Crop Profile for Corn in Illinois

Prepared July, 2000

General Production Information

Production Facts	
U.S. Rank/Percent:	2nd / 17.2%
Acres Planted:	10,800,000
Harvested:	10,800,000
Production:	1,425 million bushels
Statewide Average:	140 bushels per acre
National Average:	134 bushels per acre
Price per Bushel:	$2.70
Value of Production:	$3,848,715,000

ClickHERE for production statistics.
Click HERE for National Corn Profile.

Production Practices

Corn is grown in nearly every area of the state with the highest density of corn acreage in the central section. Planting may begin as early as the 15th of April in Southern Illinois and the 1st of May in Northern Illinois.

In areas of dairy production, such as around St. Louis and in the Northern tier of counties, corn is primarily used for feed grain. In the central part of the state corn may be processed for oil, sweeteners, and corn meal or shipped to feed grain or export markets. Only about 120,000 acres of corn is ensiled, and most of that is in the dairy region of the state. Much of the state also has extensive seed corn production fields, which is affected by pests with the same frequency as grain corn. However, commercial seed corn production fields are more intensely scouted and a higher level of management is used to control pests.

Because most farmland is in the state is owned by landlords, there is little tolerance for poorly managed fields. This is further exacerbated by the level terrain of much of the state and the ease with which uneven stands or weeds can be seen. This low tolerance often drives farmers to maintain exceptionally clean and aesthetic fields.

There is currently a great deal of controversy over the marketability of grain with GMO traits. In 1999, with over 30 percent of all corn bearing at least one GMO trait, this has come to be a significant concern.

The Crop Profile/PMSP database, including this document, is supported by USDA NIFA.

Cultural Practices

Corn is typically grown in a rotation with soybeans and less often with wheat, sorghum, or alfalfa. About 30 percent of the corn in the state is grown as continuous corn. Conservation tillage practices areregularly used for field corn with no-till practiced on about 20 percent of the corn acreage annually. About 50 percent of the acreage is cultivated with a row cultivator and an estimated 40 percent is rotary hoed annually. Approximately half of all pesticide applications are applied by the farmer and the other half are applied by licensed dealers and applicators. However, a greater proportion of preemergence herbicides are applied by the farmer than is applied by contract applicators. This situation is reversed for post emergence herbicide applications. Approximately 90% of insecticides are for soil insects and are applied by the farmer at planting with planter boxes. Fungicide use is generally limited to the seed treatments that have been applied to the seed prior to purchase.

Insect Pests

In a typical year, the major insect pests can cause severe economic damage in 15% or more of the total acreage. The four major soil insect pests of corn (corn rootworms, cutworms, white grubs, and wireworms) all feed on some subterranean part of the corn plant during their life cycle. The type of injury that each pest inflicts is different, and the occurrence of the insect and damage caused by each insect vary significantly from year to year and region to region.

Avg. % Crop Loss and % Crop Area Infested by Insects

Common Name	Scientific Name	Avg. % Crop Loss	% Crop Area Infested
Billbugs	*none*	0.0	<1
Black Cutworm	*Agrotis ipsilon*	0.1	25
Corn Leaf Aphids	*Rhopalosiphum maidis*	0.0	<1
European Corn Borer	*Ostrinia nubialis*	1	10
Grasshoppers	*Malanoplus spp.*	0.1	1
Northern Corn Rootworm	*Diabrotica barberi*	0.3	5
Stalk Borer	*Papaipema hebris*	0.1	1
Two Spotted Spider Mites	*Tetranychus urticae*	0.1	2

Western Corn Rootworm	*Diabrotica virgifera virgifera*	0.3	10
White Grubs	*Phyllophaga spp.*	0.1	2
Wireworms	*Limonius spp.*	0.1	1

Insecticides:
In 1997, Illinois corn producers used 4,266,000 lbs of insecticides which were applied to 44% of corn acreage in Illinois. These six pesticides account for 79.9% of insecticide used on Illinois corn. (4)

Insecticide Application Information

Insecticide	Area Applied (%)	Total Applied (lbs) '000	Rate/ Application
Chlorpyrifos	16	2,105	1.16
Permethrin	9	105	0.11
Tefluthrin	4	57	0.12
Terbufos	4	1,117	1.24
Cyfluthrin	2	1	0.006
Tebupirimphos	2	22	0.12

Insecticide Rates, MOA, REI, PHI and Target Insects

Trade Name	Common Name	Rate	Units	MOA	REI hrs	PHI days	Target insects
Sevin XLS	Carbaryl	2-4	pts/a	Carb			rootworm, armyworm, flea beetles, grasshoppers
Furadan	Carbufuran	2.5	Fl/oz /1000 ft	Carb		30	Corn rootworm larvae, cutworms, white grubs, grasshoppers

Fortress 2.5G	Chlorethoxyfos	3	oz /1000 ft					Black cutworm, corn rootworm, white grubs
Lorsban 4E **Lorsban 15G**	Chlorpyrifos	½-4 3.5-8	pts/a oz/1000ft				35	Black cutworm, corn leaf aphids, corn rootworm, corn borer, white grubs, armyworm, billbugs, flea beetles, grasshoppers, stalk borer
Aztec 2.1G	Cyfluthrin + Tebupirimphos	6.7	Oz/1000ft					Black cutworm, corn rootworm, white grubs
Dimethoate 400	Dimethoate	2/3-1	pt/a				14	Corn leaf aphids, corn rootworm, grasshoppers, spider mites
Asana XL	Esfenvalerate	5.8-9.6	oz					Black cutworm, corn rootworm beetle, armyworm, flea beetles, grasshoppers, stalk borer, chinch bugs
Dyfonate II 15G	Fonofos	4.0-8.0	oz					Corn rootworm larvae, corn borer, white grubs
Warrior 1EC	Lambda-cyhalothrin	1.92-3.84	oz					Black cutworm, corn rootworm, corn borer, flea beetles, grasshoppers, stalk borer
Lindane	Lindane							Corn borer, white grubs
Malation 57% EC	Malation	1.5	pt				5	Corn leaf aphids

Penncap-M	Methyl Parathion	1-4	pts			12	Corn leaf aphids, corn rootworm beetles, corn borer, armyworm, flea beetles, grasshoppers
Ambush 2E **+ others**	Permethrin	6.4-12.8	oz			30	Black cutworm, corn rootworm, borer, armyworm, flea beetles, hop vine borer, stalk borer
Thimet 15G	Phorate	8	oz/1,000			30	Corn rootworm larvae, white grubs, wireworms
Force 1.5G	Tefluthrin	8-10	oz/1,000				Black cutworm, corn rootworm, white grubs, wireworms
Counter CR	Terbufos	6.0	oz/1,000				Corn rootworm, white grubs, cutworms, wireworms

Insects

Black Cutworm (*Agrotis ipsilon)*
Black cutworm adult moths migrate to southern Illinois from March-May and lay eggs in vegetation in or around cornfields. The eggs hatch and larvae feed on available vegetation, Earlier instars feed on corn leaves; later instars cut the plants off near the ground. Fields subject to cutworm infestation often have preplant infestations of weeds, heavy surface debris, poor drainage, or a history of cutworm damage. An annual average of 3% of all fields are treated with post harvest insecticides, and up to 7% of acreage is treated with preplant or preplant-incorporated insecticide applications. Postemergence rescue treatments are justified when 3% or more of plants are cut and larvae are still present; preventative treatments are best utilized in no-till systems or where cutworm damage forces replanting of field.

The most harmful cutworms, including the black cutworm, are those that cut off and feed on young seedlings. Young cutworm larvae (first through third instars) are very small, and the larvae feed primarily on corn leaves. This injury is not economic. Older cutworm larvae (fourth and later instars) cut the plants off at, just below, or just above the soil surface. If the growing point is destroyed or the plant is cut below the growing point, the plant will not survive. Large numbers of black cutworms can drastically reduce the plant populations.

Although some growers apply soil insecticides to prevent an infestation of cutworms, this practice is usually not justified economically throughout most of the Corn Belt. Densities of cutworms are sporadic and difficult to predict. Consequently, most growers now scout their cornfields, looking for the presence of cutworms and their injury, and apply a "rescue" or therapeutic insecticide if the numbers of cutworms found exceed established economic thresholds.

Corn Leaf Aphids (*Rhopalosiphum maidis*)
Winged corn leaf aphids are blown into Illinois by the prevailing winds. Hot, dry weather is unfavorable for natural enemies and can lead to severe infestations of aphids, Heavy infestations will wilt, curl, and cause necrosis of the upper leaves. Aphids excrete honeydew, which coats leaves and reproductive structures and may interfere with pollination. Certain varieties of corn favor aphid survival and may have up to 9 generations a year.

Corn Rootworm, Northern (*Diabrotica barberi*) and **Corn Rootworm, Western** (*Diabrotica virgifera virgifera*
The larvae of corn rootworm beetles cause the most economic damage every year in Illinois. The larvae overwinter in the soil and undergo three instars while feeding on corn roots, causing lodging and reducing nutrient and water uptake. It is estimated that of the 11,200,000 acres in Illinois corn about 200,000 acres are treated annually for corn rootworm.

The corn rootworm complex consists of four species: Mexican corn rootworm (Diabrotica virgifera zeae Krysan & Smith), northern corn rootworm (D. barberi Smith & Lawrence), southern corn rootworm (D. undecimpunctata howardi Barber), and western corn rootworm (D. virgifera virgifera). Corn rootworm larvae chew on and tunnel inside or along the roots during the summer months. As they feed, the larvae prune roots back to the stalk. Extensive feeding weakens the root systems. Injured plants cannot take up water and nutrients efficiently and are susceptible to lodging. Yield losses are a result of both root pruning and lodging.

Management of corn rootworms is usually accomplished by crop rotation or the use of soil insecticides to prevent severe injury to the roots. A corn-soybean rotation usually provides excellent control of rootworm larvae because the larvae survive only on corn roots, rootworm adults do not lay many eggs in soybeans, and rootworms complete only one generation each year. A corn-soybean rotation may fail to control rootworms when volunteer corn plants in a soybean field attract egg-laying beetles or when rootworms exhibit prolonged diapause, a biological phenomenon that allows some eggs, primarily those of northern corn rootworms, to remain dormant in the soil for more than one winter. This trait has become more common in Illinois within the last few years.

Corn planted after corn is susceptible to injury by corn rootworm larvae, depending upon the size of the rootworm population. Most producers who grow corn after corn in the Corn Belt usually apply a soil insecticide at planting time to protect the corn roots from larval feeding injury. Most growers apply granular insecticides in either a seven-inch

European corn borer (*Ostrinia nubialis)*
First generation corn borer larvae feed on foliage and bore into the stems of whorl-stage plants. Second-generation larvae tunnel into ears, ear stalks, and stalk which causes breakage, lodging, stress, and can significantly reduce yield. It has been estimated that at least 10% of cornfields are infested every year by 3 or more larvae per plant, and that this level of damage causes an estimated 9 to 16% yield loss annually. Annually, from 2-5% of acres are treated in Illinois for corn borer. During outbreak years, as many as 1 millions acres have been treated.

Grasshoppers (*Malanoplus spp.*)
Grasshopppers populations usually thrive during hot, dry summers when their naturally-occurring pathogens are suppressed; populations also tend to increase the year after a drought. Grasshoppers occur throughout Illinois and are usually most damaging in the southern half of the state. Grasshoppers are of minor to moderate importance in Illinois, as they usually prefer to feed on weeds but will readily move into crops if weeds are not available. Up to 11% of field margins may be treated during outbreak years.

Stalk borer (*Papaipema nebris*)
Stalk borer moths lay their eggs on field edges from late August to frost. Fields with poor weed control are most likely to suffer damage from stalk borers. While relatively few acres of corn fields are treated annually for stalk borers, the distribution of borers corresponds with the distribution of weed hosts. The larvae borer into the stalks of plants, causing, death, twisting, bending, tillering, and many infested plants will not produce an ear.

Twospotted Spider mites (*Tetranychus urticae*)
These mites suck fluids from corn plants; heavy infestations of twospotted spider mites cause leaves to wilt, turn yellow, and die. In drought conditions, spider mites can cause devastating losses. Twospotted spider mites are generally a minor pest and on the average, 1 percent of corn acres are treated annually.

White Grubs (*Phyllophaga spp.)*
White grubs are relatively minor pests in Illinois, and damage is usually minimal, with less than 1% of acres treated for grubs annually. White grubs are larvae of several species of scarab beetles, often called May or June beetles. The species most damaging to corn are in the genus Phyllophaga and have three-year life cycles. Peak levels of injury usually occur during the year following large flights of the adults. The beetles prefer to lay eggs in ground covered with vegetation, for example, weedy soybean fields and sod. White grubs chew off roots hairs, reducing water and nutrient uptake, and severely damaged plants will wilt and die, causing severe stand reductions. Symptoms of white grub injury visible above ground are irregular emergence, reduced stands, and stunted or wilted plants. Injured plants often cannot take up phosphorous efficiently, so the plants may turn purple. Injury is generally spotty throughout the field.

Wireworms (*Limonius spp.*)
Wireworm larvae mature in soil in 2-5 years and feed on the germinating roots of corn plants. They are usually problematic in the southern half of Illinois and cause severe damage in bottomlands and on poorly drained upland soil. It is estimated that 2-3% of corn in Illinois is treated for wireworms annually, with 200,000 acres of cornfields treated annually.

Wireworms, the larval stages of click beetles, attack the seed or drill into the base of the stem below ground, damaging or killing the growing point. Aboveground symptoms are wilted, dead, or weakened plants and spotty stands. The adults prefer to lay eggs in grassy fields or small-grain stubble. Injury in a field in a particular year can usually be attributed to the condition of the field two to four years earlier when the beetles were laying eggs. Fields with a corn-soybean-small-grain rotation and fields of corn planted after sods have the greatest potential for wireworm damage.

Infestations of both wireworms and white grubs are difficult to predict because of their lengthy life cycles. Although most entomologists discourage the widespread application of soil insecticides to prevent injury caused by these pests, some growers continue to use soil insecticides for this purpose. In certain cropping schemes, the use of soil insecticides may be justifiable.

Other minor arthropod pests:

- **Armyworm** (Psuedaletia unipuncta)
- **Billbugs**[8,9]
- **Clover Leaf Weevil** (Hypera punctata)
- **Cutworm spp**. (Agrotis gladiaria, Feltia decens, Crymodes devastator, Euxoa detersa, Peridroma saucia)
- **Fall Armyworm** (Spodoptera frugiperda)
- **Grape Colaspis** (Colaspis brunnea)
- **Japanese Beetle** (Popillia japonica)
- **Pea Aphid** (Acyrthosiphon pisum)
- **Seedcorn Maggot** (Delia platura)
- **Webworms, Garden** (Achyra rantalis)

Diseases

For corn, the most frequently cited diseases and pathogens are:

- **stalk rots, primarily anthracnose** (Colletotrichum graminicola, and Fusarium spp. and Diplodia spp.)
- **ear rots** (Fusarium spp., et al.)
- **leaf blights** (Helminthosporium maydis, Exerohilum turcicum)
- **viruses** (Maize dwarf mosaic, maize chlorotic mottle, corn lethal necrosis).

Common soil borne fungal infections produce early season stand losses that can adversely affect crop yields.

In Illinois, farmers are utilizing conservation tillage systems that assist in soil and water retention. However, the presence of a mulch layer from previous crops also modifies many of the physical, chemical, and biological components of the soil and its ecosystem. Numerous studies have documented changes in temperature, water retention capacity, soil microbiology, soil tilth and structure, and chemical composition when farmers have modified their tillage from conventional tillage to either reduced or no-tillage systems.

Population dynamics of root pathogens associated with crop residues may change dramatically as tillage systems change. Fusarium species of fungi, in particular, increase when residues are present. These fungi are common root rotters and also invade corn stalks, causing stalk rots. Higher disease incidence has also been reported with another common soilborne fungus, Rhizoctonia solani. This fungus infects virtually all common field crops and can reduce early season vigor and growth.

A third group of fungi that thrive in cool, wet soils are Pythium species. These fungi cause a soft rotting of soybean hypocotyls and infect the mesocotyl region of corn (the mesocotyl tissue links the new plant with the primary root system). Mesocotyl infections, causing loss of the primary root system, result in reduced growth or death of the seedling. The cooler and wetter conditions associated with reduced tillage increase activity of Pythium fungi.

Seed Treatments and soil-applied fungicides[15]

Corn seeds are treated to avoid infection by diseases in the soil and on the seed coat. Essentially all hybrid corn seed is treated with a broad-spectrum protectant fungicide that adds very little additional cost to production. Other uses in Illinois for commercial grain corn production are extremely rare.

Fungicides for Corn Diseases [1]

Tradename	Common name	Target Diseases
Apron 25W, 50W	Metalaxyl	downy mildew, Pythium and *Phytoptera* spp
Tilt	Propicozanole	gray leaf spot, eye spot, and Helminthosporium leaf blight
Dithane DF, F-45, M-45		common rust and Helminthosporium leaf blight.

Weeds

Weeds will be present in every field every year. The severity of populations is determined by local field management conditions such as tillage, crop rotations, and herbicide use. The prevalence of specific weeds throughout the state is dependent upon soil type, rainfall and moisture, temperatures, and day-length for the region. Perennial weeds have become more of a problem as tillage has been reduced. Approximately fifty percent of all corn fields will report 3 or more weeds present during mid-season scouting [12]. Losses attributed to weeds in field corn average from 3 to 7 percent annually[14]. Crop losses in corn from weeds statewide were estimated as $151 million.

% Crop Infested and Avg. % Crop Loss

Weed Name	% of Crop Infested	Avg. % Crop Loss
Barnyardgrass	30	0.1
Black nightshade	30	0.1

Canada thistle	7	
Common cocklebur	90	0.1
Common lambsquarters	90	0.4
Common milkweed	32	
Common ragweed	90	0.1
Crabgrass	60	0.2
Fall panicum	60	0.1
Giant foxtail	95	1.5
Giant ragweed	90	1.4
Hedge bindweed	3	
Hemp dogbane	37	
Jimsonweed	80	0.1
Johnsongrass	30	0.1
Pennsylvania smartweed	8	
Pigweed spp.	90	0.6
Quackgrass	40	0.8
Shattercane	40	0.4
Smartweed	60	0.1
Tall morningglory	70	0.2
Velvetleaf	90	0.2
Wirestem muhly	10	0.1
Woolly cupgrass	5	
Yellow nutsedge	80	0.1

Table 1. Relative Weed Infestation. Results from a grower opinion survey conducted in 1992 of the twelve states in the North Central Region.

Click HERE for information on weed resistance

Herbicide Application Information

Herbicide	Area Applied (%)	Total Applied (lbs)	Rate/ Application (Lbs/acre)
Atrazine	79	10,400	1.07
Metolachlor	31	7,410	2.14
Acetochlor	29	6,730	2.06
Dicamba	19	803	.37
Cyanazine	15	3,840	2.25
Dimethenamid	8	1,270	1.17
Bentazon	8	375	.44
Glyphosate	7	412	.51
Nicosulfuron	7	23	.03
Primisulfuron	7	14	.02
Bromoxynil	6	180	.27
2,4-D	6	229	.35
Prosulfuron	5	11	.02
Halosulfuron	4	17	.04
Simazine	2	357	1.39
Alachlor	1	164	2.29
Flumesulam	1	5	.06

Herbicide Active Ingredients, Rates, MOA, REI, PHI and Primary Target

Trade name	Component ingredients			Product rates		Unit	MOA*	REI	PHI	Primary
	active a	active b	active c	low	hi	rate		hrs	days	Target
Bladex	cyanazine			1.3	3.3	# prod	P	12		Grass
Extrazine II	atrazine	cyanazine		1.4	4.4	# prod	P/P	12	21	Grass/BL
Micro-Tech	alachlor			4	7	pt	s	12		Grass

Sutan+	butylate			4.75	4.75	pt	s			Grass
Surpass	acetochlor			1.5	3	pt	s	12	21	Grass
Atrazine 90DF	atrazine			2.2	2.2	# prod	P	12	21	BL
Axiom 68DF	FOE5043	metribuzin		13	23	oz prod	s	12		Grass
Balance	isoxaflutol			0	2.5	oz prod	b	12		Grass/BL
Contour	atrazine	imazethapyr		1.33	1.33	pt	a/P	12	45	BL
Doubleplay	acetochlor	eradicane		4.5	4.5	pt	s/s	12		Grass
Dual II Mag	metolachlor			1	2	pt	s	12	30	Grass
Eradicane	EPTC			4.75	4.75	pt	s			Grass
Frontier	dimethenamid			1	2	pt	s	12	40	Grass
Harness	acetochlor			1.5	2.75	pt	s	12	21	Grass
Hornet	clopyralid	flumetsulam		3.2	4.8	oz prod	a/h	48	85	BL
Marksman	atrazine	dicamba		0	3.5	pt	h/P	48		BL
Prowl/ Pentagon	pendimethalin			2	4.8	pt	m	12		Grass
Python	flumetsulam			0.8	1.25	oz prod	a	12	85	BL
Princep	simazine			2.2	4	# prod	P	12		BL
2,4-D amine	2,4-D			0.33	0.5	pt	h	48	7	BL
Accent	nicosulfuron			0.66	0.66	oz prod	a	4	30	Grass
Accent Gold	nicosulfuron	clopyralid	flumetsulam	2.9	2.9	oz prod	a/P	48	85	Grass/BL
Aim	carfentrazone			0.33	0.33	oz prod	a	12		BL
Atrazine +Oil	atrazine			1.44	2.2	# prod	P	12	21	BL

Basis	rimsulfuron	thifensulfuron		0.33	0.33	oz prod	a	4	30	BL
Basis Gold	atrazine	nicosulfuron	rimsulfuron	14	14	oz prod	a/P	12	30	Grass/BL
Beacon	primisulfuron			0.75	0.75	oz prod	a	12	60	Grass
Buctril	bromoxynil			1	1.5	pt	p	12	30	BL
Buctril +atrazine	atrazine	bromoxynil		1.5	3	pt	p/P	12	30	BL
Celebrity B&G	dicamba	nicosulfuron		6.66	6.66	oz prod	h/a	12		Grass/BL
Clarity	dicamba			0.5	1	pt	h	12		BL
Exceed	primisulfuron	prosulfuron		1	1	oz prod	a	12	60	BL
Extrazine II	atrazine	cyanazine		1.3	3	# prod	P	12	21	BL
Hornet	clopyralid	flumetsulam		3.2	4.8	oz prod	a/h	48	85	BL
Laddok S-12	atrazine	bentazon		1.3	2.3	pt	P/p	12	21	BL
Liberty ATZ	glufosinate	atrazine		32	40	fl oz	r/P	12	70	Grass/BL
Liberty	glufosinate			16	28	fl oz	r	12	70	Grass/BL
Lightning	imazapyr	imazethapyr		1.28	1.28	oz prod	a	12	45	Grass/BL
Marksman	atrazine	dicamba		2	3.5	pt	P/h	48		BL
NorthStar	primisulfuron	dicamba		5	5	oz prod	a/h			BL
Permit	halosulfuron			0.66	1.3	oz prod	a	12	30	BL
Poast Plus	sethoxydim			24	24	fl oz	l	12	60	Grass
Resolve	dicamba	imazethapyr		5.3	5.3	oz prod	a/h	12	45	Grass/BL
Resource	flumiclorac			4	8	fl oz	c	12	28	BL
Roundup Ultra	glyphosate			1.5	2	pt	r	4	7	Grass/BL
Scorpion III	2,4-D	clopyralid	flumetsulam	4	4	oz prod	a/h	48	85	BL

Sencor/ Lexone	metribuzin			2	5	oz prod	P	12	60	BL
Spirit	primisulfuron	prosulfuron		1	1	oz prod	a	12	60	BL
Stinger	clopyralid			0.25	0.5	pt	h	12	40	Bl
Tough 5EC	pyridate			0.75	1.5	pt	p	12	68	BL
Micro-Tech	alachlor					pt	s	12		Grass

***Mode of Action codes used:** a=ALS inhibitor, h=growth hormone type, p=photosystem inhibitor non-mobile in plant, P= photosystem inhibitor, mobile, c=contact action, b=bleaching action, s=shoot inhibitor, m=mitotic inhibitor, l=lipid synthesis (meristem) inhibitor, r=amino acid synthesis inhibitor

For more information on herbicide modes of action see: http://ext.agn.uiuc.edu/CropProfiles/herbMOA.htm

Weed Resistance

Weed resistance to herbicides is now recognized as a major threat to corn production within the state. Weed species resistant to herbicides in Illinois now include common lambsquarters, giant foxtail, kochia, and redroot pigweed. The herbicides that have resulted in the development of resistant weeds include the triazines, sethoxydim, and the imidazolinone and sulfonylurea chemistries. The potential for resistance development is greatest for herbicides with systemic modes of action and long half-life. The likelihood of resistance also increases if the herbicide is used at high rates or repeatedly in the same field.

The use of imidazolinone and sulfonylurea herbicides, which have the ALS inhibition mode of action, has raised concerns about the development of new resistant weeds. These herbicides have been well received by farmers and their use continues to expand on both corn and soybean crops. Because of a broad-spectrum of weed control and their use on both corn and soybeans in rotation, the potential for development of resistance to this class of compounds is high. If herbicides with alternative modes of action are not available the risk rises significantly. After populations of resistant weeds develop, only expensive or environmentally unsound remedies may remain.

Barnyardgrass (*Echinochloa crusgalli*)
This summer annual germinates from 0 to 5 inches deep in the soil. The seeds remain viable for several years, and plants may emerge throughout the summer. Barnyardgrass in most troublesome in low, moist, warm areas.

Black Nightshade (*Solanum ptycanthum*)
This summer annual can produce thousands of berries; each berry contains up to 50 seeds. While nightshade is generally not considered a serious pest in Illinois, severe infestations in individual fields do occur. Tillage and

row cultivation are effective for early, newly emerged seedlings.

Canada thistle (*Cirsium arvense*)
Canada thistle is a perennial weed with a vigorous, rhizomatous root system. Propagation is by rootstock and seeds; only female plants produce seed. Canada thistle is listed as a noxious weed in Illinois, and is most severe in the northern counties of Illinois. Preplant tillage and row cultivation can control small seedlings but are less effective in controlling plants arising from rootstocks.

Common Cocklebur (*Xanthium pennsylvanicum*)
Common cocklebur is a summer annual weed. Its seeds are spread by attaching to animal fur or by tillage or harvesting equipment. Cocklebur is a serious competitor for moisture. Cultivation, tillage, and mowing will all help control cocklebur establishment.

Common Lambsquarters (*Chenopodium album*)
Common lambsquarters produce numerous small seeds with germinate after an overwintering process. Optimal temperature for germination is 70F, but can germinate between 40 to 94, which suggests early germination capabilities. Survival is favored by rains which dilute or leach herbicides from the soil surface.

Common Milkweed (*Asclepias syrica L.*)
This perennial weed reproduces by seeds and adventitious buds that sprout from underground roots. Seedlings produce vegetative buds 18-21 days after germination, and seeds may remain viable for up to three years. Seeds may germinate from as deep as 2 inches in the soil, and undisturbed fields or fields with reduced tillage and moist soils are favored. Problems with common milkweed have been increasing due to the decrease in tillage and row cultivation.

Common Ragweed (*Ambrosia artemisiifolia*)
Common ragweed is a summer annual that is favored by moist soils and can be a serious problem in individual fields. Control of common ragweed with tillage or row cultivation is effective in controlling small seedlings.

Crabgrass spp. (*Digiteria spp.*)
A warm season grass most often troublesome in the southern and southeastern part of the state. The plants generates stolons and may result in a severe infestation from a single plant. May be most severe during the late part of the growing season after herbicides have degraded or and holes remain in the canopy. Tillage and row cultivation also help control.

Fall Panicum (*Panicum dichotomiflorum*)
Fall panicum is a summer annual that grows best in warm, wet, fertile soils. The plant tillers profusely and in late August and September the tillers open and scatter hard-coated seeds. These seeds may remain viable for years, and fall panicum is most often a problem in reduced or no-till fields whose undisturbed soils are favorable for germination. Fall panicum has shown some resistance to atrazine, and is one of the most serious grass weeds in the state.

Giant Foxtail spp. (*Setaria spp.*)
The three species of foxtails in Illinois are giant foxtail *(Setaria faberi)*, green foxtail *(S. viridis)* and yellow foxtail *(S. glauca)*. Giant foxtail is the most competive of the three species. Foxtails are considered the most important weeds species in Illinois. One plant may produce several heads with 500-1000 seeds per head that can

germinate in one to several years after production. These plants are adapted to most Illinois conditions, tend to grow in clumps that compete with crops and make cultivation and plowing difficult. All foxtails are more serious in reduced and no-till fields.

Giant Ragweed (*Ambrosia trifida*)
Wet weather favors giant ragweed, and this summer annual may be a severe problem in isolated fields. The seeds of giant ragweed may remain viable in the soil for several years. Small seedlings can be controlled with row cultivation and tillage.

Hemp dogbane (*Apocynum cannabium*)
This perennial weed is capable of regrowth from perennating rootstock within six weeks of emergence. The underground root system may extend laterally 20 feet per year and downward as far as 14 feet. The northwest quarter of the sate is usually most severely infested with dogbane. Tillage can reduce dogbane infestations, but is ineffective once populations are established.

Jimsonwee (*Datura stramonium*)
Jimsonweed produces several hundred hard-coated seeds per plant which may remain viable in the soil for years. This summer annual grows best under warm temperatures and moist soils. Jimsonweed infestations harm soybean crops via competition for water, especially in dry years. The shade of its leaves in shorter crops increases yield loss due to decreased nutrient uptake. Jimsonweed also contains the alkaloids, atropine, hyoscyamine, and hyoscine, which are toxic. Even small amounts of jimsonweed can cause harvest problems.

Johnsongrass (*Sorghum halepense*)
Johnsongrass is a perennial noxious weed in Illinois and produces prolifically via rootstock and seeds. Rhizomes overwinter; both rhizomes and seeds sprout in the spring. Seeds may survive for several years before germination. Surface tillage is not an effective control.

Morningglories (*Ipomoea* spp.)
Tall morningglory and ivyleaf morningglory are the two major annual morningglory species found on Illinois soils. The seeds of these summer annuals may survive for several years in soil. Infestations are most common in moist soils along river bottomland, but these plants can be found most anywhere in the state. Annual morningglories adapt to crops by vining about the crop, so shading by the canopy is not particularly successful in reducing growth. Newly emerged seedlings can be controlled by tillage and cultivation, but this may result in conditions that favor emergence by weeds deeper in the soil profile. After vines begin to twine about the stems of the crop, cultivation may not be as effective.

Pennsylvania Smartweed (*Polygonum* spp.)
This summer annual grows best on wet soils and is widely distributed across Illinois. Smartweed emerges early in the spring and can be a severe problem is tillage is delayed to wet soils, as seedbed preparation may result in transplanting larger plants rather than destroying them.

Pigweeds (*Amaranthus spp.*)
Pigweeds are prolific seed producers, and one female can produce over 100,000 seeds in one growing season. The seeds of this plant may remain viable for years. Pigweeds are a problem in no-till systems because undisturbed soils favor germination of the minuscule seeds, and the debris keeps the field moist and allows for extended germination. Other favorable germination locations are where excess nitrogen is available, and where no soil

applied herbicides have been used. Localized populations of some biotypes of pigweed have shown triazine or acetolactate synthase (ALS)-inhibitor resistance.

Quackgrass (*Elytrigia repens*)
Quackgrass is a cool season perennial that reproduces by rhizomes, and to a lesser amount by seeds. New plants sprout at axillary buds, and rhizomes may remain viable for years. Quackgrass is most often a problem in the northern part of the state. Tillage can help control this weed.

Velvetleaf (*Abutilon theophrasti*)
Velvetleaf is the most significant annual broadleaf weed in Illinois corn, most damaging in the Northern and Central parts of the state. Velvetleaf is a serious competitor for moisture in drought conditions. Cultivation can somewhat control velvetleaf when used in the early season.

Wirestem muhly (*Muhlenbergia frondosa*)
This perennial grass reproduces from rhizomes; it tillers profusely and flowers in August and September. The northwest quarter of the state is most often infested with wirestem muhly.

Yellow nutsedge (*Cyperus esculentus*)
Yellow nutsedge causes the most severe perennial weed infestations and is quite serious across Illinois. It reproduces from tubers as the seed does not survive overwintering, and tubers can adapt to almost any soil type and conditions. Tubers germinate at up to 12 inches of soil and remains viable for up to three years in soil. Severe infestations can occur in various parts of the state.

Weed control practices

Although the weed species present in each field do affect herbicide selection, other less obvious factors also have significant impact. For instance, no-till and conservation tillage practices are more prevalent in areas where rolling terrain prevails. Where no-till and conservation tillage practices are used there is a greater reliance on persistent herbicides that have burndown characteristics and do not need mechanical incorporation.

Farm size also may affect herbicide selection. In Illinois, large open spaces encourage the amalgamation of farmland, the use of large farm equipment, and a higher percentage of farm operation by non-owners (70% of farms in Illinois are operated by someone other than the owner). As a result, operators strive for weed-free fields, with the intent of maintaining their lease by exceeding the expectations of the landlord. In addition, open spaces, straight rows, and numerous access roads put each field on public display. Weeds are hard to hide when you look down between the rows for nearly one-half mile. As a result, the expectations for weed-free fields tend to be high, and farmers are inclined to spend more for weed control.

Because their fields are on public display, operators are also less tolerant of crop injury. A stunted or injured crop is an embarrassment to the farmer, and farmers make concerted efforts to avoid cosmetic injury even though yield effects may be minimal. In addition, large fields exacerbate concerns about drift injury. For example, a farmer with an 80-acre corn field would not want to risk injuring his neighbor's adjacent soybeans by applying 2,4-D or dicamba to his corn. Where fields are smaller and farther apart the concern about drift injury is greatly reduced. Another factor having a significant impact on herbicide selection is regional preferences for specific products. Farmers' perceptions of new products often arise from performance complaints and crop injury claims from other local producers. Unfavorable weather in an area in the first or second year after product introduction can greatly reduce herbicide efficacy and slow the acceptance of the product to a near standstill. Concerns about crop injury and carryover injury are also factors that affect product preference. Carryover injury on corn from imazaquin and clomazone in 1989, and the resultant poor acceptance of the products thereafter, are prime examples of how dry, cool and windy weather can affect the acceptance of new products.

Regional product preferences are also based on the manufacturer's marketing and promotional efforts. Newly introduced products that carry guarantees capture market shares quickly. Products that carry more complete guarantees tend to be favored. The availability of marketing and sales personnel for a specific product or set of products also greatly affects a farmer's choice.

Exposure to herbicides

Approximately 50% of all herbicides are applied by custom applicators with sophisticated equipment bearing air filtration systems. The remaining applications are applied by farmers with a wide range of equipment types. Larger pieces of equipment, such as those used to apply and incorporate preemergence herbicides, typically have a cab and air filtration system. However, for postemergence and spot applications, smaller vehicles which have exposed operators may be used. The frequency with which small vehicles are used is unknown. Other factors affecting operator exposure include: distance between the spray boom and the operator, prevailing weather conditions, protective clothing worn by applicators, and the prevalence of vapors and dispersed spray droplets. To date these factors have not been quantified.

Applications of granular or dry formulations of herbicides are used on about 1 million acres of field corn annually. Although the number of dry formulations available has increased in recent years, most new dry formulations are water-dispersable granules that have reduced dust inhalation risk. Dry formulation packaging has also reduced container disposal problems.

Exposure of either farmers or custom applicators during mixing and loading has not been well researched. We can speculate that the increase in use of pesticides that are available in highly concentrated dry formulations has great potential for reducing such exposure.

Of the 11,200,000 corn acres planted in Illinois in 1997, 98% of them receive at least one herbicide application. The average amount of herbicide per acre was 2.92lbs of active ingredient. (4)

Within the past few years only tridiphane, which the manufacturer voluntarily withdrew from the market, is a recent loss to corn production. While actual losses of registrations have been few, restrictions placed on many herbicides have increased. Atrazine, alachlor, bromoxynil, cyanazine, and paraquat are all restricted-use pesticides. They may be purchased and applied only by or under the direction of certified, licensed applicators. Groundwater advisories have been added to many labels to prevent mixing, loading, and application in areas of high risk for runoff or leaching. Many additional restrictions have been placed on atrazine and cyanazine to limit the time, rate, and location of application to reduce contamination of surface and ground water resources. It is likely that additional restrictions will be imposed on individual products, to limit not only water contamination, but also drift, wildlife exposure, and residues in foods.

A number of new products have been registered for weed control for corn. These products expand the spectrum of weeds controlled and the window for applications. Unfortunately, many of these new products have the ALS inhibition mode of action and, as mentioned above, significantly increase the potential for development of resistant weeds.

Contacts

David Pike
S-310 Turner Hall
University of Illinois
1102 S. Goodwin
Urbana, IL. 61801
(217) 333-4424

Kevin Steffey
S-322 Turner Hall
University of Illinois
1102 S. Goodwin
Urbana, IL. 61801
(217) 333-4424

Mohammed Babadoost
S-310 Turner Hall
University of Illinois
1102 S. Goodwin
Urbana, IL. 61801
(217) 333-4424

References

1. Anonymous. 1996. Crop Protection Reference, 12th ed. Chemical and Pharmaceutical Press, New York.
2. Anonymous. 1997. Illinois Agricultural Pest Management Handbook, 1997. University of Illinois at Urbana-Champaign, College of Agricultural, Consumer, and Environmental Sciences Cooperative Extension Service, 400 pages.
3. Pike, D.R., W.H. Kuhlman, W.H. Luckmann, M.C. Shurtleff, K.L Steffey. 1992. Illinois Pest Profiles. Illinois Natural History Survey, Urbana, IL. 95 pages.
4. Anonymous. 1998. United States Department of Agriculture Agricultural Chemical Usage, 1997 Field Crops Summary.
5. Anonymous. 1997. IASS Reports. Overview of Illinois Agriculture 1997 http://www.agr.state.il.us/cestimat.htm
6. Anonymous. 1997. United States Department of Agriculture Crop Production 1997 Summary. January 1998 National Agricultural Statistics Service, Cr Pr 2-1(98) http://usda.mannlib.cornell.edu/reports/nassr/

field/pcp-bban/crop_production_annual_summary_01.13.98
7. Hager, A.G, L.M. Wax, F.W. Simmons, E.W. Stoller. 1997. Waterhemp management in agronomic crops. Vocational Agriculture Service, Information Services, College of Agricultural, Consumer and Environmental Sciences, University of Illinois at Urbana Champaign
8. Rice, M., Extension Entomologist, Department of Entomology. Billbugs: an early surprise. Iowa State University, Ames, Iowa. Integrated Crop Management. Issue IC-478(11), June 2, 1997 http://www.ipm.iastate.edu/ipm/icm/1997/6-2-1997/billbugs.html
9. Willson, H., and Eisley, B., 1995. Insect Pests of Field Crops: Billbugs, The Ohio State University Extension Bulletin. Bulletin 545. http://www.ag.ohio-state.edu/~ohioline/b545/b545_10.html
10. Spencer, J., 1998. Behavioral Change And High Populations Suggest Rootworm Problem. In 1998 College of Agricultural, Consumer and Environmental Sciences University of Illinois at Urbana-Champaign Information Services News and Public Affairs. http://www.ag.uiuc.edu/news/articles/884787024.html
11. Pike, D. R., H. W. Kirby, and S. T. Kamble. 1993. Distribution and Severity of Pests in the Midwest. University of Illinois, College of Agricultural, Consumer, and Environmental Sciences, Department of Crop Sciences, Project #93EPIX-1-0107
12. Pike, D. R. 1998. The occurrence and densities of weeds in Illinois and Iowa as noted from crops scouting records. North Central Region Pesticide Impact Assessment Program, Project #95EPIX 1-0207
13. Pike, D.R., W.H. Kuhlman, W.H. Luckmann, M.C. Shurtleff, K.L Steffey. 1992. Illinois Pest Profiles. Illinois Natural History Survey, Urbana, IL. 95 pages.
14. Pike, D. R. Estimation based on experience.
15. Pike, D. R., K. L. Steffey, M. E. Gray, H.. W. Kirby, D. I. Edwards, R. H. Hornbaker, 1995. Biological and Economic Assessment of Pesticide Use of Corn and Soybeans. NAPIAP Rpt No. 1-CA-95.http://ext.agn.uiuc.edu/piap/assess/assessmt.htm
16. Pike, D. R. 1995. Field Corn and Soybean Pesticide Use Summaries. Special report 1996-02.
