suggested that phosphorus and potassium fertilizer required for both the wheat and soybeans be applied prior to seeding the wheat. This practice will reduce the number of field operations necessary at planting time and will hasten the planting operation.

The maintenance recommendations for phosphorus and potassium in a double-crop wheat and soybean system are presented in Tables 49 and 50, respectively. Assuming a wheat yield of 50 bushels per acre followed by

a soybean yield of 30 bushels per acre, the maintenance recommendation would be 71 pounds of  $P_2O_5$  and 54 pounds of  $K_2O$  per acre.

**Table 48. — Maintenance Fertilizer Required for Various Yields of Crops**

Yield (Bu. or tons per acre)	$P_2O_5$	$K_2O$
<i>Pounds per acre</i>		
<b>Corn grain</b>		
90 bu.....	39	25
100.....	43	28
110.....	47	31
120.....	52	34
130.....	56	36
140.....	60	39
150.....	64	42
160.....	69	45
170.....	73	48
180.....	77	50
190.....	82	53
200.....	86	56
<b>Oats</b>		
50 bu.....	19	10
60.....	23	12
70.....	27	14
80.....	30	16
90.....	34	18
100.....	38	20
110.....	42	22
120.....	46	24
130.....	49	26
140.....	53	28
150.....	57	30
<b>Soybeans</b>		
30 bu.....	26	39
40.....	34	52
50.....	42	65
60.....	51	78
70.....	60	91
80.....	68	104
90.....	76	117
100.....	85	130
<b>Corn silage</b>		
90 bu.; 18T.....	48	126
100; 20.....	53	140
110; 22.....	58	154
120; 24.....	64	168
130; 26.....	69	182
140; 28.....	74	196
150; 30.....	80	210
<b>Wheat</b>		
30 bu.....	27	9
40.....	36	12
50.....	45	15
60.....	54	18
70.....	63	21
80.....	72	24
90.....	81	27
100.....	90	30
110.....	99	33
<b>Alfalfa, grass, or alfalfa-grass mixtures</b>		
2T.....	24	100
3.....	36	150
4.....	48	200
5.....	60	250
6.....	72	300
7.....	84	350
8.....	96	400
9.....	108	450
10.....	120	500

### Time of Application

Although the fertilizer rates for buildup and maintenance in Tables 43 through 47 are for an annual application, producers may apply enough nutrients in any one year to meet the needs of the crops to be grown in the succeeding two- to three-year period.

For perennial forage crops, broadcast and incorporate all of the buildup and as much of the maintenance phosphorus as economically feasible prior to seeding. On low-fertility soils, apply 30 pounds of phosphate ( $P_2O_5$ ) per acre using a band seeder. If a band seeder is used, you may safely apply a maximum of 30 to 40 pounds of potash ( $K_2O$ ) per acre in the band with the phosphorus. Up to 300 pounds of  $K_2O$  per acre can be safely broadcast in the seedbed without damaging seedlings.

Topdress applications of phosphorus and potassium on perennial forage crops may be applied at any convenient time. Usually this will be after the first harvest or in September.

### High Water Solubility of Phosphorus

The water solubility of the  $P_2O_5$  listed as available on the fertilizer label is of little importance under typical field crop and soil conditions on soils with medium to high levels of available phosphorus, when recommended rates of application and broadcast placement are used.

There are some exceptions when water solubility is important. These include the following:

1. For band placement of a small amount of fertilizer to stimulate early growth, at least 40 percent of the phosphorus should be water soluble for application to acid soils and preferably 80 percent for calcareous soils. As

**Table 49. — Maintenance Phosphorus Required for Wheat-Soybean Double-Crop System**

Wheat yield (bu./acre)	Soybean yield (bu./acre)				
	20	30	40	50	60
<i>P<sub>2</sub>O<sub>5</sub> (lb./acre)</i>					
30.....	44	53	61	69	78
40.....	53	62	70	78	87
50.....	62	71	79	87	96
60.....	71	80	88	96	105
70.....	80	89	97	105	114
80.....	89	98	106	114	123

**Table 50. — Maintenance Potassium Required for Wheat-Soybean Double-Crop System**

Wheat yield (bu./acre)	Soybean yield (bu./acre)				
	20	30	40	50	60
<i>K<sub>2</sub>O (lb./acre)</i>					
30.....	35	48	61	74	87
40.....	38	51	64	77	90
50.....	41	54	67	80	93
60.....	44	57	70	83	96
70.....	47	60	73	86	99
80.....	50	63	76	89	102

Table 51. — Characteristics of Some Common Processed Phosphate Materials

Material	Pct. P <sub>2</sub> O <sub>5</sub>	Pct. water soluble	Pct. citrate soluble	Total pct. available
Ordinary superphosphate 0-20-0	16-22	78	18	96
Triple superphosphate	44-47	84	13	97
Mono-ammonium phosphate 11-48-0	46-48	100	..	100
Diammonium phosphate 18-46-0	46	100	..	100
Ammonium polyphosphate 10-34-0 11-37-0	34-37	100	..	100

shown in Table 51, the phosphorus in nearly all fertilizers commonly sold in Illinois is highly water soluble. Phosphate water-solubility in excess of 75 to 80 percent has not been shown to give further yield increases above those that have water-solubility levels of 50 to 80 percent.

2. 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.

## Secondary Nutrients

The elements that are classified as secondary nutrients include calcium, magnesium, and sulfur. Deficiency of calcium has not been recognized in Illinois where soil pH is 5.5 or above. Calcium deficiency associated with acid soils should be corrected by the use of limestone adequate to correct the soil pH.

Magnesium deficiency has been recognized in isolated situations in Illinois. Although the deficiency is usually associated with acid soils, there have been instances of low magnesium reported on sandy soils where the soils were not excessively acid. The soils most likely to be deficient in magnesium include sandy soils throughout Illinois and low-exchange capacity soils of southern Illinois. Deficiency will be more likely where calcitic rather than dolomitic limestone has been used and where potassium test levels have been high (above 400). Suggested soil test magnesium levels are 60-75 pounds per acre on sandy soils and 120-150 pounds per acre on silt loam or finer textured soils for grain crops.

Recognition of sulfur deficiency has been reported with increasing frequency throughout the Midwest. These deficiencies probably are occurring because of (1) increased use of S-free fertilizer, (2) decreased use of sulfur as a fungicide and insecticide, (3) increased crop yields, resulting in increased requirements for all of the essential plant nutrients, and (4) decreased atmospheric sulfur supply.

Organic matter is the primary source of sulfur in soils. Thus soils low in organic matter are more likely to be deficient than are soils with a high level of organic matter. Since sulfur is very mobile and can be readily leached,

deficiency is more likely to be found on sandy soils than on finer textured soils.

Response to sulfur fertilization was observed at three out of 27 locations in Illinois in 1977. Two of the sites were eroded soils low in organic matter in northwestern Illinois. The third site was a soil high in organic matter in central Illinois. Research is continuing to aid in delineating soil areas and soil conditions where sulfur deficiency may occur.

Sulfur soil tests are available to aid in predicting where sulfur deficiency may occur. The most common procedure used for analysis is to extract the soil with a calcium phosphate solution. Using this procedure, soils containing less than 12 pounds per acre are considered deficient, soils containing 12 to 20 pounds per acre are marginal, and soils containing more than 20 pounds per acre have an adequate supply.

In addition to soil test values, one should also consider organic matter level, potential atmospheric sulfur contributions, subsoil sulfur content, and moisture conditions just prior to soil sampling in determining whether a sulfur response is likely. If organic matter levels are greater than 2.5 percent, use sulfur on a trial basis even when the soil test reading is low. If the field in question is located in an area downwind from industrial operations where significant amounts of sulfur are being emitted, use sulfur on a trial basis even when the soil test reading is low. Since sulfur is a mobile nutrient supplied principally by organic matter oxidation, abnormal precipitation (either high or low) could adversely affect the sulfur status of samples taken from the soil surface. If precipitation has been high just prior to sampling, some samples may have a low reading due to leaching. If precipitation were low and temperatures warm, some soils may have a high reading when in fact the soil is not capable of supplying adequate amounts of sulfur throughout the growing season.

## Micronutrients

The elements that are classified as essential micronutrients include zinc, iron, manganese, copper, boron, molybdenum, and chlorine. These nutrients are classified as micronutrients because they are required in small (micro) amounts. Confirmed deficiencies of these micronutrients in Illinois have been limited to boron deficiency of alfalfa, zinc deficiency of corn, and iron and manganese deficiency of soybeans.

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

Table 52. — Soil Situations and Crops Susceptible to Micronutrient Deficiency

Micronutrient	Sensitive crop	Susceptible soil situations	Season favoring deficiency
Zinc (Zn)	Young corn	<ol style="list-style-type: none"> <li>1. Low organic matter either inherent or because of erosion or land shaping</li> <li>2. High pH, i.e. &gt;7.3</li> <li>3. Very high phosphorus</li> <li>4. Restricted root zone</li> <li>5. Coarse textured (sandy)</li> <li>6. Organic soils</li> </ol>	Cool, wet
Iron (Fe)	Wayne soybeans, grain sorghum	<ol style="list-style-type: none"> <li>1. High pH</li> </ol>	Cool, wet
Manganese (Mn)	Soybeans, oats	<ol style="list-style-type: none"> <li>1. High pH</li> <li>2. Restricted root zone</li> <li>3. Organic soils</li> </ol>	Cool, wet
Boron (B)	Alfalfa	<ol style="list-style-type: none"> <li>1. Low organic matter</li> <li>2. High pH</li> <li>3. Strongly weathered soils in south-central Illinois</li> <li>4. Coarse textured (sandy)</li> </ol>	Drought
Copper (Cu)	Corn	<ol style="list-style-type: none"> <li>1. Infertile sand</li> <li>2. Organic soils</li> </ol>	Unknown
Molybdenum (Mo)	Soybeans	<ol style="list-style-type: none"> <li>1. Strongly weathered soils in south-central Illinois</li> </ol>	Unknown
Chlorine (Cl)	Unknown	<ol style="list-style-type: none"> <li>1. Coarse-textured soils</li> </ol>	Excessive leaching by low Cl water

the soil is ineffective because the manganese becomes unavailable in soils with a high pH.

Wayne and Hark soybean varieties often show iron deficiency on soils with a very high pH (usually 7.4 to 8.0). The symptoms are similar to 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 has 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 a 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.

Recent research in Minnesota has shown that time of iron application is critical if an effective control is to be attained. Researchers recommend that a rate of 0.15 pound iron per acre as iron chelate be applied to leaves within 3 to 7 days after chlorosis symptoms develop (usually in the second trifoliate stage of growth). Waiting for soybeans to grow to the fourth or fifth trifoliate stage before applying iron did not result in a yield increase. Because iron applied to the soil surface between rows does not help, directed applications directly over the soybean plants are preferred.

Corn yield response to zinc fertilization was observed

at three out of 27 locations in Illinois in 1977. All responding soils were in northwestern Illinois in 1977. Two of the locations were on eroded sites low in organic matter and the third was on a sandy soil which had an excessively high phosphorus level. Response to zinc was not observed at any of the other 24 locations studied, even though six of these other locations had low or marginal zinc soil test levels. On the basis of the results obtained in 1977, deficiency of zinc does not seem to be widespread in Illinois. Identification of the deficiency at some locations, however, indicates that we need to continue to look for zinc deficiency, especially under soil situations conducive to the problem.

In order to identify areas before micronutrient deficiencies become important, we need to continually observe the most sensitive crops in soil situations in which the elements are most likely to be deficient (Table 52).

In general, deficiencies of most micronutrients are accentuated by one of five situations: (1) strongly weathered soils, (2) coarse-textured soils, (3) soils high in pH, (4) organic soils, and (5) soils inherently low in organic matter or low in organic matter because of removal of topsoil by erosion or land-shaping processes.

The use of micronutrient fertilizers should be limited to the application of specific micronutrients to areas of known deficiency. Only the deficient nutrient should be applied. An exception to this would be when farmers already in the highest yield bracket try micronutrients on an experimental basis in fields that are yielding less than would be expected under good management, which includes an adequate nitrogen, phosphorus, and potassium fertility program and a favorable pH.

## Method of Fertilizer Application

Broadcast and row fertilization. On high-fertility soils, both maintenance and buildup phosphorus will be efficiently utilized when broadcast and plowed or disked in. However, on low-fertility soils it would be advisable to broadcast the buildup fertilizer and apply the maintenance fertilizer in the row. Farmers in central and northern Illinois who plant early may find it advantageous to apply some row fertilizer for promotion of early vigorous growth in soils that remain cool and wet in early spring.

“Pop-up” fertilization. “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 “pop-up” application or by fertilizer that is placed in a band to the side and below the seed. With these two placements there seldom will be a difference of more than a few days in the time the root system intercepts the fertilizer band.

“Pop-up” fertilization means placing 40 to 50 pounds of fertilizer per acre 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 tube from the fertilizer hopper is positioned to do this; the fertilizer is not mixed with the seed prior to planting.

“Pop-up” fertilizer should contain all three major nutrients in a ratio of about 1-4-2 of N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O (1-1.7-1.7 of N-P-K). The maximum safe amount of N + K<sub>2</sub>O for “pop-up” placement is about 10 to 12 pounds per acre in 40-inch rows and correspondingly more in 30- and 20-inch rows. It is, in fact, necessary to apply more in narrow rows to have an equal amount per foot of corn row.

The term “pop-up” is a misnomer. The corn does not emerge sooner than it does without this kind of application, and it may come up 1 or 2 days later. The corn may, however, grow more rapidly during the first 1 to 2 weeks after emergence.

“Pop-up” fertilizer is unsafe for soybeans. In research conducted at Dixon Springs by George McKibben, a stand was reduced to one-half by applying 50 pounds of 7-28-14 and to one-fifth with 100 pounds of 7-28-14.

Foliar fertilization. Researchers have known for many years that plant leaves absorb and utilize nutrients sprayed on them. Foliar fertilization has been successfully used for certain crops and nutrients. This method of application has had the greatest use with nutrients required in only small amounts by plants. Nutrients required in large amounts, such as nitrogen, phosphorus, and potassium, have usually been applied to the soil rather than to plant foliage.

The possible benefit of foliarly applied nitrogen fertilizer was researched at the University of Illinois in the 1950's. Foliarly applied nitrogen increased corn and wheat yield, provided that the soil was deficient in ni-

Table 53. — Yields of Corsoy and Amsoy Soybeans After Fertilizer Treatments Were Sprayed to the Foliage Four Times, Urbana

Treatment per spraying, lb./acre				Yield, bu./acre	
N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	Corsoy	Amsoy
0	0	0	0	61	56
20	0	0	0	54	53
0	5	8	1	58	56
10	5	8	1	56	58
20	5	8	1	55	52
30	7.5	12	1.5	52	46

trogen. Where adequate nitrogen was applied to the soil, additional yield increases were not obtained from foliar fertilization.

Additional research in Illinois was conducted on foliar application of nitrogen to soybeans in the 1960's. This effort was an attempt to supply additional nitrogen to soybeans without decreasing nitrogen symbiotically fixed. That is, it was thought that if nitrogen application was delayed until after nodules were well established, then perhaps symbiotic fixation would remain active. Single or multiple applications of nitrogen solution to foliage did not increase soybean yields. Damage to vegetation occurred in some cases because of leaf “burn” caused by the nitrogen fertilizer.

Although considerable foliar fertilization research had been conducted earlier in Illinois, new research was conducted in 1976 and 1977. This new research was prompted by a report from a neighboring state which indicated that soybean yields had recently been increased by as much as 20 bushels per acre in some trials. Research in that state differed from our earlier work on soybeans in that, in addition to nitrogen, the foliar fertilizer increased yield only if phosphorus, potassium, and sulfur were also included. Researchers there thought that soybean leaves became deficient in nutrients as nutrients were translocated from vegetative parts to the grain during grain development. They reasoned that foliar fertilization, which would prevent leaf deficiencies, should result in increased photosynthesis that would be expressed in higher grain yields.

Foliar fertilization was conducted at several locations in Illinois during 1976 and 1977 — ranging from Dixon Springs in southern Illinois to DeKalb in northern Illinois. None of the experiments gave economical yield increases. In some cases there were yield reductions, which were attributed to leaf damage caused by the fertilizer. Table 53 contains data from a study at Urbana where soybeans were sprayed four times with various fertilizer solutions. Yields were not increased by foliar fertilization.

## 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 does not contain strong acids that kill soil bacteria and earthworms.

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.

Agronomists can often refute the specific claims of the quacks on theory and with research results, but then the

quacks come up with new claims or fall back on the old cliché, "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 about purchasing new products or accepting a sales agency for them.

## SOIL MANAGEMENT AND TILLAGE SYSTEMS

Intensive use of a moldboard plow, disk, harrow, and cultivator was once the only practical tillage system that could give the crop producer reasonable assurance of establishing a crop and controlling weeds. Modern herbicides and implements have made alternatives to the traditional intensive tillage system possible. When choosing a tillage system, one should consider crop yields, costs, and soil erosion. With these areas in mind, one must evaluate the tillage method as it relates to soil type, slope, drainage, and temperature, timeliness, and fertilizer distribution, and each method's potential for weed, insect, and disease control.

The following four sections describe tillage systems used in Illinois and list some advantages and disadvantages of each.

### Moldboard Plow System (Conventional Clean Tillage)

Primary tillage is done with a moldboard plow. Secondary tillage includes one or more operations with a disk, field cultivator, harrow, or similar implement.

#### Advantages

1. The uniform fine seedbed gives good seed-soil contact and easy planting.
2. Insecticides and herbicides are most effective in a uniform, fine seedbed that is free of crop residues.
3. Survival of some insects, especially European corn borer, is reduced because corn stalk residues are buried.
4. The system is flexible and adaptable to a wide range of soil and crop conditions.
5. Use of labor and machinery is reasonably well distributed with fall plowing.
6. Yields are as high as or higher than with alternative tillage systems over a wide range of soil and weather conditions.
7. A wide selection of herbicides can be used, and weed control is usually better than with alternative tillage systems.

#### Disadvantages

1. Bare soil is very susceptible to wind and water erosion.
2. Soil crusting is often a problem with a uniform fine seedbed.
3. Fuel consumption and machinery costs are high.

### Chisel Plow System

Primary tillage is done with a chisel plow, usually in the fall, followed by use of a disk or field cultivator in the spring.

#### Advantages

1. Machinery costs are slightly lower than with moldboard plowing due to lower energy requirements per acre.

2. The soil surface is rough and partially covered by crop residues that reduce raindrop impact and runoff, resulting in more water infiltration and less soil erosion.

3. Soil roughness and residues protect the soil from wind erosion.

4. Less time is required for primary tillage compared to that for moldboard plowing.

5. Yields are comparable to other tillage systems, especially on well-drained soils. On poorly drained soils, the chisel plow system can be used for at least three or four years before moldboard plowing without any significant yield decrease.

#### Disadvantages

1. If secondary tillage is incomplete, a heavy planter with disk openers and a coulter in front of each row may be needed for planting in rough, residue-covered soil.

2. Soil temperatures are lower, especially on poorly drained soils, resulting in slightly slower early corn growth in the northern two-thirds of Illinois.

3. Stands are sometimes slightly lower than with conventional tillage.

4. A tractor must be available with adequate horsepower to pull a chisel plow.

5. Slightly higher herbicide rates may be required to give satisfactory weed control.

6. Crop residues on the soil surface may harbor insects and disease-causing organisms.

7. Erosion control may be lost in the spring if excessive spring tillage is used.

### Disk System

A heavy disk is used for primary tillage in the fall or spring. A field cultivator or a light disk is used for secondary tillage. The general advantages and disadvantages of the chisel plow system apply to the disk system, provided that the disk is set to produce a rough soil surface covered with some crop residues.

### No-Tillage System (Zero-Tillage)

Seed is planted in previously undisturbed soil by means of a special heavy planter equipped to plant through residue in firm soil. Fertilizers and pesticides must be applied to the soil surface or in the narrow, tilled area of the row. Weeds growing at planting are killed with a contact herbicide.

#### Advantages

1. Power, labor, and fuel costs are greatly reduced compared to those resulting from other tillage systems.

2. The planter can be used in crop residues, sod, or in a conventionally tilled seedbed.

3. Soil erosion is greatly reduced compared to that from other systems.

4. Plant residues on the soil surface reduce evaporation, conserving soil moisture for use by the crop.

## Disadvantages

1. Low soil temperatures often delay emergence and cause slow early growth.

2. Special planting equipment is needed. It is difficult to get adequate seed-soil contact, a uniform planting depth, and uniform seed cover with most available planters.

3. Rodents and birds may reduce stands.

4. Some insect and crop disease problems may be enhanced when crop residues are left on the soil surface.

5. Weed control is entirely dependent on herbicides since cultivation is nearly impossible in heavy residues.

6. Higher herbicide rates or more costly herbicide combinations are usually needed for adequate weed control.

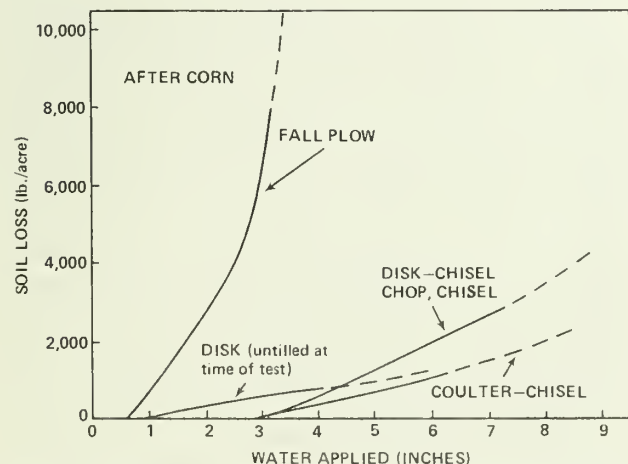
7. Water runoff is comparable to that from the moldboard plow system.

## Soil Erosion and Tillage

Bare, smooth soil left by moldboard plowing and intensive secondary tillage is extremely susceptible to soil erosion. Many Illinois soils have subsurface layers that are unfavorable for root development. Soil erosion slowly but permanently removes the soil that is most favorable for crop growth, resulting in gradually decreasing soil productivity and value. Even on soils without root-restricting subsoils, erosion removes nutrients that must be replaced with additional fertilizer to maintain yields.

Sediment from eroding fields increases water pollution, reduces the storage capacity of lakes and reservoirs, and decreases the efficiency of drainage systems.

Effective erosion control systems usually include one or more of three features: (1) the soil is protected with a cover of vegetation, such as a mulch of crop residue; (2) the soil is tilled so that a maximum amount of water is absorbed with a minimum of runoff; (3) long slopes are divided into a series of short slopes so that the water cannot get "running room."



Soil loss following corn and before spring tillage (1974). (Fig. 13)

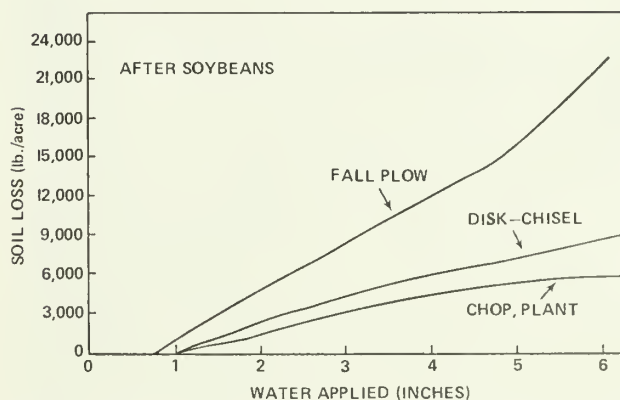
Chisel plow, no-tillage, and other tillage systems that leave a protective mulch of crop residues at the soil surface, or that leave the soil surface rough and porous, are often called conservation tillage systems. Figures 13 and 14 illustrate the effectiveness of these conservation tillage systems in reducing soil erosion from a 5-percent slope in simulated rainfall tests on a Catlin silt loam at Urbana. Nearly 1,000 pounds of soil per acre was lost from a moldboard-plowed area subjected to 1.25 inches of intense rain. Nearly 4 inches of water was required to erode that amount of soil where a chisel plow, disk, or no-tillage system was used. Soil erosion after soybeans was considerably greater than after corn, but conservation tillage resulted in greatly reduced soil loss compared to that from moldboard plowing.

Conservation tillage will not completely control water erosion on all soils; contouring is necessary for all tillage systems on sloping soils. Chisel plows, for example, often leave shallow furrows that can concentrate rainwater and erode severely if the tillage direction is uphill and down. Long or steep slopes may also require terraces or other practices. Contact your district conservationist, Soil Conservation Service for technical assistance in developing erosion control systems.

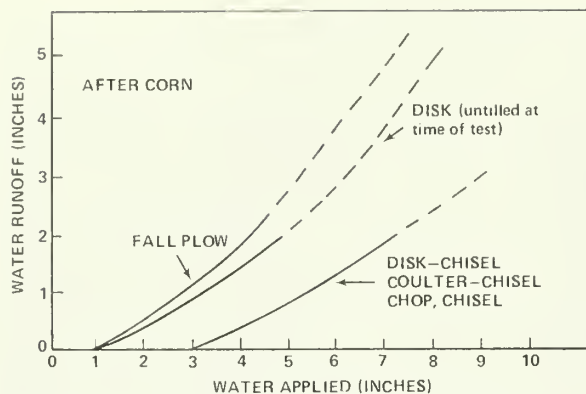
## Water and Nutrient Losses

Water runoff starts earliest on soils with the smoothest surfaces, such as those created by moldboard plow, disk, and zero-tillage systems. Since the rough surface of chisel-plowed soil provides barriers to runoff, more water is required before runoff occurs.

Of the first 4 inches of water applied before spring tillage after corn in the simulated rainfall tests at Urbana, the runoff was 2 inches from fall-plowed soil, 1.5 inches from untilled soil, and less than 0.25 inch from chisel-plowed soil (Figure 15). Differences in runoff after planting were not as great because the soil surface was smoothed by secondary tillage and planting operations.



Soil loss following soybeans and before spring tillage (1974). (Fig. 14)



Water runoff for tillage treatments after corn. (Fig. 15)

Runoff after soybeans was much higher than after corn, and there were only slight differences between treatments (Figure 16). Thus, runoff after soybeans is very difficult to control with common tillage systems.

Only small amounts of nitrogen and phosphorus were lost in runoff water with any of the tillage systems. Measurements of total nitrogen and total phosphorus losses correlated directly with soil losses. Thus, most nutrient losses will be controlled if soil erosion is controlled.

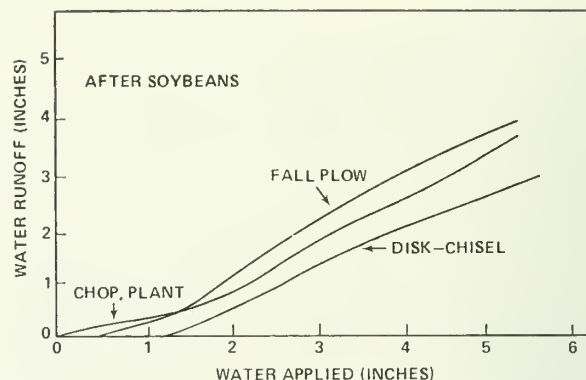
### Crop Production With Conservation Tillage

Crop germination, emergence, and growth are largely regulated by soil temperature, moisture content, and nutrient placement. Tillage practices influence each of these components of the soil environment. Conservation tillage systems differ from conventional clean tillage in several respects.

**Soil temperature.** Crop residue on the soil surface insulates the soil from the sun's energy. Higher soil temperatures than normal are desired for early plant growth. Later in the season, cooler temperatures than normal are desired, but complete crop canopy at that time restricts any influence crop residue might have on soil temperature.

Minimum soil temperatures occur between 6 and 8 a.m. Tillage or crop residue has little effect on minimum soil temperature. Maximum soil temperatures at a depth of 4 inches occur between 3 and 5 p.m. During May, fields tilled by the fall-plow method have soil temperatures 3° to 5° F. warmer than those with a mulch of cornstalks.

The main effect of tillage on soil temperature occurs from late April until the crop forms a canopy that shades the soil surface. During May and early June, the lower soil temperatures caused by a mulch are accompanied by slower growth of corn and soybeans. The growth differences are greatest in years with above-normal rainfall. In dry years, there is little difference in early growth. Whether the lower soil temperature and subsequent slower early growth result in reduced yields depends largely on weather conditions during the summer, par-



Water runoff for tillage treatments after soybeans. (Fig. 16)

ticularly during tasseling and silking. Slower growth may delay this process until weather conditions are better, but best yields normally occur when corn tassels and silks early.

**Soil moisture.** Surface mulch reduces evaporation. Wetter soil is an advantage in dry summer periods, but a disadvantage at planting time and during early growth on soils with poor internal drainage.

**Stand establishment.** Good contact between the seed and moist soil, uniform planting depth, and enough loose soil to cover the seed are necessary to produce uniform stands. Shallower than normal planting in the cool, moist soil common to many conservation tillage seedbeds may partially offset the disadvantage of lower temperatures, providing that a uniform depth is maintained and seeds are covered. Check planter adjustments frequently.

Planters must be equipped to handle the large amounts of crop residue and firm soil in no-till and some other conservation tillage seedbeds. A coultter, sweep, chisel, or other narrow tillage device must be mounted ahead of the planter unit to handle residue in the row area and open a slot in the soil for seed placement. Extra weight on the planter may be necessary to penetrate firm, undisturbed soil.

**Fertilizer placement.** Phosphorus and potassium fertilizers and limestone are not mobile in the soil; they remain at or near the soil surface unless they are moved by a tillage operation. This movement is least with a no-till system and greatest when soils are moldboard plowed. Research has shown that surface-applied fertilizers remain in the upper 2 inches of soil with no-till; in the upper 3 to 4 inches with chisel plow or disk tillage; and are uniformly distributed throughout the plowed layer when the tillage system includes moldboard plowing. Roots can use nutrients placed close to the surface with conservation tillage because the crop residue mulch tends to keep soil moist. Experiments in Illinois indicate that nonuniform distribution of fertility with conservation tillage does not reduce yields and should not be a major concern in deciding to adopt a conservation tillage system.

Nitrogen can be applied to the soil surface or injected as anhydrous ammonia or low pressure solutions. A coulter mounted ahead of the applicator knife may be needed if anhydrous ammonia is applied through heavy trash. Care must be taken to insure a good seal behind the applicator; special packing wheels may be needed for the firm soil of no-tillage systems. Surface-applied solutions containing urea as the nitrogen carrier are subject to nitrogen loss unless incorporated or moved into the soil by rain. Large amounts of surface trash can interfere with soil entry and increase the potential for loss. Surface-applied ammonium nitrate has been from 10 to 20 percent more efficient than urea for no-till corn in Illinois experiments.

Research indicates that from 10 to 20 percent more nitrogen may be required for no-till than for conventional tillage. This need may result from a reduced rate of nitrogen release from organic matter caused by the lower soil temperature, and from an increased potential for denitrification losses caused by the wetter soils.

## Weed Control

Weed control is essential for profitable crop production with any tillage system. Cloddy soil surfaces and crop residues left by some tillage systems interfere with herbicide distribution and incorporation. Herbicide rates must not be skimpy, especially with conservation tillage. (Consult the *Illinois Field Crops Weed Control Guide*, page 58, for specific herbicide recommendations.)

**Problem weeds.** Perennial weeds such as milkweed and hemp dogbane may be a greater problem with conservation tillage systems. Current programs for control of weeds such as johnsongrass and yellow nutsedge call for high rates of preplant herbicides that should be thoroughly incorporated. Wild cane is another weed that is best controlled by preplant, incorporated herbicides. Volunteer corn is often a problem with tillage systems that leave the corn relatively shallow. Surface germinating weeds, such as fall panicum and crabgrass, may also increase with reduced tillage systems unless control programs are monitored closely.

**Herbicide application.** Surface-applied and incorporated herbicides will not give optimal performance under tillage systems that leave large amounts of crop residue and clods on the soil surface. These problems interfere with herbicide distribution and thorough herbicide incorporation.

Herbicide incorporation is impossible in no-till systems. Residual herbicides must be effective since mechanical cultivation is usually impossible. Residual herbicide rates may need to be higher under no-till and reduced tillage systems because of herbicide tie-up on crop residues. Increasing the volume of spray per acre in heavy vegetation or residues may improve control. Up to 60 gallons of water per acre may be needed for no-till in dense sod.

**Cultivation.** Cultivation is possible with all tillage systems except no-till with heavy trash.

High amounts of crop residues may, however, interfere with rotary hoes and sweep cultivators. Disk cultivators will work, but may tend to bury too much of the residue for effective moisture conservation. Rolling cultivators are effective across a wide range of soil and crop residue conditions.

**Herbicide carryover.** Herbicide carryover potential is greater in conservation tillage systems because higher herbicide rates may be needed, and because there is less dilution of herbicides with the soil when moldboard plowing is not done. Herbicide carryover is affected by climatic factors and soil conditions. Warm, wet weather and soils lead to faster breakdown than do cool, dry conditions. Soils with a pH above 7.4 tend to have greater atrazine carryover problems than those with pH values from 6.0 to 7.3.

The carryover problem can be reduced by using less of the more persistent herbicides in combination with other herbicides, or by using less persistent herbicides. Early application of herbicides reduces the potential for herbicide carryover.

Carryover can be detected by growing a sensitive species (bioassay) in soil samples from suspected fields to detect harmful levels of persistent herbicides. Carryover is not a problem if the same crop or a tolerant species is to be grown the next cropping season.

**No-till weed control.** Existing weed growth is destroyed before planting in conventional and in most conservation tillage systems. No-till systems require a knock-down herbicide like Paraquat or Roundup to control existing vegetation. This vegetation may be a grass or legume sod, or early germinating annual and perennial weeds. Alfalfa, maretail, and certain perennial broadleaf weeds will not be controlled by Paraquat. It may be necessary to treat these with Banvell or 2,4-D either before Paraquat application or after regrowth. Do not apply these translocated herbicides with Paraquat since the contact action to the foliage may prevent translocation.

## Insect Control

Insects should not limit the adoption of conservation tillage systems. Most soil insect problems in corn that might be magnified by conservation tillage practices can be controlled with soil insecticides applied at planting. Outbreaks of above ground foliage-feeding pests can be controlled with properly timed sprays. Close monitoring of fields with insect outbreaks is very important.

Insect populations are greatly affected by soil texture, chemical composition, moisture content, temperature, and organisms in soils. Tillage operations affect some of these soil conditions and change the environment in which the insects must survive. Some tillage operations favor specific pests while others tend to reduce pest

problems. Since insect species differ in life cycles and habits, each must be considered separately.

Northern and western corn rootworms are the primary soil insect pests of corn in Illinois. Damage is primarily confined to corn following corn. Additional research on the effects of conservation tillage on rootworm populations is needed. General observations by entomologists and farmers indicate that conservation tillage practices may favor increased winter survival of rootworm eggs. Fall or spring plowing have produced highly variable results on rootworm survival in Illinois tests. Moldboard plowing is not recommended as a control measure for corn rootworms.

European corn borer larvae overwinter in corn stalk residues. Tillage systems that leave corn stalks on the surface could result in increased populations of first-generation moths and subsequent damage by the first brood in late June or early July.

Black cutworm outbreaks in corn appear more frequently with conservation tillage systems than in conventionally tilled fields, probably because cutworm moths deposit eggs on vegetation or surface debris. Recent research by the Illinois Natural History Survey suggests that egg-laying occurs prior to planting. Chickweed and other winter annual weeds not buried by tillage serve as hosts for egg-laying and cutworm survival. These preliminary observations indicate that both weeding and tillage practices contribute to cutworm problems.

### No-Till Pest Problems

Insect problems occur more frequently in no-till corn than in other conservation tillage systems, and are often more serious. No-till gives pests a stable environment for survival and development. Soil insecticides can be profitably applied to corn following grass sod or in any rotation where grass and weeds are prevalent. It does not generally pay to apply a soil insecticide to no-till corn following corn (except in rootworm infested areas), soybeans, or a small grain. A diazinon planter-box seed treatment should, however, be used to protect against damage by seed-corn beetles and seed-corn maggots.

Table 54 provides information on the effects of tillage practices on pest problems in corn, based on estimates of extension entomologists.

**Disease control.** The potential for plant disease is greater when mulch is present than it is when fields are clear of residue. With clean tillage, residue from the previous crop is buried or otherwise removed. Since buried residue is subject to rapid decomposition, infected residue is likely to be removed through decay.

Volunteer corn is likely to be a problem unless the soil is moldboard-plowed in the fall or the zero-till system is used. If the volunteer corn is a disease-susceptible hybrid, the possibility for early infection with diseases such as southern corn leaf blight increases.

Table 54. — Estimate of the Effect of Different Tillage Practices on Insect Populations in Corn<sup>a</sup>

Pest	Spring plowing	Fall plowing	Reduced tillage	No-till <sup>b</sup>	Effective chemical control <sup>c</sup>
Seed-corn beetles ..	0	0	?	+	Yes
Seed-corn maggots .	0	0	?	+	Yes
Wireworm .....	0	—	?	+(Sod)	Yes
White grubs .....	0	—	?	+(Sod)	No
Corn root aphids...	—	—	?	+(Sod)	?
Corn rootworm ....	— <sup>d</sup>	— <sup>d</sup>	+ <sup>d</sup>	+(Corn)	Yes
Black cutworms ...	?	?	?	+	Yes
Billbugs .....	—	—	—	+(Sod)	Yes
European corn borer	—	—	+	+	Yes
True armyworms ..	—	—	—	+(Sod)	Yes
Common stalk borer	—	—	—	+	No
Slugs .....	—	—	—	+	No
Mice .....	—	—	—	+(Sod)	Yes

<sup>a</sup> + = the practice will increase the populations or potential for damage by the pest.

— = it will reduce the population or potential for damage.

0 = no effect on the pest.

? = effect unknown on the pest.

<sup>b</sup> The preceding crop will have a direct influence on the pest problem(s) in no-till corn.

<sup>c</sup> More specific information on insect pest management is presented in the current *Insect Pest Management Guide — Field and Forage Crops*. This circular is revised annually; only the latest edition should be used.

<sup>d</sup> Results, based on general observation, are tentative.

Although the potential for plant disease is greater with mulch tillage than with clean tillage, the erosion control benefit of mulch tillage is great. This benefit needs to be balanced against the increased potential for disease. Disease-resistant hybrids and varieties can be used to reduce problems of plant disease. Crop rotation or modification of the tillage practice may be justified if a disease problem appears likely.

### Crop Yields

Conservation tillage systems have produced yields comparable to those from conventional tillage on most Illinois soils when stands are adequate and pests are controlled. Yields on poorly drained fine-textured soils (silty clay loam, silty clay, and clay) have been consistently higher when soils are moldboard-plowed after corn. Soils with root-restricting claypan or fragipan subsoils, on the other hand, have frequently produced higher corn yields where moisture conserving conservation tillage is used (Table 55).

Symerton silt loam is a dark prairie soil with good internal drainage that is free of root restricting layers in the upper 40 to 48 inches. Yields with chisel plow and conventional systems have been nearly identical. No-till corn yields are lower due to inadequate weed control.

Drummer silty clay loam is a dark, heavy, poorly drained prairie soil that is sticky and compacts easily if tilled when wet. A cornstalk mulch with chisel, disk, or zero-tillage results in slow early growth and lower yields. Corn yields with chisel and spring disk systems are similar to yields with conventional tillage following soybeans.

Cisne silt loam is a poorly drained claypan soil that is common in south-central Illinois. The claypan subsoil restricts root development and water use by the crop.

Table 55. — Corn Yields with Plow, Chisel, and No-Tillage Systems

Tillage system	Well drained Symerton silt loam <sup>a</sup>	Poorly drained Drummer silty clay loam <sup>b</sup>	Claypan Cisne silt loam <sup>c</sup>	Fragipan Grantsburg silt loam <sup>d</sup>
	<i>Bushels per acre</i>			
Moldboard plow . . .	112	165	87	112
Chisel plow . . . . .	110	159	114	
No-till . . . . .	99	144	108	115

<sup>a</sup> Elwood, 1972-75.  
<sup>b</sup> Urbana, 1974-77.  
<sup>c</sup> Brownstown, 1974-77.  
<sup>d</sup> Dixon Springs, 1967-76.

Reduced evaporation with the cornstalk mulch of chisel and zero-till systems conserves water for crop use, frequently resulting in higher yields than with clean tillage.

Grantsburg silt loam is a light-colored, sloping soil that is common in southern Illinois. A dense hardpan or fragipan in the subsoil restricts root development. The residue mulch with conservation tillage frequently produces higher yields as a result of moisture conservation.

### Production Costs

Will the switch from a conventional moldboard plow system to a conservation tillage system be profitable? The answer depends on whether one weighs the importance of three primary factors: costs, yields, and erosion control.

The tillage system used on a farm in part determines the most efficient and profitable machinery set. A reduction in machinery costs per acre can be expected if total and peak power requirements are reduced, and if a complete change is made to a conservation tillage system. Purchasing new equipment for the conservation tillage system will not decrease machinery costs, and may in-

Table 56. — Estimated Costs of Machinery and Pesticides With Different Tillage Systems

Tillage system	Machinery related <sup>a</sup>	Pesticides	Total
	<i>Dollars per acre</i>		
Fall plow . . . . .	33	8-22	41-55
Spring plow . . . . .	36	8-22	44-58
Chisel . . . . .	31	8-22	39-53
Disk . . . . .	28	8-22	36-50
No-Till . . . . .	22	18-32	40-54

<sup>a</sup> Machinery-related costs include fixed and variable machinery costs, labor at \$5 per hour, and timeliness.

crease them, if the same tractors and equipment from the other tillage system are maintained. For example, the machinery cost per acre is not reduced if a plow, disk, and other conventional tillage equipment are maintained and used occasionally with an otherwise no-till system.

Reduced manpower and machine hours can be an advantage for reduced tillage systems. It must be pointed out, however, that equipment must be selected to suit the farm size and tillage system if reduced machinery costs are to be realized. Labor time can be reduced with a no-tillage system because there are no fall tillage operations. In such a situation, the combine size could be reduced to use the additional labor or the additional labor could be applied to other productive activities.

Additional or more expensive pesticides and fertilizers (for example, a contact herbicide for no-tillage systems) can increase the cost of a conservation tillage system. On the other hand, fuel costs and other machinery-related costs are reduced with less tillage. Fuel conservation is a benefit of reduced-tillage systems, but savings in fuel and machinery costs are likely to be offset by additional costs for pesticides. Therefore, the total cost factor shows no clear advantage for any reasonable tillage system if equivalent yields are obtained (Table 56).

## IRRIGATION

Since Illinois receives an average of 36 inches of precipitation annually and has a potential moisture loss through evapotranspiration (E.T.) of only 30 inches, need we be interested in irrigation? Even though there is a year now and then when rainfall is below normal, do these occur frequently enough to justify the expense of buying irrigation equipment, or of developing a water source, and of applying the water? The answer is *yes* for a growing number of farmers in Illinois.

While it is true that every section of Illinois normally receives more water as rain and snow each year than is lost by E.T., at some time during the growing season soil moisture is not sufficient for optimum crop growth.

At least 20 inches of water are needed to produce a good crop of corn or soybeans in Illinois with current cultural practices. All sections of the state average at least 15 inches of rain during the four-month period of May through August. Thus at least five inches of stored subsoil moisture are needed in a "normal" year to produce satisfactory yields.

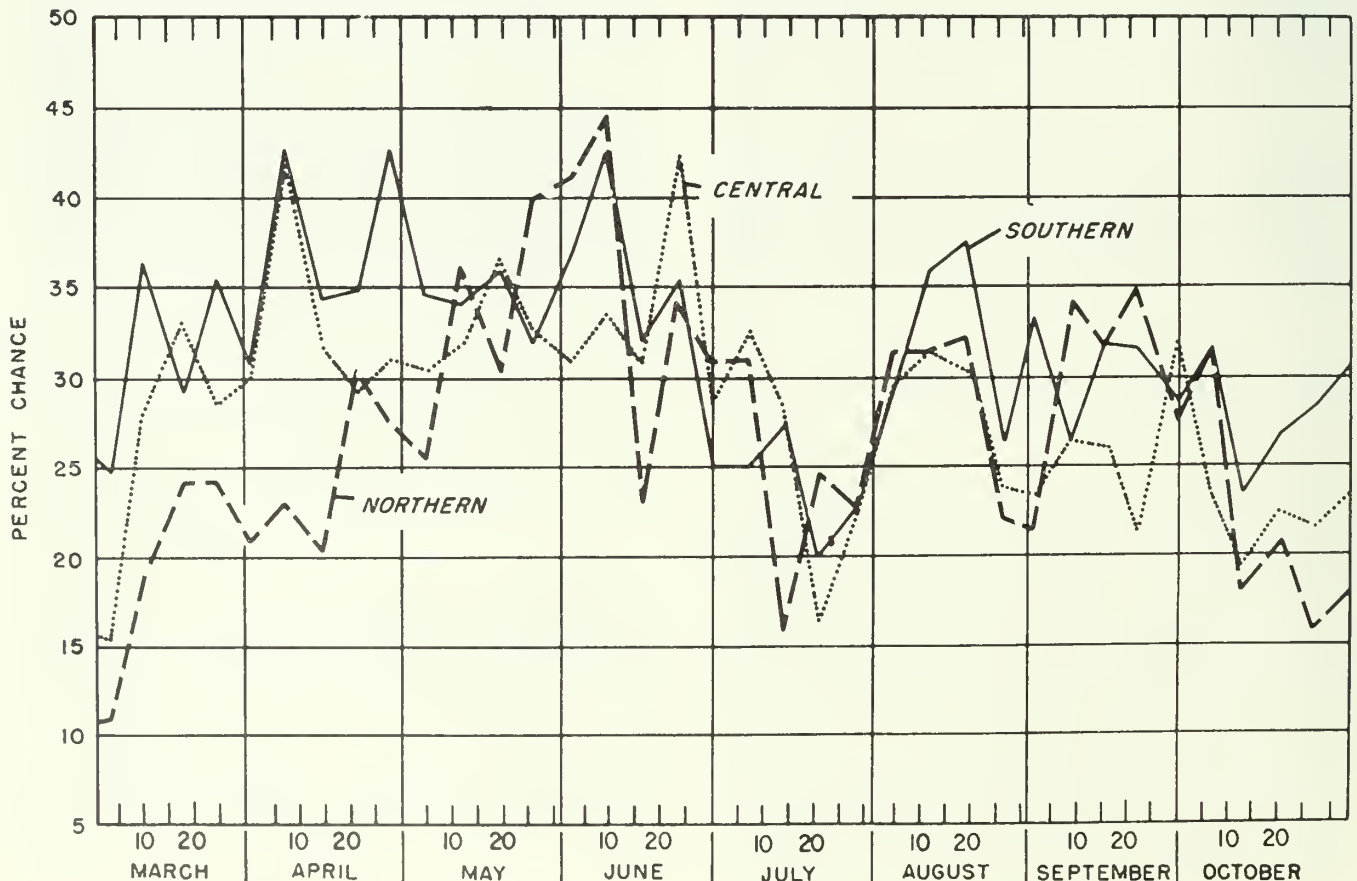
Crops growing on deep soil with high water-holding capacity (fine-textured soil with high organic matter content) may get by quite well if precipitation is not appreciably below normal and if the soil is filled with moisture at the beginning of the season.

Sandy soils and soils with subsoil layers that restrict water movement and root growth are not able to store as much as five inches of available moisture. Crops on these soils suffer from inadequate moisture every year. Most of the other soils in the state can hold more than five inches of available moisture in the top five feet. Crops on these soils may suffer from moisture deficiency when subsoil moisture is not fully recharged by about May 1 or when summer precipitation is appreciably below normal or poorly distributed through the season.

The probability of getting 1 inch or more of rain in any week is shown in Figure 17. One inch of rain per week will not replace E.T. losses during the summer, but it is sufficient to keep lack of moisture from severely limiting crop growth on soils with reasonably good moisture-holding capacity.

This probability is lowest in all sections of Illinois during the last half of July, when corn normally is pollinating and soybeans are flowering.

An increasing number of farmers are installing irrigation systems to prevent the detrimental effects of moisture deficiency. Some years of below-normal summer rainfall and other years of erratic rainfall distribution through the season have been at least partially responsible for the increase. Current high costs of production and some



Chance of one inch or more rain in one week. (Fig. 17)



periods of high commodity prices have given added importance to the need for stabilizing yields at high levels. As other yield-limiting factors are eliminated, adequate moisture to assure top yields becomes increasingly important. Most of the irrigation development has been on sandy soils or other soils with correspondingly low levels of available water. Some installations have been made on deeper, fine-textured soils and other farmers are considering irrigation of such soils.

## **Irrigation and Yields**

Research in the North Central states from 1950 through 1958 indicated that irrigation increased corn yields by 30 bushels per acre on loams and by nearly 60 bushels on sands. In those experiments, plant population and fertilization both were high enough to make use of the added moisture.

A study at Dixon Springs from 1955 to 1965 evaluated corn irrigation on Grantsburg silt loam, where root growth is restricted by a fragipan in the subsoil. Yields were increased an average of 30 bushels per acre per year by irrigation. The cost of irrigation, however, was nearly as great as the value of the additional crop produced.

In 1974 irrigation research of corn and soybeans was initiated on Plainfield sand at the Illinois River Valley Sand Field in Mason County. From 1974 to 1976, three frequencies of irrigation were studied: daily, twice a week, and once a week. Total amount of water per week was constant and was equivalent to about  $\frac{1}{4}$  inch per day. In 1974 corn yields of 180 bushels per acre and soybean yields of 58 bushels per acre were obtained. Nonirrigated yields were not taken in 1974. Corn yields slightly higher than 200 bushels per acre were obtained in 1975 and 1976 with irrigation and with high fertility treatments. Unirrigated corn yielded 70 to 80 bushels per acre with the same fertility treatments. Irrigated corn with no fertilizer added yielded less than 30 bushels per acre on this sandy soil. Full season soybeans yielded 55 and 45 bushels per acre in 1975 and 1976. The yields from non-irrigated soybean plots in those years were 30 and 16 bushels, respectively.

In 1977 an experiment was initiated on the Agronomy Research Center at Brownstown which evaluates irrigation and drainage variables on Cisne and Hoyleton silt loams. Surface drainage is accomplished by land shaping to assure uniform, slow runoff. Subsurface drainage is by 3-inch diameter perforated plastic drain tubes installed on 20-foot spacings. The tubes are placed at a shallow depth — just above the clay pan layer. Surface irrigation water is distributed through gated pipe and runs down furrows between the rows. Sprinkler irrigation is by a solid-set system with a low application rate. The water source is a pond constructed on the farm and the plots are in the watershed of the pond. Runoff water, whether from rain or from irrigation, accumulates in the pond.

Average corn yields in this experiment were 53 bushels per acre with no irrigation, 150 bushels per acre with sprinkler, and 145 bushels per acre with surface irriga-

tion. Plots having unimproved drainage averaged 109 bushels per acre. Those with surface drainage only averaged 96 bushels per acre; with subsurface only, 107 bushels per acre; with both surface and subsurface 121 bushels per acre.

Data from Iowa State University indicate that corn yields may be reduced as much as 40 percent when four consecutive days of visible wilting are encountered at the time of silk emergence. Their studies have also shown similar yield reductions in soybeans from severe drought during the pod-filling stage.

## **Irrigation for Double Cropping**

Proper irrigation can eliminate the most serious problem in double cropping: inadequate moisture to get the second crop off to a good start. No part of Illinois has better than a 30-percent chance of getting an inch or more of rain during any week in July and most weeks of August. If one has irrigation equipment, double-crop irrigation should receive high priority in the operational program. If one is not irrigating but is considering it, the possibility of double cropping under irrigation should be taken into account in making the decision. Soybeans planted at Urbana July 6 following wheat harvest have yielded as much as 38 bushels per acre with irrigation.

In Mason County, soybeans planted the first week in July have yielded as much as 30 bushels per acre with irrigation.

While it may be difficult to justify investing in an irrigation system for double-crop soybeans alone, the potential benefits from irrigating double-crop beans added to the benefits from irrigating other crops may make the investment worthwhile. Some farmers report that double cropping will have top priority in their irrigation programs.

## **Fertigation**

The method of irrigation most common in this area — overhead sprinkler — is the one best adapted to applying fertilizer along with water. Fertigation permits nutrients to be applied to the crop as they are needed. Several applications can be made during the growing season with little if any additional cost of application. Nitrogen can be applied during periods when the crop has a heavy demand for both nitrogen and water. Corn uses nitrogen and water most rapidly during the three weeks before tasseling. About 60 percent of the nitrogen needs of corn must be met by silking time. Generally, it is recommended that nearly all the nitrogen for the crop should be applied by the time it is pollinating, even though appreciable uptake occurs after this time. Fertilization through irrigation can be a convenient and timely method of supplying part of the plant's nutrient needs.

In Illinois, fertigation appears to be best adapted to sandy areas where irrigation is likely to be needed even in wettest years. On finer-textured soils with high water-holding capacity, one may be faced with need for nitro-

gen but with no lack of moisture. Neither irrigating just to supply nitrogen nor allowing the crop to suffer for lack of nitrogen is an attractive alternative. Even on sandy soils, only part of the nitrogen should be applied with irrigation water, with preplant and sidedress applications providing the rest of it.

Other problems associated with fertigation can only be mentioned here. These include (1) possible lack of uniformity of application, (2) loss of ammonium nitrogen by volatilization in sprinkling, (3) loss of nitrogen and resultant ground-water contamination by leaching if overirrigation occurs, (4) corrosion of equipment, and (5) incompatibility of some fertilizer materials and low solubility of some. Good discussions of these and factors affecting them can be found in textbooks, scientific journals, farm periodicals, and trade journals.

### Cost and Return

The best data we now have on the cost of irrigation come from the University of Nebraska. For 1976 the total cost of irrigating field corn with a center-pivot system was about \$80 an acre per year. This figure includes capital equipment costs of \$56 an acre per year and operating costs of \$23 an acre per year. The total cost of producing irrigated corn in Nebraska in 1977 was reported to be about \$312 per acre. This figure includes the cost of irrigation and a cost of 7 percent for land evaluated at \$700 per acre. It also includes added costs for seed, fertilizer, pesticides, labor, and management beyond those for unirrigated corn. The break-even price for an irrigated corn yield of 140 bushels per acre was \$2.23 per bushel; for the unirrigated yield of 55 bushels per acre, it was \$2.44 per bushel.

Another important factor in considering irrigation costs is the relationship of these costs to the cost of land. If the capital costs of an irrigation system are \$400 per acre (including the well, power source, etc.) and land costs \$2,000 per acre, the irrigation equipment cost is 16.7 percent of the total. If the land cost is \$4,000 per acre, the same \$400 cost for irrigation equipment becomes 9.1 percent of the total. Irrigating existing acreage now under cultivation will help stabilize production from year to year. Many farmers are weighing this alternative against the purchasing or leasing of additional land. One farmer reports that he added irrigation for 160 acres at the same cost as that of purchasing an additional 20 acres.

If the annual cost of irrigation is \$80 per acre, a 30-bushel-per-acre increase in corn yield would pay the added cost if the price were \$2.67 per bushel. With a high level of management, yield increases of twice this amount might be expected on sandy soils during most years in Illinois.

With a soybean price of \$5 per bushel, a yield increase for irrigation of 16 bushels per acre would be needed to recover costs. Yield increases were approximately double these amounts in 1974 and 1975 in Mason County experiments. Good evaluations of soybean irrigation on finer-textured soils in Illinois are not available as yet.

### The Decision To Irrigate

If a producer is convinced that it will be profitable for him to install an irrigation system, he must have an adequate source of water. Such sources do not exist at present in many parts of the state. We are fortunate in that underground water resources are generally good in the sandy areas where irrigation is most likely to be needed. A relatively shallow well in some of these areas may provide enough water to irrigate a quarter section of land. In some areas of Illinois, particularly the northern third, deeper wells may provide a relatively adequate source of water for irrigation.

Many farmers are pumping their water from streams for irrigation. This can be a relatively good and low-cost source; but, of course, the stream may dry up in a drought year. Impounding surface water on an individual farm is possible in many areas of the state, and some farmers are doing that. However, an appreciable loss may occur both from evaporation and from seepage into the substrata. The rule-of-thumb figure is that you probably need to store 2 acre-inches of water for each acre-inch actually applied to the land. Although in many areas the water-development costs are likely to be beyond the range of feasibility for an individual farmer, such development by groups of farmers, cooperatives, or governmental agencies could produce a sufficient water supply in one containment for a number of irrigators.

27,000 gallons of water are required to make a one-inch application on one acre (one acre-inch). A flow of 450 gallons per minute will give one acre-inch per hour. Thus a 130-acre center pivot system with a flow of 1,220 gallons per minute can apply  $\frac{1}{2}$  inch of water over the entire field in 24 hours of operation. Since some of the water is lost to evaporation and some may be lost from deep percolation or runoff, the net amount added will be less than  $\frac{1}{2}$  inch.

The Illinois State Water Survey and the Illinois State Geological Survey at Urbana can provide information on the availability of water for irrigation. Submit a legal description of the site on which you plan to develop a well and request information regarding its suitability for irrigation-well development.

At present, no permit is required in Illinois to use water for irrigation. The Riparian Doctrine, which governs the use of surface waters, states that a person is entitled to a reasonable use of the water which flows over or adjacent to his or her land, as long as that person does not interfere with someone else's right to use the water. No problem results as long as there is plenty of water for everybody. But when the amount of water becomes limiting, legal determinations may have to be made as to whether one's use interferes with someone else's rights concerning the water. It may be important to have a legal record established in order to verify the date on which the use of water for irrigation began.

Assuming you believe that it will be profitable for you to irrigate and that you have an assured supply of water, how do you find out what type of equipment is available

and what will be best for your situation? University representatives have discussed this question in various meetings around the state; but they cannot, of course, design a system for each individual farm. Your county extension adviser can provide you with a list of dealers located in Illinois and others who serve Illinois. This list gives the kinds of equipment each dealer sells, but will not give you information about the characteristics of those systems.

We suggest that you contact as many dealers as you wish and discuss your needs with them in relation to the type of equipment they sell. You will then be in a much better position to determine what equipment to purchase. To the best of our knowledge, there are no consulting irrigation engineers or agronomists in the state at present, except for those staff members employed by irrigation manufacturers or dealers, or by universities.

### **Management Requirements**

Irrigation will provide maximum benefit only when it is an integral part of a high-level management program. Good seed or plant starts of proper genetic origin planted at the proper time and at a sufficiently high plant population, accompanied by optimum fertilization, good pest control, and other recommended cultural practices, is necessary to assure the highest benefit from irrigation.

Farmers who invest in irrigation may become disap-

pointed if they do not manage the irrigation properly. They often overextend their systems so much that they cannot maintain adequate soil moisture when the crop requires it. For example, the system may be designed to apply 2 inches of water to 100 acres once a week. In 2 or more successive weeks, soil moisture may be limiting, with potential evapotranspiration equaling 2 inches per week. If the system is used on one 100-acre field one week and another field the next week, neither field may receive much benefit, especially if moisture stress comes at a critical time, such as during pollination. Inadequate production of marketable products may result.

Currently we suggest that irrigators follow the cultural practices they would use to obtain the most profitable yield in a year of ideal rainfall. In many parts of the state 1975 was such a year. Other years have been nearly ideal in some sections of Illinois. If a farmer's yield is not already appreciably above the county average for that farmer's soil type, he or she needs to improve management of other cultural factors before investing in an irrigation system.

The availability of irrigation on the farm permits the use of optimum production practices every year. If rains should come as needed, the investment in irrigation equipment would not have been needed that year, but no operating costs would have been involved. If rainfall should be inadequate, however, the yield potential would still be realized every year.

## 1979 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 cultivation and good cultural practices are adequate for weed control, you may not need herbicides. Much of the risk can be decreased by heeding these precautions:

- Use herbicides only on approved crops.
- Use recommended amounts. Applying too much herbicide may damage crops, may cause illegal residues, and is costly. Using too little herbicide can result in poor weed control.
- 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.
- Guard against possible injury to nearby susceptible plants, such as soybeans, grapes, and tomatoes. Droplets and vapors from 2,4-D, MCPA, 2,4,5-T, and dicamba sprays may drift several hundred yards. The amine form of 2,4-D is safer to use than the volatile ester form, but even the amine 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 dicamba or the ester form of 2,4-D.
- Apply herbicides only when all animals and persons

not directly involved in the application have been removed from the area. Avoid unnecessary exposure.

- Check label for proper method of disposing of container. Triple rinse and puncture metal containers and haul them to a sanitary landfill. Haul paper containers to a sanitary landfill or burn them.

- Return unused herbicides to a safe storage place promptly. Store them in original containers, away from unauthorized persons, particularly children.

- 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 employees assume no responsibility for results from using herbicides, regardless of whether 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. Most weed control programs combine good cultural practices, mechanical weed control, and herbicide applications. If weeds are not a serious problem, herbicide applications may not be needed.

Good cultural practices to aid weed control include preparation of a good seedbed, adequate fertilization, seeding on the proper date, use of the optimum row width, and seeding at the rate for optimum stands.

A uniform, weed-free seedbed discourages weed growth and encourages crop germination. If preplant incorporated herbicides are used, incorporation should be a part of normal seedbed preparation. Excessive preplant tillage may intensify soil crusting.

Planting in relatively warm soils helps crops compete better with weeds. Good weed control during the first 3 to 5 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 population also help discourage weed growth.

Narrow rows will shade the centers faster and help the crop compete better with the weeds. There is increased interest in drilling soybeans in narrow rows. Since herbicides alone may not always give adequate weed control, it is often preferable to keep rows wide enough to allow cultivation. However, some of the newer herbicides are improving the chances of adequate control without cultivation.

Early cultivations are most effective when weeds are small. Use the rotary hoe after weed seeds have germinated but before most 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 adequate control appears doubtful, use the rotary hoe while weeds are still small enough to be controlled.

Row cultivators also should 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; it may hinder harvesting and encourage erosion.

Preemergence or preplant herbicides may provide a convenient and economical means of early weed control by allowing delayed and faster cultivation. Herbicides can replace some cultivation, for, unless the soil is crusted, little cultivation is needed where weeds are controlled.

## 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 plans as required during the season. Herbicide performance depends on the weather and on wise selection and application. Your decisions on herbicide use should be based on the nature and seriousness of your weed problem.

Corn or soybeans occasionally may be injured by some of the herbicides registered for use on them. Crop tolerance ratings for various herbicides are given in the table on the last page of this article. Usually the benefits from weed control are much greater than the adverse effects from herbicides. Corn or soybeans under stress from soil crusting, depth of planting, or adverse weather are more subject to herbicide injury. Plants 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. Select and apply herbicides at the correct rate in order to reduce crop injury. The application rates for some herbicides vary greatly with soil texture and organic matter.

You also must consider the kinds of weeds likely to be present. The herbicide selectivity table at the end of this guide lists various herbicides and various weeds' susceptibility to them.

Crop planting intentions for the next season also must 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 for soybeans is uniform and sufficiently early to reduce the risk of injury to wheat following soybeans. Refer to the herbicide label for crop rotation and grazing restrictions.

## Names of Some Herbicides

Trade	Common (generic)
AAtrex, Atrazine	atrazine
Amiben	chloramben
Amino triazole, Weedazol	amitrole
Amitrol-T, Cytrol	amitrole-T
Banvel	dicamba
Basagran	bentazon
Basalin	fluchloralin
Bicep	metolachlor + atrazine
Bladex	cyanazine
Butoxone, Butyrac	2,4-DB
Cobex	dinitramine
Dowpon M, Basfapon	dalapon
Dual	metolachlor
Dyanap, Ancrack, Klean-Krop	naptalam plus dinoseb
Eptam, Eradicane	EPTC
Evik	ametryn
Furloe Chloro IPC	chlorpropham
Igran	terbutryn
Kerb	pronamide
Lasso	alachlor
Lorox	linuron
Modown	bifenox
Paraquat	paraquat
Premerge-3	dinoseb
Princep	simazine
Prowl	pendimethalin
Ramrod, Bexton, Propachlor	propachlor
Roundup	glyphosate
Sencor, Lexone	metribuzin
(several)	2,4-D
Sinbar	terbacil
Surflan	oryzalin
Sutan+	butylate
Tenoran	chloroxuron
Tolban	profluralin
Treflan	trifluralin
Vernam	vernolate

Some herbicides have different formulations and concentrations under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

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.

In this article, the term "registered" refers to registration of the herbicide by the U.S. Environmental Protection Agency and implies EPA review and approval.

## Herbicide Combinations

Herbicides often are combined to control more weed species, reduce 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.

Problems sometimes occur when mixing emulsifiable concentrate (EC) formulations with wettable powder (WP) or water dispersible liquid (WDL) formulations, or with water dispersible granules (WDG). These problems can sometimes be prevented by using proper mixing procedures. Fill the tank at least half full with water or liquid fertilizer before adding herbicides. If using liquid fertilizers, check compatibility in a small lot before mixing a tankful. The addition of compatibility agents (salt stable emulsifiers) may be necessary. Wettable powders and WDL's should be added to the tank before EC's. Pre-emulsify EC's by mixing with equal volumes of water before adding them to the tank. Empty and clean spray tanks often to prevent accumulation of material on the sides and the bottom of the tank.

Some of the herbicide combinations that have been registered are listed below. The herbicide listed first is the one that carries label or supplemental instructions on mixing. The other herbicide's label also may carry mixing instructions.

### Corn

AAAtrex + Princep (PPI, Pre)<sup>1</sup>  
Atrazine + propachlor (Pre)  
Banvel + atrazine (Post)  
Banvel + Lasso (Pre, early Post)  
Banvel + 2,4-D (Post)  
Bladex + atrazine (Pre, PPI)  
Bladex + Paraquat (NT)  
Bladex + Sutan+ (PPI)  
Dual + AAAtrex (Pre, PPI)  
Eradicane + atrazine (PPI)  
Eradicane + Bladex (PPI)  
Lasso + atrazine (PPI, Pre, early Post)  
Lasso + Bladex (Pre)  
Paraquat + atrazine (NT)  
Paraquat + atrazine + Lasso (NT)  
Paraquat + atrazine + Princep (NT)  
Prowl + atrazine (Pre)  
Prowl + Banvel (Pre)  
Prowl + Bladex (Pre)  
Prowl + Paraquat (NT)

Prowl + Paraquat + Bladex (NT)  
Prowl + Paraquat + atrazine (NT)  
Roundup + Atrazine + Princep (NT)  
Roundup + Lasso + atrazine (NT)  
Roundup + Lasso + Princep (NT)  
Sutan+ + atrazine (PPI)

### Soybeans

Amiben + Lasso (Pre)  
Amiben + Lorox (Pre)  
Amiben + Treflan (PPI)  
Cobex + Sencor or Lexone (PPI)  
Dyanap + Lasso (Pre)  
Furloe + Lasso (Pre)  
Lasso + Lorox (Pre)  
Lexone or Sencor + Lasso (Pre, PPI)  
Modown + Lasso (Pre)  
Paraquat + Lorox (NT)  
Paraquat + Lorox + Lasso (NT)  
Paraquat + Sencor (NT)  
Paraquat + Sencor + Lasso (NT)  
Premerge + Amiben (Pre)  
Premerge + Lasso (Pre)  
Prowl + Amiben (Pre)  
Prowl + Lorox (Pre)  
Prowl + Sencor or Lexone (PPI, Pre)  
Roundup + Lasso + Lorox (NT)  
Roundup + Lasso + Sencor or Lexone (NT)  
Sencor + Amiben (Pre)  
Sencor or Lexone + Treflan (PPI)  
Surflan + Dyanap or Klean-Krop (Pre)  
Surflan + Lorox (Pre)  
Surflan + Lorox + Paraquat (NT)  
Surflan + Sencor or Lexone (Pre)  
Surflan + Sencor or Lexone + Paraquat (NT)  
Tolban + Sencor or Lexone (PPI)  
Vernam + Treflan (PPI)

<sup>1</sup> PPI = preplant incorporated, Pre = preemergence, Post = postemergence, NT = no-till.

Applying two herbicides at different times is referred to as a sequential or overlay treatment. The user can apply two treatments of the same herbicide (split application), or he can use two different ones, provided such uses are registered. He can apply them at the preplant and preemergence stages or at preemergence and post-emergence. One herbicide may be broadcast while the other is banded or directed.

Labeling requirements for sequences are becoming strict. Some products now suggest other herbicides that can be used in sequence with them, while other labels make more general recommendations on sequencing.

### 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 overcome

some of the dependence upon rainfall.

Depth and thoroughness of incorporation depend upon type of equipment, depth and speed of operation, 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.

Most annual weed seeds germinate in the top 1 or 2 inches of soil; therefore, most of the herbicide should be placed in that area for best results. The tandem disk is the most common implement for 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. Disking twice using blades less than 22 inches in diameter or disking followed by field cultivating usually distributes herbicides more evenly than field cultivating twice. Field cultivating once alone is not generally recommended.

Speed and depth of incorporation are important in obtaining satisfactory results with all equipment. Keep in mind that if the herbicide is incorporated too deep, dilution may reduce its effectiveness. Incorporation may be poor in wet soils.

## Herbicides for Corn

### *Preplant Herbicides*

Some herbicides may be applied prior to planting. Some require incorporation, while it is optional for others. Preplant herbicides are usually broadcast, and some may be applied with fluid fertilizer.

Atrazine can be applied within 2 weeks before planting corn, and incorporated to overcome some of the dependence upon rainfall. Incorporation should not be too deep.

Atrazine is very effective for control of many broadleaf weeds. Control of annual grass weeds is often satisfactory. However, atrazine may not adequately control fall panicum, crabgrass, and giant foxtail. See further details under the discussion of preemergence applications for corn.

**Sutan+** (butylate) should be incorporated immediately. Where possible, application and incorporation should be done in the same operation.

Sutan+ is primarily for control of annual grass seedlings, but it also can suppress yellow nutsedge. Broadleaf weed control can be improved by combining Sutan+ with atrazine or Bladex, or by following with the application of an appropriate postemergence herbicide.

Sutan+ (6.7E) is used alone at the rate of  $4\frac{3}{4}$  to  $7\frac{1}{2}$  pints per acre. The higher rates may be used to help control heavy infestations of wild cane and nutsedge and to suppress rhizome johnsongrass. Although Sutan+ contains a "safening agent" to decrease the risk of corn injury, some injury is possible.

**Sutan+** (butylate) plus atrazine can be tank mixed at rates of  $1\frac{1}{4}$  to 2 pounds of atrazine 80W or 1 to  $1\frac{1}{2}$  quarts of atrazine 4L plus  $3\frac{3}{4}$  to  $7\frac{1}{3}$  pints of Sutan+ (6.7E) per acre. The higher rate of atrazine is suggested for relatively dark soils. In areas of heavy infestations of wild cane, johnsongrass, or nutsedge,  $4\frac{3}{4}$  to  $7\frac{1}{3}$  pints of Sutan+ per acre may be used.

**Bladex** (cyanazine) plus **Sutan+** (butylate) can be tank mixed at the rate of 2 to  $2\frac{1}{2}$  pounds of Bladex 80W or  $1\frac{1}{2}$  to 2 quarts of Bladex 4L plus  $3\frac{3}{4}$  to  $7\frac{1}{3}$  pints of Sutan+ (6.7E) per acre. The higher rates are for use on medium-to-heavy soils and for the control of wild cane and nutsedge. Incorporate shallowly for best results.

**Eradicane** (EPTC) should be preplant broadcast and incorporated immediately. Eradicane may be used on field, sweet, and silage corn, but should not be used on corn grown for seed. The suggested rate is  $4\frac{3}{4}$  to  $7\frac{1}{3}$  pints per acre within 2 weeks before planting. The higher rate is for heavy infestations of wild cane or nutsedge and suppression of rhizome johnsongrass. High rates, unfavorable growing conditions, or use of certain hybrids may increase the risk of injury. Eradicane can be tank mixed with atrazine or Bladex.

**Princep** (simazine) or **Princep plus atrazine** may be applied either before or during final seedbed preparation. Best results usually have been obtained when the herbicide is applied within 2 weeks prior to planting, although application within 4 weeks may be satisfactory.

Princep improves the control of fall panicum and crabgrass. Because Princep is less soluble than atrazine and may be more persistent, follow label precautions to reduce carryover. Princep and atrazine are used in a 1:1 or 2:1 combination.

**Dual** (metolachlor) or **Dual plus atrazine** may be used preplant incorporated, but preemergence is usually preferred except for nutsedge control. For nutsedge apply 2 to 4 pints of Dual 6E and incorporate into the top 2 inches of soil.

**Lasso** (alachlor) or **Lasso plus atrazine** may be used preplant within 7 days before planting corn. A surface application is usually preferred for control of annual grasses, but incorporation may improve nutsedge control. Incorporation of  $2\frac{1}{2}$  to  $3\frac{1}{2}$  quarts of Lasso 4E per acre can suppress nutsedge. See further details in the preemergence section.

### *Preemergence Herbicides*

Atrazine has very good corn tolerance. It can be used on field, sweet, silage, pop, or seed corn. Atrazine controls annual broadleaf weeds and some annual grasses. Where fall panicum, crabgrass, or giant foxtail are problems, consider using combinations of atrazine with Bladex, Dual, or Lasso.

Atrazine is formulated as an 80-percent wettable powder and a 4-pound-per-gallon liquid suspension, and as a 90-percent water dispersible granule (WDG). Rates vary with soil organic matter and texture, weed prob-

lems, and whether atrazine is used alone or in combinations.

If you use atrazine at more than 3 pounds of active ingredient per acre, or if you apply after June 10, plant only corn or sorghum the next year. If you use atrazine in the spring, do not plant small grains, small-seeded legumes, or vegetables the next fall or spring. Soybeans planted the year following atrazine may be injured if you had applied more than recommended amounts unevenly, or if you use Sencor or Lexone on the soybeans.

Carryover injury can be minimized by accurate mixing and application, early application, use of the lowest rates consistent with good weed control, use in combinations, and by thorough tillage of the soil before planting subsequent crops. There is usually less risk of atrazine carryover following warm moist seasons than following relatively cool dry seasons. Atrazine carryover is greater on high pH (over 7.5) soils.

**Bladex (cyanazine)** does not persist in the soil as long as atrazine, but corn tolerance is better with atrazine than with Bladex. Bladex controls fall panicum and giant foxtail better than atrazine, but control of pigweed and velvetleaf may not be as good (see selectivity table on the last page).

Broadcast rates are 1½ to 5 pounds of Bladex 80W, 1¼ to 4 quarts of Bladex 4L or 8 to 27 pounds of Bladex 15G per acre. Rates should be adjusted for soil texture and organic matter to reduce the possibility of corn injury.

Bladex may be tank mixed with atrazine or Lasso. Since combination rates vary greatly with soil texture and organic matter, refer to the Bladex label for specific rate information.

**Bladex plus atrazine** provides better grass control than atrazine alone and reduces the chances of atrazine carryover. The combination may be mixed at a 3:1, 2:1 or 1:1 ratio of Bladex to atrazine. The 2:1 or 3:1 ratio will provide better grass control than the 1:1 ratio.

**Ramrod, Bexton, or Propachlor (propachlor)** is primarily used on soils with more than 3 percent organic matter. It controls annual grasses and pigweed, but control of most other broadleaf weeds should not be expected. Propachlor will usually perform better than other preemergence grass herbicides on high organic soils and under dry conditions.

Corn tolerance to propachlor is good. It is registered for use on field corn, silage corn, sweet corn, and seed corn fields. It is irritating to the skin and eyes, so observe label precautions.

The broadcast rate is 6 to 9 pounds per acre of propachlor 65W or 20 to 30 pounds per acre of propachlor 20G (granules). Use proportionately less for band application.

**Propachlor plus atrazine** is a combination best adapted to soils with more than 3 percent organic matter. The mixture controls broadleaf weeds better than propachlor alone and controls annual grasses better than atrazine alone. However, velvetleaf may not be controlled.

Propachlor plus atrazine is available as a prepackaged mixture of wettable powder used at the rate of 5 to 8 pounds per acre. The tank-mix rate is 4½ to 6 pounds of propachlor 65W and 1½ to 2 pounds of atrazine 80W on soils with more than 3 percent organic matter.

**Lasso (alachlor)** performs better than propachlor on soils with less than 3 percent organic matter. Lasso may require a little more moisture initially, but weed control may last longer. Lasso is not as irritating to handle as propachlor. However, observe label precautions.

Lasso can control annual grasses and pigweed. Some other broadleaf weeds can be controlled by using an appropriate combination of Lasso and a postemergence herbicide treatment.

The broadcast rate is 2 to 3½ quarts of Lasso 4E or 16 to 26 pounds of Lasso II 15G per acre. Adjust the rate for soil texture and organic matter. Corn does not tolerate Lasso quite as well as it does propachlor; slight injury occasionally has occurred to certain hybrids. Lasso may be used on field, sweet, and silage corn, and on seed corn.

**Dual (metolachlor)** is registered for use on field corn (not silage corn) by itself and with AAtrex. Dual is chemically similar to Lasso and controls the same weeds as Lasso, but it may last a little longer to help control late-emerging grasses and nutsedge. Corn tolerance appears to be slightly less to Dual than to Lasso. The broadcast rate is 2¾-4 pints of Dual 6E per acre. Do not graze or feed fodder.

**Bicep (metolachlor + atrazine)** is a prepackaged mix of Dual plus atrazine. The rates of Bicep 4.5L are 2 quarts per acre on light, coarse-textured soils, and 4 quarts per acre on dark, fine-textured soils.

**Lasso plus atrazine** is less irritating to handle and controls fall panicum better than propachlor plus atrazine. Velvetleaf control varies according to reduced rates of atrazine used in the combination, but most other broadleaf weeds can be controlled under favorable conditions. Application may be made from immediately after planting until weeds reach the 2-leaf stage and the crop is no more than 5 inches tall (see postemergence section).

Suggested rates for tank mixing are 1½ to 2½ quarts of Lasso and 1¼ to 2 pounds of atrazine 80W per acre, depending upon soil organic matter. See the Lasso label for instructions on making compatibility tests and mixing.

**Banvel (dicamba) plus Lasso (alachlor)** is registered for preemergence use on field corn. Adding Banvel to Lasso improves control of broadleaf weeds without creating risk of carryover injury to crops the following year. However, there is some risk of injury to corn from Banvel applied preemergence, especially if recommended rates are exceeded, applications are not accurate and uniform, or corn is planted too shallow (less than 1½ inches). Do not use on coarse-textured soils or soils low in organic matter. The rate is 1 pint of Banvel plus 2½ quarts of Lasso per acre on fine-textured soils with more than 2½ percent organic matter.



**Prowl (pendimethalin)** is registered for use on field corn and silage corn. It is available as a 4-pound-per-gallon emulsifiable concentrate for use at rates of  $\frac{3}{4}$  to 2 quarts per acre alone, or  $\frac{3}{4}$  to  $1\frac{1}{2}$  quarts in combination with atrazine, Bladex, or Banvel. Rates should be adjusted for soil texture and organic matter. It controls annual grasses and gives some control of broadleaf weeds such as pigweed, lambsquarters, smartweed, and velvetleaf. Prowl should be applied only to the soil surface. Do not incorporate for corn since incorporation increases the injury risk considerably.

#### **Postemergence Herbicides**

**Lasso (alachlor) plus atrazine tank mixture** can be applied to emerged corn no more than 5 inches tall. Grass beyond the 2-leaf stage will not be satisfactorily controlled; occasionally some leaf burn may occur. If applied in fluid fertilizer, application must be made before the crop emerges (see preemergence section for further information).

**Lasso (alachlor) plus Banvel (dicamba) tank mixture** can be used on emerged corn no more than 3 inches tall. Grasses beyond the 2-leaf stage may not be satisfactorily controlled (see preemergence section for further information).

**Banvel + atrazine** can be applied up to 3 weeks after planting but before grass reaches  $1\frac{1}{2}$  inches tall. The rate is  $\frac{1}{2}$  pint of Banvel plus  $1\frac{1}{4}$  to 2 pounds of atrazine 80W per acre.

Atrazine can be applied to corn postemergence after planting but before grass weeds are more than  $1\frac{1}{2}$  inches high. Results on grasses more than  $1\frac{1}{2}$  inches tall have been rather erratic. Many annual broadleaf seedlings are more susceptible than grass weeds and may be treated until they are up to 4 inches tall. Velvetleaf is sometimes easier to control postemergence than preemergence, especially if reduced rates are used in preemergence combinations.

The addition of nonphytotoxic oils, oil-surfactant mixes, or surfactants has generally increased the effectiveness of postemergence atrazine. 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 also are marketed for postemergence use with 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 those with the surfactants.

Corn has sometimes been damaged from postemergence applications of atrazine and oil. There have been some cases of severe injury where corn has been under stress from prolonged cold, wet weather or other factors. Do not use more than  $2\frac{1}{2}$  pounds of atrazine 80 W or 2 quarts of atrazine 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 atrazine is applied after June 10, do not plant any crop except corn or sorghum the next year because of increased risk of herbicide carryover from late application. Refer to the label for other precautions.

**Bladex (cyanazine)** is registered for postemergence use through the 4-leaf stage of corn growth but before weeds exceed  $1\frac{1}{2}$  inches in height. The rate is  $1\frac{1}{2}$  to  $2\frac{1}{2}$  pounds of Bladex 80W in 15 to 30 gallons of spray per acre. (Do not use Bladex 4L.) Injury to corn may occur under cold, adverse growing conditions or when corn is under other stresses. The injury may be only temporary yellowing or may be more severe. Corn should not be treated after the 4-leaf stage. Certain agricultural surfactants or vegetable oils may be added to Bladex as specified on the label, but do not use petroleum crop oils or apply with liquid fertilizers for postemergence application.

**2,4-D** is one of the most economical and effective treatments for controlling many broadleaf weeds in corn. Use drop nozzles if corn is more than 8 inches high to 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 or apply by air, but do not apply 2,4-D to corn from tasseling to dough stage. After hard dough to dent stage, you can apply 1 to 2 pints of certain 2,4-D's by air or high clearance equipment to control late germinating broadleaf weeds that may interfere with harvest, or to suppress certain perennial weeds.

Some corn injury may result from applying 2,4-D. 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 injury. Applications during periods of high temperatures and high humidity also increase probability of injury. Corn hybrids vary in their sensitivity to 2,4-D, depending upon their genetic makeup.

Apply no more than the recommended rate; this will help reduce corn injury. The suggested broadcast rates of acid equivalent per acre are  $\frac{1}{6}$  to  $\frac{1}{4}$  pound of ester formulations or  $\frac{1}{2}$  pound of amine. This would be  $\frac{1}{3}$  to  $\frac{1}{2}$  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 vaporize and injure nearby susceptible plants. This vapor movement is more likely with high-volatile than with low-volatile esters. Amine formulations have very low volatility and are less likely to injure nearby susceptible plants. However, spray particles of either the ester or the amine form can drift and cause injury.

**Banvel (dicamba)** controls smartweed better than 2,4-D. However, Banvel has presented a much more serious problem of injury to soybeans than 2,4-D. Thus,

Banvel should be applied before soybeans in the area are 10 inches high. Soybean yields are seldom reduced where slight injury occurs early. However, yields can be reduced if severe injury occurs when soybeans are blooming. Banvel also can injure other susceptible plants, such as vegetables and ornamentals. Use extreme caution to avoid injury to desirable plants from either contaminated sprayers or drift of Banvel from treated areas. Spray thickeners have reduced, but not eliminated, problems with movement of Banvel.

Banvel may be applied until corn is 3 feet high or until 15 days before tasseling. When spraying near soybeans, do not spray corn after it is 2 feet high. If corn is more than 8 inches high, drop nozzles 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  $\frac{1}{4}$  to  $\frac{1}{2}$  pint per acre. Use the higher rate for taller and older weeds.

Do not use Banvel on sweet corn, popcorn, or seed corn. Do not graze or harvest corn for dairy feed before the ensilage (milk) stage.

A mixture of  $\frac{1}{4}$  pint of Banvel plus  $\frac{1}{2}$  pint of 2,4-D amine (4 pounds per gallon) per acre is more economical than a full rate of Banvel and may present less risk of corn injury than 2,4-D alone. Use drop nozzles on corn more than 8 inches high when using a Banvel-plus-2,4-D mixture.

**Basagran (bentazon)** is registered for use postemergence in corn in a manner similar to that for soybeans (see soybean section). Since corn is quite tolerant of Basagran, there is special interest in its use in seed corn production fields.

#### **Directed Postemergence Herbicides**

Directed sprays are sometimes needed 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 by the time 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 the corn. Corn leaves that come into contact with the spray can be killed, and injury may affect yields.

**Lorox (linuron)** may be applied as a directed spray after corn is at least 15 inches high (free standing) but before weeds are 8 inches tall (preferably not more than 5 inches). This height difference occurs in few fields and lasts only a few days. Lorox can control both grass and broadleaf weeds.

The broadcast rate is  $1\frac{1}{4}$  to 3 pounds of Lorox 50W per acre, with the lower rates suggested for use on small weeds and lighter soil types. 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. *Consider this an emergency treatment.*

**Evik 80W (ametryn)** is registered for directed use when corn is more than 12 inches tall and weeds are less than 6 inches tall. The rate is 2 to  $2\frac{1}{2}$  pounds Evik 80W per acre (broadcast) plus 2 quarts of surfactant per 100 gallons of spray mixture. Extreme care is necessary to keep the spray from contacting the leaves. Injury to corn is possible, so *use only as an emergency treatment.* To avoid possible yield reduction, Evik should not be applied within 3 weeks of tasseling.

## **Herbicides for Soybeans**

You must consider the kinds of weeds likely to be present when you select preplant and preemergence herbicides for soybeans. The herbicide selectivity table on the last page lists various herbicides and their relative activity on various weeds.

Soybeans occasionally may be injured by the herbicides registered for use on them. Fortunately, soybeans usually can outgrow modest amounts of early injury with little or no effect on yield. Use high-quality seed of disease-resistant varieties and do not plant too deep. However, planting too shallow may place the seed too near preemergence herbicides such as Sencor, Lexone, Lorox, or Modown and result in excessive herbicide injury to soybean seedlings. Soybeans injured by a herbicide may be predisposed to disease.

#### **Preplant Herbicides**

Herbicides can be incorporated with various implements, but the one most commonly used in Illinois is the tandem disk. Disking twice in different directions distributes the herbicide more uniformly. The second incorporation, whether with disk or field cultivator, *should not* be deeper than the first. Streaking may result from using the field cultivator unless soil is in good tilth and the equipment is operated correctly.

See the earlier section on herbicide incorporation and the product label for further information on incorporation of preplant herbicides.

**Dinitroaniline herbicides.** There are five related dinitroaniline herbicides registered for incorporation prior to planting soybeans — Basalin, Cobex, Prowl, Tolban, and Treflan. The rates, time of application, and length of time between application and incorporation vary for each product; however, weed control, persistence in the soil, and soybean tolerance are quite similar when recommended rates are used. These products can control annual grasses, including wild cane and johnsongrass seedlings. They usually control pigweed and lambsquarters and may provide some control of smartweed and annual morningglory. Control of most other broadleaf weeds usually requires combinations or sequential treatments with other herbicides.

Soybeans sometimes are injured by preplant dinitroaniline herbicides. Injured plants may be stunted and

exhibit swollen hypocotyls and inhibited lateral roots. Injury is not usually considered serious, but it may be significant under cool, wet conditions where other factors, such as seedling diseases, also affect the plants.

Although the different dinitroaniline herbicides are chemically similar, persistence in the soil varies. Cobex has the shortest persistence, while Treflan has the longest. Tolban, Prowl and Basalin persist about as long as Treflan. Corn, sorghum, or small grains that follow a dinitroaniline herbicide may be injured if excessive rates were used, the application was made relatively late in the season or was not uniform, or the previous growing season was extremely dry and cool. Use no more than the recommended rate and apply the herbicide uniformly. Using the reduced rates of dinitroaniline herbicides that are specified in some approved combinations also may decrease the possibility of residue problems the next season. Carryover injury has been greater with reduced tillage systems. The more thorough tillage methods tend to dilute the herbicide and thus reduce risk of injury from herbicide residue. Reduced tillage methods have some advantages, but where conditions suggest increased risk from herbicide residue and where erosion risks are not too great, consider more thorough tillage for that season.

**Treflan (trifluralin)** can be applied alone anytime in the spring before planting, but it should be incorporated into the soil within 8 to 24 hours of application.

The rate is 1 to 2 pints of Treflan 4E per acre. Use 2 pints on silty clay loam or clay loam soils with more than 4 percent organic matter. Treflan is also available as a 5-percent granule. Treflan may be tank mixed with Amiben.

**Cobex (dinitramine)** controls the same weeds as Treflan, but soybean tolerance is not as good. The suggested rates are  $\frac{2}{3}$  to  $1\frac{1}{2}$  quarts of Cobex 2E per acre. Cobex incorporation should be shallow but thorough, and should be within 24 hours after application.

**Tolban (profluralin)** has crop tolerance and persistence equivalent to that of Treflan when rates are adjusted to give equivalent control of weeds. Rates are 1 to 3 pints of Tolban 4E per acre. Tolban should be incorporated within 4 hours after application.

**Prowl (pendimethalin)** may be applied within 60 days before planting and should be thoroughly incorporated within 7 days. With enough rain, incorporation may not be necessary. Prowl controls the same weeds as Treflan but may also reduce competition from velvetleaf. The suggested rate is 1 to 3 pints of Prowl 4E per acre.

**Basalin (fluchloralin)** can be applied within 8 weeks before planting. It should be incorporated within 8 hours of application. Rates are 1 to 3 pints of Basalin 4E per acre. Weed control is similar to that obtained from Treflan.

**Sencor and Lexone (metribuzin)** are cleared for pre-plant incorporation with several herbicides. (Refer to herbicide combination list.) The rate is usually  $\frac{1}{2}$  to 1 pound of Sencor or Lexone 50W or  $\frac{1}{2}$  to 1 pint of 4L

per acre in these combinations. When used in this manner, metribuzin should usually be applied within 10 days of planting, and incorporation should be relatively shallow but thorough.

**Vernam (vernolate)** controls annual grasses and pigweed. Control of annual morningglory, velvetleaf, and yellow nutsedge is sometimes fair. Some soybean injury may occur in the form of delayed emergence, stunting, and leaf crinkling. Vernam can be applied within 10 days prior to planting. Incorporate immediately to prevent surface loss. The broadcast rate is  $2\frac{1}{3}$  to  $3\frac{1}{2}$  pints of Vernam 7E or 20 to 30 pounds of Vernam 10G per acre. Vernam may be tank mixed with Treflan. The tank mix may decrease the risk of soybean injury, but it may also decrease control of velvetleaf and yellow nutsedge.

**Lasso (alachlor)** can be preplant incorporated at rates of  $2\frac{1}{2}$  to  $3\frac{1}{2}$  quarts per acre for suppression of nutsedge. Apply within 7 days before planting and do not incorporate too deeply. Preemergence application is usually preferred for control of annual grasses.

#### *Preemergence Herbicides*

**Amiben (chloramben)** controls many annual grass and broadleaf weeds in soybeans. Do not expect control of annual morningglory or of cocklebur. Control of velvetleaf and jimsonweed may be erratic. Amiben occasionally injures soybeans, but damage is usually not severe.

The recommended broadcast rate is 1 to  $1\frac{1}{2}$  gallons of Amiben 2S or 20 to 30 pounds of Amiben 10G per acre. The lower rate often may not provide adequate weed control. If it does not rain within 3 to 5 days, you should rotary hoe or harrow. A tank mix of Amiben plus Lasso is registered and may improve consistency of performance.

**Lorox (linuron)** is best adapted to silt loam soils that contain less than 2 to 3 percent organic matter. It is not generally recommended for use alone on soils with more than 4 percent organic matter. Although the margin of safety between dependable weed control and crop damage is rather narrow, accurate and uniform application may reduce the possibility of crop injury. Rates must be adjusted accurately for soil texture and organic matter. Broadleaf weeds are usually controlled better than grass weeds. Annual morningglory is not controlled, and control of cocklebur is variable. Lorox is often used in a mixture with Lasso or as an overlay treatment after Treflan.

**Lasso (alachlor)** controls annual grasses plus pigweed. The broadcast rate is 2 to  $3\frac{1}{2}$  quarts of Lasso 4E or 16 to 26 pounds of Lasso II 15G per acre. Soybean seedlings often show a crinkling and drawstring effect on the first to second trifoliolate leaves, but these symptoms should not cause concern.

**Lasso plus Lorox** will provide better broadleaf control than Lasso alone. The broadcast rate is  $1\frac{1}{2}$  to 3 quarts of Lasso 4E plus 1 to 3 pounds of Lorox 50W.

Rates must be adjusted to soil texture and organic matter. On silt loam soils with less than 3 percent organic matter, such as occur in southern Illinois, the common rate is 1½ to 2 quarts of Lasso 4E plus 1 to 1½ pounds of Lorox 50W.

Sencor or Lexone (metribuzin) usually controls most annual broadleaf weeds except annual morningglory. Control of giant ragweed, jimsonweed, and cocklebur may be marginal, and annual grass control is marginal to erratic at rates needed to minimize injury.

The margin of safety between dependable weed control and crop damage is rather narrow. Stress caused by cold, wet weather, soybean seedling diseases, depth of planting, or injury from other herbicides may increase the possibility of soybean injury from Sencor or Lexone. Planting soybeans about 1½ inches or deeper may help reduce the risk of herbicide injury.

Adjust rates accurately for soil conditions and *do not apply to sandy soils*. The suggested label rate alone is ¾ to 1½ pounds of Sencor 50W or ¾ to 1 pound of Lexone 50W per acre (¾ to 1½ pints of Sencor 4 or ¾ to 1 pint of Lexone 4L). Sencor or Lexone may be tank mixed with many herbicides or used preemergence following preplant incorporation of some herbicides.

Sencor or Lexone plus Lasso is a preemergence combination to improve grass control and decrease risk of soybean injury. Adjust Sencor or Lexone rates carefully to soil texture and organic matter. The rates for this combination vary somewhat on the three different labels but are ¾ to 1 pound of Sencor or Lexone 50W (¾ to 1 pint of the flowables) plus 1½ to 2½ quarts of Lasso 4E on most Illinois soils. Accurate, uniform application is essential in order to minimize risk of soybean injury.

Prowl can be applied preemergence in combination with Amiben, Lexone, Lorox, or Sencor. When applied to the soil surface, Prowl may cause soybean injury in the form of stem callousing, which can lead to soybean lodging.

Surflan (oryzalin) is a preemergence dinitroaniline herbicide for soybeans grown on soils with less than 5 percent organic matter. Do *not* use on soils of more than 5 percent organic matter. Surflan can control annual grasses, pigweed, and lambsquarters if adequate rain occurs. If adequate rain does not fall within seven days after application, you should rotary hoe to control emerging weeds.

Furloe Chloro-IPC (chlorpropham) can be used to control smartweed. A broadcast rate of 2 to 3 quarts of Furloe 4E per acre is suggested. A tank mix with Lasso is registered for preemergence use. Furloe is also registered for preemergence surface application after preplant application of Treflan.

Modown (bifenox) controls smartweed, jimsonweed, and velvetleaf, but does not provide good control of annual morningglory, cocklebur, and annual grasses. It is approved as a sequential treatment over Treflan and as a tank mix with Lasso. Soybeans may show stunting and

crinkling from Modown. This injury may last only a few weeks and usually has not caused yield reductions.

The rate alone or over Treflan is 2 to 2½ pounds of Modown 80W per acre. The tank-mix rate with Lasso is 1½ to 2 pounds of Modown 80W plus 2 to 2½ quarts of Lasso per acre.

Dyanap (dinoseb plus naptalam) can be applied to soybeans from planting until the unifoliolate leaves of the seedling unfold and expose the growing point. Weed control from preemergence applications has been rather variable. A tank mix of Dyanap plus Lasso or Surflan is registered to improve grass control.

Ancrak and Klean-Krop are other trade names for the formulated mixture of dinoseb plus naptalam. However, they are not registered in combination with Lasso or for postemergence application. Klean-Krop is registered for preemergence use with Surflan.

Premerge-3 (dinoseb) is registered for tank mixing with Lasso or Amiben for preemergence use until soybeans begin to emerge (cracking stage). See the post-emergence section for further information on dinoseb.

#### Postemergence Herbicides

The postemergence use of herbicides for soybeans has not been very popular in Illinois. Most postemergence herbicides for soybeans do not control annual grasses, and their use for broadleaf weeds is too often an emergency or "rescue" treatment. Soybeans are injured by some of the herbicides available for postemergence use. If there is a height difference between soybeans and weeds, the amount of soybean injury can be decreased by directing the spray toward the weeds while minimizing the spray's contact with the soybeans.

Dinoseb water-soluble salts are sold under several trade names, including Premerge. Dinoseb is registered for early postemergence use when soybeans are still in the cotyledon stage. Do not apply if the first leaves have opened and exposed the terminal bud. Do not apply if the soil surface is moist.

Dinoseb is primarily a contact herbicide that controls broadleaf weeds. It is registered for tank mixing with Lasso for early postemergence use.

The postemergence rates for dinoseb vary with air temperature, formulation, and type of application (see label). Do not apply if the air temperature is more than 95° F. *Caution: Dinoseb is quite toxic to man and animals. Exercise extreme caution when using this material.*

Premerge is registered as a salvage treatment over the tops of soybeans after true leaves have unfolded and until soybeans begin to bloom. Crop injury is likely and the grower assumes the risk. The rate is 1 to 2 pints per acre. Do not use surfactant. You may need additional postemergence treatments for satisfactory weed control.

Tenor (chloroxuron) can be applied from the time trifoliolate soybean leaves form until broadleaf weeds are 1 to 2 inches tall. Weed control with chloroxuron has been somewhat erratic, and soybeans usually show some

injury. The broadcast rate is 2 to 3 pounds per acre of Tenoran 50W plus 1 pint of an approved compatible surfactant per 25 gallons of spray.

Basagran (bentazon) can control many broadleaf weeds, such as cocklebur, jimsonweed, and velvetleaf. It is weak on pigweed, lambsquarters, and annual morning-glory. It can provide some control of yellow nutsedge, but not of annual grasses.

The suggested rate for Basagran is  $\frac{3}{4}$  to  $1\frac{1}{2}$  quarts per acre, depending on weed size and species. Application should be done when weeds are small (2-3 inches) and actively growing. Spraying during warm sunny weather can also improve performance. Use 20 to 40 gallons of water per acre in order to get complete weed coverage. Adding a surfactant or oil to Basagran may increase performance, but may also increase the chance of soybean injury.

Dyanap (dinoseb plus naptalam) can be applied to soybeans after the second trifoliolate leaf opens until beans become 20 inches tall. Weeds should be less than 6 inches tall (less than 3 inches tall is preferable) for most effective control. Two to 3 quarts per acre is recommended for control of cocklebur, jimsonweed, smartweed, and annual morningglory less than 3 inches tall. Four quarts per acre may control cocklebur and jimsonweed taller than 3 inches, but do not expect control of most other species at that size. A split application of 2 quarts at the second trifoliolate stage followed by 2 quarts 10 to 14 days later is recommended for severe weed infestations.

Best results are obtained by using high pressure (40 to 60 pounds per square inch) and 8 to 10 gallons of water per acre. Since this procedure will cause spray particles to be small, try to minimize drift. Do not apply Dyanap to wet soybean foliage. Although leaf burn can occur, the crop usually recovers within 2 to 3 weeks with little yield loss.

Butoxone SB and Butyrac 200 (2,4-DB) are used for directed postemergence control of cocklebur in soybeans. 2,4-DB also may give some control of annual morning-glory and giant ragweed. Injury symptoms include leaf wilting, stem curvature, and cracking of stems and if excessive rates are used or if unfavorable conditions exist, yields may be reduced. Consider 2,4-DB for emergency control of cocklebur when potential benefit from weed control is more significant than risk of soybean injury.

Directed sprays may reduce severity of injury. 2,4-DB can be directed when soybeans are at least 8 inches high and cockleburs are less than 3 inches high. Do not spray on more than the lower third of the soybean plant. Do not apply if soybeans show symptoms of *Phytophthora* root rot disease or are under drouth stress.

Directed postemergence application of Tenoran, dinoseb, Paraquat, or 2,4-DB (alone or in combination with Lorox) are registered. Do not spray on more than the lower  $\frac{1}{3}$  of the soybean plant. Refer to the product labels for correct rates and precautions.

## Paraquat Harvest Aid

Paraquat is registered for drying weeds in soybeans. It may be applied when beans are fully developed and when at least half of the leaves have dropped and the rest are turning yellow. If applied before beans are fully developed, yield reductions can result. Do not apply unless beans are ready to withstand frost.

The recommended broadcast rate is  $\frac{1}{2}$  to 1 pint per acre. The higher rate is for cocklebur. Use the suggested rate in 20 to 40 gallons of spray per acre for ground application or in 2 to 5 gallons per acre for aerial application. Add 1 quart of Ortho X-77 or similar surfactant per 100 gallons of spray. Do not pasture livestock within 15 days of treatment, and remove livestock from treated fields at least 30 days before slaughter.

## No-Till and Double-Crop

Corn and soybeans are sometimes produced without seedbed preparation, either in last year's crop residue (no-till) or as a second crop after small grain harvest or forage removal (double-crop). The no-till concept of planting has greatly improved the probability of success of double-cropping by conserving both soil moisture, and time.

The practice of no-till puts chemical weed control to a real test. You must control both vegetation existing at planting and seedling weeds that germinate after planting. Existing vegetation may be a perennial grass sod, a legume, or legume-grass sod, an annual cover crop, or weeds that emerged before planting.

Paraquat (1 or 2 pints per acre) plus a *nonionic* surfactant, such as Ortho X-77, at  $\frac{1}{2}$  pint per 100 gallons of diluted spray is generally used to "knock down" existing foliage before crop emergence. Since Paraquat provides only contact action, a minimum of 40 gallons or more of spray per acre is suggested to insure adequate coverage of the foliage. In situations where fall panicum, smartweed, or certain perennial weeds are a problem, Roundup (3 pints per acre) should be considered as an alternative treatment for control of the foliage prior to crop emergence. Following forage removal in a double-crop program, poor "knock down" of the defoliated forage or weeds may result unless some regrowth has been allowed to occur prior to treatment. Labeled applications of 2,4-D or Banvel can also improve control of broadleaf perennials when used in registered crops, such as corn or sorghum.

## No-Till Corn

Atrazine plus Paraquat (1 to 2 pints per acre) with 8 ounces of Ortho X-77 surfactant per 100 gallons of spray is the most common herbicide treatment used in no-till corn. For control of fall panicum and crabgrass, a mixture of Lasso plus atrazine or atrazine plus Princep should give better control than atrazine alone. Bladex, Prowl, Prowl plus atrazine, and Prowl plus Bladex are registered for use in no-till corn. These herbicides and

herbicide combinations are cleared for use in tank mixtures with Paraquat plus X-77 surfactant. Roundup plus Lasso plus atrazine also are cleared for no-till corn and may be useful where certain perennials are a problem.

### No-Till Soybeans

Preemergence herbicides registered in soybeans as tank mixes with Paraquat (1 to 2 pints per acre) plus Ortho X-77 surfactant (8 ounces per 100 gallons of diluted spray) are Lorox, Lasso plus Lorox, Sencor, Lasso plus Sencor, Surflan plus Lorox, Surflan plus Sencor or Lexone. Lasso plus Lorox, and Lasso plus Sencor or Lexone are also registered as a tank mix with Roundup.

Dow General plus diesel fuel is labeled as a "knock down" herbicide for no-till soybeans planted in wheat stubble. Results vary considerably with temperature and coverage.

### Remarks

Several precautions should be observed in no-till cropping systems. Crop seed should be planted to the proper depth and adequately covered to avoid possible contact from herbicide sprays. (Several herbicide labels give planting depths necessary to avoid possible injury.) Pre-emergence applications of the herbicide treatment may give better weed control than preplant applications since the planting process may expose untreated soil containing viable weed seed. The total reliance on chemical weed control and large amounts of crop residue present under no-till cropping systems may require that the higher labeled herbicide rates be used to obtain acceptable weed control.

## Herbicides for Sorghum

Sorghum acreage is not large in Illinois. However, some is grown in southern Illinois and in bottomlands where weed problems are severe. Because of small acreages, most dealers do not stock specialty sorghum herbicides, so herbicides registered for use with both corn and sorghum often are used.

**Atrazine** may be used for weed control in sorghum (grain and forage types) or sorghum-sudan hybrids. Application may be made preplant, preemergence, or post-emergence. Sorghum tolerates postemergence application better than earlier applications. Injury may occur from preplant or preemergence applications when sorghum is under stress from unusual soil or weather conditions or when rates are too high. The rate of application for preplant and preemergence is 2 to 3 pounds of atrazine 80W per acre. The postemergence rate is 2½ to 3¾ pounds per acre. Follow rates and precautions on the product label carefully. Rotational crop recommendations and weed control are the same as for atrazine used in corn. Failure to control fall panicum has been one of the big problems.

**Ramrod, Bexton, or Propachlor (propachlor)** may be used alone or in combination with atrazine, Milogard, or

Bladex for sorghum. Propachlor will improve grass control, but rates must not be skimpy, especially on soils relatively low in organic matter. For specific rates, consult the product label.

**Igran (terbutryn)** may be applied alone or in tank-mix combination with atrazine 80W or Milogard 80W, but the combinations are recommended. Heed all label precautions, including rotational restrictions.

**Milogard (propazine)** has better sorghum tolerance than either atrazine or Igran, but grass control is not as good. Only corn or sorghum may be planted in rotation within 12 months after treatment.

**2,4-D** may be applied postemergence for broadleaf control in 4- to 12-inch tall sorghum. Use drop nozzles if sorghum is more than 8 inches tall. Rates are similar to those for use in corn.

**Banvel (dicamba)** is registered for postemergence use in sorghum to control broadleaf weeds. Sorghum tolerance is fair. However, since sorghum often is ready for postemergence treatment when soybeans are beginning to bloom, potential drift damage to soybeans is great. An application of ½ pint can be made within 10 to 25 days after sorghum emerges. Earlier or later treatment can cause serious injury to sorghum.

## Herbicides for Small Grains

Small grains seeded in the fall or early spring often compete very well with most weeds if the stand is good and a good fertilization program is followed. Herbicide suggestions for small grains underseeded with a legume differ from those for small grains growing alone. If wild garlic is a problem, do not underseed with a legume; see the specific weed section for herbicide suggestions.

**2,4-D** is used to control certain broadleaf weeds. Winter wheat is more tolerant to 2,4-D than oats, but do not spray wheat in the fall. Small grains can be sprayed in the spring after the grain (wheat or oats) has fully tillered but before it begins rapid stem elongation. Spraying in the boot stage may injure the crop and reduce yield. If the small grain is underseeded with a legume, use only the amine formulation of 2,4-D at ½ pint per acre. If there is no legume underseeding, apply 1 pint 2,4-D amine or ¾ pint of 2,4-D ester per acre. Follow rate suggestions accurately in order to minimize possible injury. Ester formulations may be used where there are no legume underseedings and are suggested for control of wild garlic (see specific weed section).

**MCPA** is less likely to damage oats and legume underseedings than 2,4-D, but it is more expensive and will not control as many different weed species. For small grains underseeded with a legume, use ¼ pound per acre (active ingredient) when the small grain is between the tiller and boot stages and when legumes are 2 to 3 inches tall.

**Banvel (dicamba)** should not be used on small grains that have a legume underseeding. It will control wild buckwheat and smartweed better than 2,4-D but is poorer for controlling mustards. It may be used alone or in combination with 2,4-D. Banvel should be applied after winter wheat has fully tillered and before it begins to joint (nodes begin to form in the stem). Do not apply later or lodging and yield reductions can occur. The rate is ¼ pint of Banvel alone or with 4 to 6 ounces of 2,4-D (active ingredient) per acre.

#### **Small Grain Stubble Fields**

Stubble fields of small grains that have not been underseeded with a legume or double-cropped often are neglected and become infested with weeds after harvest, which supply weed seeds to affect future crops. Tillage can be used to control weeds in stubble fields but may subject the land to erosion. Mowing may control some weeds, but many species grow back rapidly.

In small grain stubble not underseeded with legumes, most broadleaf weeds can be controlled with 2,4-D, and dalapon can control many grasses. Rates may be varied depending on the kind and size of weeds present. Usually ¼ to 1 pound of 2,4-D and 3 to 7 pounds of dalapon are adequate. Weeds should be treated when actively growing. Be sure to follow label directions carefully.

#### **Herbicides for Forage Crops**

Weed control in alfalfa and clovers differs according to crop species and type of seeding — crop alone (pure seeding) or in combination with a grass species. Be sure to consult the label for proper use. Alfalfa and most clovers can be established without a companion crop and where there is not a forage grass-legume mixture by using Eptam or Balan.

**Eptam 7E (EPTC)** may be applied at a rate of 3½ to 4½ pints per acre and immediately incorporated just before planting. It is most effective on grasses and also can give some control of nutsedge, especially at the higher rates.

**Balan (benefin)**, used preplant, is incorporated at a rate of 3 to 4 quarts per acre and may be applied up to 10 weeks before planting. The rate varies with soil type. Balan will control many annual grasses and some broadleaf weeds.

**Butoxone or Butyrac (2,4-DB)** can be used postemergence to control broadleaf weeds in alfalfa and most clovers after the companion crop is removed or in legume-only or legume-grass seedings established without a companion crop. Rates are 1 to 2 quarts per acre of ester formulations or 1 to 3 quarts of the amine formulation. Ester formulations may be used on alfalfa and birdsfoot trefoil, but do not use them on most clovers. Do not graze livestock on or cut hay from treated fields within 30 days after treatment.

**Princep (simazine)** can be applied to pure alfalfa stands established more than 12 months. Apply after the

last cutting in the fall but before the ground is permanently frozen. Princep can control many grasses and broadleaf weeds but will not control most well-established perennial or biennial weeds. Rates are 1 to 1½ pounds per acre of Princep 80W, depending on soil type. If excessive rates are used, applications are made at the wrong time, or unfavorable conditions exist, crop injury can occur.

**Kerb (pronamide)** can be applied to established stands of clover, birdsfoot trefoil, crown vetch, or alfalfa. Fall application is considered best for most weeds. Pronamide will control most annual grass and broadleaf weeds and help suppress quackgrass. Do not apply to mixed stands of legumes and forage grasses. Rates vary from 2 to 4 pounds Kerb 50W per acre. Do not graze or harvest for forage within 120 days of treatment.

**Sinbar (terbacil)** can be applied to pure stands of alfalfa that are at least a year old. It controls many annual grasses and broadleaf weeds. Apply ½ to 1½ pounds per acre when alfalfa is dormant (fall or spring) but not when the ground is frozen. Injury may result when it is used on certain types of soil or under unfavorable growing conditions.

**Sencor or Lexone (metribuzin)** can be used in established stands of alfalfa or alfalfa-forage grass mixtures. Higher rates will reduce stands of forage grasses in the mixtures. It should be applied during the dormant season early in the spring before growth begins or in the fall after alfalfa growth ceases. The rate is ¾ to 2 pounds of 50W or ¾ to 2 pints of 4L, depending upon the weed species to be controlled. Do not graze or harvest within 28 days after application.

**Furloe Chloro IPC (chlorpropham)** may be applied to active, semidormant, or dormant alfalfa that is established or to newly seeded alfalfa with three or more trifoliolate leaves. Application for control of chickweed and downy brome may be made from October through January using 1 to 2 quarts of the 4 EC. After the beginning of February, 2 to 3 quarts can be used. The rate for granules is 40 pounds per acre of the 10 G. Do not apply within 40 days of harvest. Do not apply to alfalfa-grass mixtures.

**Premerge-3 (dinoseb)** can be used for chickweed control in pure stands of alfalfa or clover. Rates are 1½ to 2 quarts per acre for new stands and 1 to 1½ quarts per acre for established stands. Repeat applications may be needed for weeds that emerge after treatment or for heavy infestations. Do not graze or feed treated forages to livestock within 6 weeks of application. *Caution: Dinoseb is quite toxic to man and animals.*

#### **Herbicides for Grass Pastures**

Pasture weed control must be part of a total program of good management that includes proper grazing, good fertilization, and reseeding as necessary.

2,4-D at ½ to 1 pound per acre should provide adequate control of most broadleaf weeds. Higher rates may

be needed for more resistant weeds and some perennials. Milk cows should not be grazed on treated land for 7 days after treatment.

**2,4,5-T** is more effective than **2,4-D** on woody plants. It may be used alone or in combination with **2,4-D**. Do not graze dairy cows on lands treated with **2,4,5-T** for 6 weeks. Meat animals should not graze on pastures recently treated with **2,4,5-T** within 2 weeks of slaughter. It is illegal to spray **2,4,5-T** on ditchbanks, lakes, ponds, or around homes.

**Kuron 2,4,5-TP (silvex)** will control most woody plants about as effectively as **2,4,5-T**. **Silvex** may be used around waterways, water impoundments, and recreation areas. However, you should observe the same grazing restrictions as with **2,4,5-T**.

**Banvel (dicamba)** can control many broadleaf weeds when used at a rate of 1 to 4 pints per acre. Delay grazing 7 to 40 days and delay harvest 37 to 70 days, depending on the amount applied. Do not use where desirable legumes are present; they can be killed by this rate of **Banvel**. Take precautions to avoid injury to other nearby plants that are susceptible to **Banvel**.

## Specific Weed Problems

### Yellow Nutsedge

Yellow nutsedge is a perennial sedge with a triangular stem. It reproduces mainly by tubers. Regardless of the soil depth at which the tuber germinates, a basal bulb develops 1 to 2 inches under the soil surface. A complex system of rhizomes (underground stems) and tubers develops from this basal bulb. Yellow nutsedge tubers begin sprouting about May 1 in central Illinois. For the most effective control, soil-applied herbicides should be incorporated into the same soil layer in which this basal bulb is developing.

For soybeans, a delay in planting until late May allows time for two or three tillage operations to destroy many nutsedge sprouts. Tillage helps deplete food reserves in nutsedge tubers. Row cultivation is helpful. Preplant applications of **Lasso** or **Vernam** also will help.

**Lasso (alachlor)** applied preplant incorporated at  $2\frac{1}{2}$  to  $3\frac{1}{2}$  quarts per acre ( $\frac{1}{2}$  quart more than for surface-applied rates) often gives good control of nutsedge.

**Vernam 7E (vernolate)** applied preplant at  $3\frac{1}{2}$  pints per acre is also effective against yellow nutsedge. Immediate incorporation is necessary with **Vernam**.

**Basagran (bentazon)** is a postemergence treatment that also can help control nutsedge in soybeans. One quart per acre can be applied when nutsedge is small. A split application (two treatments) of **Basagran** also has been registered. For improved control, use preplant treatments and good tillage in addition to **Basagran**.

For corn, early preplant tillage before nutsedge sprouts is of little help for controlling nutsedge. Timely cultivation is helpful in corn, but a program of herbicide plus

cultivation has provided the most effective control of nutsedge.

Several preplant treatments are available. **Eradicane (EPTC)** or **Sutan+** at  $4\frac{1}{4}$  to  $7\frac{1}{2}$  pints per acre are effective for control of yellow nutsedge in corn. They must be incorporated immediately. **Lasso**, preplant incorporated as for soybeans, also can be quite effective. Relatively high rates of **atrazine** sometimes may give good control of nutsedge, but the results have been somewhat variable. The combinations of **Lasso**, **Sutan+**, or **Eradicane** incorporated with **atrazine** may give some control of nutsedge while also controlling many other broadleaf weeds and grasses.

**Dual (metolachlor)** can be applied preplant incorporated, or preemergence alone or in combination with **atrazine** for nutsedge control in corn. Rates of **Dual 6E** are  $2\frac{3}{4}$  to 4 pints per acre when used alone.

**Atrazine** or **Bladex (cyanazine)** as postemergence sprays are used to control emerged yellow nutsedge when it is small. Split applications of **atrazine** plus oil have been more effective than single applications. **Lorox (linuron)** directed postemergence spray also has given some control. **Basagran** can be used in corn in a manner similar to that for soybeans.

### Johnsongrass

Johnsongrass is found primarily in the southern third of Illinois. It is an aggressive perennial that can reproduce both from seeds and by rhizomes. Several herbicides can control seedlings, but the control of johnsongrass rhizomes should involve both chemical and cultural methods.

Much of the rhizome growth occurs after the johnsongrass head begins to appear. Mowing, grazing, or cultivating to keep the grass less than 12 inches tall can reduce rhizome production significantly.

Control of johnsongrass also can be improved with tillage. Fall plowing and disking bring the rhizomes to the soil surface, where many of them are winter-killed. Disking also cuts the rhizomes into small pieces, making them more susceptible to chemical control.

Johnsongrass rhizomes can be controlled or suppressed using certain herbicides in various cropping programs. Several preplant incorporated herbicides can provide control of johnsongrass seedlings in soybeans or corn (see the table at the end of this article).

**Treflan (trifluralin)**, **Tolban (profluralin)** or **Basalin (fluochloralin)** used in a three-year soybean program has been fairly successful in controlling rhizome johnsongrass. They are used at  $1\frac{1}{2}$  to 2 times the normal rate each year for two years, and then either at the normal rate or another suitable herbicide is used the third year before resuming a regular cropping sequence. Research results suggest that control may be 25 to 50 percent the first year and about 75 percent the second year. Be certain not to plant such crops as corn or sorghum following these herbicides used at these higher rates.



**Eradicane (EPTC) or Sutan+ (butylate)** has given partial control of rhizome johnsongrass in corn when used at a rate of 7½ pints per acre as a preplant incorporated treatment. However, this rate of Eradicane increases the risk of corn injury.

**Dalapon** can be used to treat emerged johnsongrass before planting corn or soybeans. Apply 5 to 7 pounds per acre after the grass is 8 to 12 inches tall. Plow about a week later and then delay planting corn or soybeans about 2 weeks. See the label for specific intervals.

Dalapon also can be used to control johnsongrass after wheat. However, much of the wheat acreage in the johnsongrass area is double-cropped or has a legume underseeding. A combination of mowing, timely dalapon application, and tillage has provided quite effective control of johnsongrass.

**Roundup (glyphosate)** can be used to control johnsongrass as a spot treatment in corn, soybeans, or sorghum. Apply 2 to 3 quarts when johnsongrass has reached at least 12 inches and is actively growing. One of the best times to apply Roundup is in small grain stubble when the johnsongrass approaches the early head stage. It also may be applied in the fall before johnsongrass turns brown. Three to 7 days should be allowed after application before tillage.

#### **Quackgrass**

Quackgrass is a perennial grass primarily found in northern Illinois. Most preemergence herbicides will not control it because it is a perennial.

**Atrazine** is quite effective when used as a split application in corn. Apply 2½ pounds of atrazine 80W per acre in the fall or spring and plow 1 to 3 weeks later. Another 2½ pounds per acre should be applied as a preplant or preemergence treatment. A postemergence application is possible but is usually less effective. A single treatment with 3¾ to 5 pounds per acre can be applied either in the spring or fall 1 to 3 weeks before plowing, but the split application usually gives better control of annual weeds. If more than 3¾ pounds of atrazine is applied per acre, do not plant crops other than corn or sorghum the following year.

**Eradicane (EPTC)** can be used to suppress quackgrass in corn where more flexibility in cropping sequence is desired. A rate of 4¾ pints per acre of Eradicane 6.7E can be used on light infestations, while 7½ pints per acre is suggested for heavier infestations. There is some risk of corn injury, especially at the higher rate. A tank mix with atrazine should improve control with lower rates of Eradicane.

**Dalapon** can be applied to quackgrass 4 to 6 inches tall in the spring at a rate of 8 pounds per acre. Plow after 4 days and delay planting corn for 4 to 5 weeks. Up to 15 pounds of dalapon per acre may be used in the fall.

**Roundup (glyphosate)** can be used for controlling quackgrass before planting either corn or soybeans. Apply

2 to 3 quarts per acre when quackgrass is 6 to 8 inches tall and actively growing (fall or spring). Delay tillage for 3 to 7 days after application.

#### **Canada Thistle**

Canada thistle is a perennial weed which, like most perennials, has large food reserves in its root system. Repeated cultivation or mowing can deplete the root reserves and eventually may kill Canada thistle. However, use of herbicides is usually easier, more effective, and more economical. There are several varieties of Canada thistle. They differ not only in appearance but also in their susceptibility to herbicides.

**2,4-D** may give fairly good control of some strains. Rates will depend on where the thistle is growing. For example, higher rates can be used in grass pastures or in noncrop areas than in corn. **Banvel** often is a little more effective than 2,4-D and may be used alone or in combination with 2,4-D.

**Atrazine** and oil applied postemergence has been fairly effective in controlling Canada thistle in corn. Make the application before thistles are 6 inches tall. **Basagran (bentazon)** can be used for control of Canada thistle in soybeans or corn when the thistles are 6 to 8 inches tall. Apply ¾ to 1 quart per acre in a single application, or, for better control, make two applications of 1 quart per acre each, 10 to 14 days apart.

**Roundup (glyphosate)** can be used at 2 to 3 quarts per acre when Canada thistle is 10 inches or more high or approaching early bud stage. Fall treatments must be applied before frost for best results. Allow 3 or more days after application before tillage.

**Amitrole or Amitrole-T**, quite effectively controls Canada thistle, but can be used only in noncrop areas. **Tordon (picloram)** gives good control of Canada thistle, but soybeans and most other broadleaf plants are extremely sensitive. Use only on noncropland.

#### **Wild Garlic and Wild Onion**

Wild garlic and wild onion are perennials that sprout in the fall from underground bulbs and aerial bulblets. Both wild garlic and wild onion form aerial bulblets in May. These plants mature about the same time as wheat and become dormant in early July. Thus, the greatest problem is in winter wheat where the aerial bulblets are harvested with the grain. Such contaminated wheat is often docked to feed grain prices or even refused at elevators.

**2,4-D** can be applied to winter wheat in the spring after the wheat tillers but before it reaches the boot stage (wheat head still inside the stem). Earlier application may reduce tiller production, while spraying during boot stage or later may injure the wheat and reduce yields. The proper time to spray winter wheat is usually late March or early April.

Ester formulations of 2,4-D have provided better control than have amine formulations. Rates of ½ to 1

pound of 2,4-D ester or  $\frac{3}{4}$  to 1½ pounds of 2,4-D amine per acre may be used. These rates may reduce wheat yields and probably will kill legume underseedings. Only about a third to a half of the wild garlic or wild onion will be killed, but the remaining plants may be so distorted that the combine header can be set to miss most of the aerial bulblets.

Wild garlic and wild onion are not usually problems in cultivated row crops such as corn and soybeans. Fall or early spring plowing plus spring tillage and cultivation greatly reduces the growth and reproduction of these weeds. Three or four years of such a program greatly reduces the problems of wild garlic or wild onion.

2,4-D used on corn stubble fields or on grass pastures in the late fall or early winter also can help. In grass pastures, 1 to 2 pounds of 2,4-D ester per acre applied

in late fall or early spring has sometimes given effective control of wild garlic and wild onion. Banvel can also be used in grass pastures at higher rates than with winter wheat, but be sure to take appropriate precautions (see "Herbicides for Grass Pastures" section).

### **Additional Information**

Not all herbicides and herbicide combinations available are mentioned in this publication. Some are relatively new and are still being tested. Some are not considered to be very well adapted to Illinois or are not used very extensively. For further information on field crop weed control, consult your county extension adviser or write to the Department of Agronomy, N-305 Turner Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

## 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 also will influence results. G = good, F = fair or variable, and P = poor.

	Grasses								Broadleaf Weeds									
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings	Shattercane	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Nightshade, black	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Velvetleaf
<b>SOYBEANS</b>																		
<b>Preplant</b>																		
Treflan, Tolban, Cobex, Basalin, Prowl	F-G	G	G	G	G	G	G	P	F	P	P	G	P	G	P	P	P-F	P
Sencor, Lexone + dininitroaniline	F	G	G	G	G	G	G	P	F	F	F-G	G	P	G	G	F	G	F-G
Vernam	F	G	G	G	G	G	G	F	F	P	P	F	P	G	P	P	P	F
<b>Preemergence</b>																		
Amiben	F-G	G	F-G	F-G	F-G	F	F	P	P	P-F	P-F	G	F	G	G	F	F-G	F
Lasso	G	G	G	G	G	P-F	P-F	F	P	P	P	F	F	G	P-F	P	P-F	P
Lasso + Lorox	F	G	G	G	G	P	P	P-F	P	F	F	G	F	G	G	F	G	F-G
Lasso + Sencor, Lexone	F	G	G	G	G	P	P	F	P	F	F-G	G	F	G	G	F	G	F-G
Lorox	F	F	F	F	F	P	P	P	P	F	F	G	F	G	G	F	G	F-G
Modown	F	F	F	F	F	P	P	P	F	P	F-G	G	F	G	F	P	G	F
Sencor, Lexone	F	F	F	F	F	P	P	P-F	P	F	F-G	G	P	G	G	F	G	F-G
<b>Postemergence</b>																		
Basagran	F-G	P	P	P	P	P	P	F	P	G	G	F	P	F	F	F	G	F-G
Dinoseb	F	P	P	P	P	P	P	P	F	F-G	F-G	G	P	G	F	F	F-G	F
Dyanap	F	P	P	P	P	P	P	P	F	G	G	G	P	G	F	F	F	P-F
Tenoran	F	P	P	P	P	P	P	P	F	F	F	F	P	F	F	F	F	P
2,4-DB	P-F	P	P	P	P	P	P	P	F-G	G	P-F	F	P	F	F	F	P	P
<b>CORN</b>																		
<b>Preplant</b>																		
Sutan +, Eradicane	F-G	G	G	G	G	F-G	F-G	F-G	P	P	P	P-F	P-F	G	P	P	P	F
Sutan +, Eradicane + atrazine or Bladex	F-G	G	G	G	G	F-G	F-G	F-G	F-G	F-G	G	G	G	G	G	F	G	F-G
Princep + atrazine	G	F-G	F-G	F	F	P	P-F	P	F-G	F-G	G	G	G	G	G	G	G	F
<b>Preemergence</b>																		
Atrazine	G	F-G	G	P	P	P	P	F	G	F-G	G	G	G	G	G	G	G	F-G
Banvel + Lasso	F-G	G	G	G	G	P	P	F	P-F	F	F-G	G	G	G	G	F	G	F
Bladex	F-G	F-G	F-G	F-G	G	P	P	P	F	F-G	G	G	G	F	G	F-G	G	F
Bladex + atrazine	F-G	F-G	G	F	F-G	P	P	P	F-G	F-G	G	G	G	G	G	F-G	G	F-G
Lasso, Dual	F-G	G	G	G	G	P-F	P-F	F	P	P	F	F	F	G	P-F	P	P-F	P
Lasso, Dual + atrazine	F-G	G	G	G	G	P	P	F	F-G	F	G	G	G	G	G	F	G	F
Prowl	F-G	F-G	G	G	G	F	F	P	P-F	P	P	G	P	G	P	P	F	F
Prowl + atrazine, Bladex	F-G	F-G	G	G	G	F	F	P	F-G	F	G	G	G	G	G	F	G	F-G
Ramrod, Bexton, Propachlor	G	G	F	F-G	F	P	P	P-F	P	P	P	F	P	G	P	P	P	P
<b>Postemergence</b>																		
Atrazine + oil	F-G	F-G	G	P	P	P	P	F	G	G	G	G	G	G	G	F	G	F-G
Banvel	G	P	P	P	P	P	P	P	G	G	G	G	G	G	G	G	G	F
Basagran	G	P	P	P	P	P	P	F	P	G	G	F	P	F	F	F	G	F-G
Bladex	F-G	G	G	F	F-G	P	P	F	F	F-G	G	F	G	F	G	F	G	F
2,4-D	F-G	P	P	P	P	P	P	P	G	G	F	G	F	G	G	G	P-F	F-G

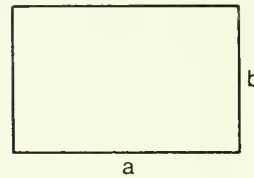
### Useful Facts and Figures

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
<b>Length</b>			
.621	kilometer, km	mile, mi.	1.609
1.094	meter, m	yard, yd.	.914
.394	centimeter, cm	inch, in.	2.54
16.5	rod, rd.	feet, ft.	.061
<b>Area</b>			
.386	kilometer <sup>2</sup> , km <sup>2</sup>	mile <sup>2</sup> , mi. <sup>2</sup>	2.59
247.1	kilometer <sup>2</sup> , km <sup>2</sup>	acre, acre	.004
2.471	hectare, ha	acre, acre	.405
<b>Volume</b>			
.028	liter	bushel, bu.	35.24
1.057	liter	quart (liquid), qt.	.946
.333	teaspoon, tsp.	tablespoon, tbsp.	3
.5	fluid ounce	tablespoon, tbsp.	2
.125	fluid ounce	cup	8
29.57	fluid ounce	milliliter, ml	.034
2	pint	cup	.5
16	pint	fluid ounce	.063
<b>Mass</b>			
1.102	ton (metric)	ton (English)	.907
2.205	kilogram, kg	pound, lb.	.454
.035	gram, g	ounce (avdp.), oz.	28.35
<b>Yield</b>			
.446	ton (metric) hectare	ton (English)/acre	2.24
.891	kg/ha	lb./acre	1.12
.891	quintal/hectare	hundredweight/acre	1.12
.016	kg/ha-corn, sorghum, rye	bu./A.	62.723
.015	kg/ha-soybean, wheat	bu./A.	67.249
<b>Temperature</b>			
(9/5·C) + 32	Celsius	Fahrenheit	5/9(F - 32)
<b>Plant Nutrition Conversion</b>			
P(phosphorus) × 2.29 = P <sub>2</sub> O <sub>5</sub>		P <sub>2</sub> O <sub>5</sub> × .44 = P	
K(potassium) × 1.2 = K <sub>2</sub> O		K <sub>2</sub> O × .83 = K	
ppm × 2 = lbs./A. (assumes that an acre plow depth of 6 2/3 inches weighs 2 million pounds)			

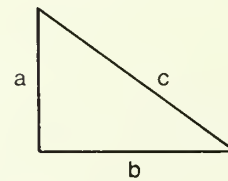
### Useful Equations

$$\text{Speed (mph)} = \frac{\text{distance (ft.)} \times 60}{\text{time (seconds)} \times 88}$$

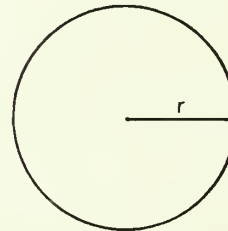
1 mph = 88'/min.



$$\text{Area} = a \times b$$



$$\text{Area} = \frac{1}{2} (a \times b)$$



$$\text{Area} = \pi r^2$$

$$\pi = 3.1416$$

$$\text{lbs./100 ft.}^2 = \frac{\text{lbs./acre}}{435.6}$$

Example: 10 tons/acre =  $\frac{20,000 \text{ lbs.}}{435.6} = 46 \text{ lbs./100 ft.}^2$

$$\text{oz./100 ft.}^2 = \frac{\text{lbs./acre}}{435.6} \times 16$$

Example: 100 lbs./acre =  $\frac{100}{435.6} \times 16 = 4 \text{ oz./100 ft.}^2$

$$\text{tsp./100 ft.}^2 = \frac{\text{gal./acre}}{435.6} \times 192$$

Example: 1 gal./acre =  $\frac{1}{435.6} \times 192 = .44 \text{ tsp./100 ft.}^2$

Water weighs = 8.345 lbs./gal.

Acres-inch water = 27,150 gal.







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