Crop Profile for Corn
In the Northern and Central Plains
(KS, NE, ND, and SD)

Prepared August 1999
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General Production Information

Approximately one-fifth of all U. S. corn was produced in the Northern and Central Plains (including KS, NE, ND, and SD) during 2004 and 2005. Nebraska led these states in corn production during 2004 and 2005, contributing 1319.7 and 1270.5 million bu respectively, followed by relatively smaller harvests in SD, KS, and DN. In addition to human consumption, the corn farmers grow in the Northern and Central Plains primarily feeds livestock, contributes to ethanol production along with other industrial uses, and exports to foreign countries. The following table summarizes corn area, yield, production, price per unit, ranks, and value of production in the region during 2004 and 2005.

Year	State	Planted	Harvested	Yield	Production	Price per Unit	Value of production	Rank**
		acres - thousand	acres - thousand	bushel	1000 bushels	$/bu	X $1,000	
2004	Kansas	3,100	2,880	150	432,000	2.12	915,840	9
	Nebraska	8,250	7,950	166	1,319,700	2.02	2,665,794	3
	North Dakota	1,800	1,150	105	120,750	1.88	227,010	16
	South Dakota	4,650	4,150	130	539,500	1.82	981,890	6
	Total	17,800	16,130		2,411,950		4,790,534	
	*Proportion	21.99	21.91		20.43		19.65	
	USA	80,929	73,631	160.4	11,807,086	2.06	24,381,294	
2005	Kansas	3,650	3,450	135	465,750	2.1	978,075	7

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	Nebraska	8,500	8,250	154	1,270,500	1.85	2,350,425	3
	North Dakota	1,410	1,200	129	154,800	1.8	278,640	14
	South Dakota	4,450	3,950	119	470,050	1.7	799,085	6
	Total	18,010	16,850		2,361,100		4,406,225	
	*Proportion	22.03	22.43		21.25		20.94	
	USA	81,759	75,107	147.9	11,112,072	1.9	21,040,707	

*Proportion of the four-state total to the US total.
** Rank within the 48 state.

Pesticide Usage on Corn for 2004

Corn is one of the major commodities in the Northern and Central Plains. The pesticide usage survey on corn for 2004 was conducted in the region by the Kansas Agricultural Statistics Service (KASS) and Kansas State University from March through May 2005. Questionnaires were mailed directly to all sampled corn growers identified by KASS based on historic data. In total, 1600 questionnaires were distributed. Overall valid responses to questionnaires were fairly low during the 2005 survey and only approximate 18% questionnaires were returned. Total 287 responses contained valid data from four states and 215 counties. The following table displays the sample distributions in terms of states and counties in the Northern and Central Plains.

Sample Allocation and Return

State	Sample Allocated	Sample Collected	Return Rate %	County
KS	400	53	13.25	47
NE	400	90	22.50	71
ND	400	50	12.50	39
SD	400	94	23.50	58
Total	1600	287	17.94	215

Sampling Acreages and Pesticide Treatment Acreages

STATE	Sampled (Acre)*	CORN (Acre)**	GM_CORN***		Insecticide Treatment		Herbicide Treatment		Fungicide Treatment	
			(Acre)	Proportion (%)	(Acre)	Prop. (%)	(Acre)	Prop. (%)	(Acre)	Prop. (%)
KS	87611	18903	6885	36.42	10217	54.05	26260	138.92	65	0.34
NE	100935	34491	17169	49.78	11624	33.70	52820	153.14	0	0.00
ND	131799	25600	15973	62.39	282	1.10	30428	118.86	700	2.73
SD	179433	33588	30148	89.76	4766	14.19	48365	143.99	0	0.00
Total	499778	112582	70175	62.33	26889	23.88	157873	140.23	765	0.68

* Total acres (including farmstead, all cropland, woodland, pastureland, wasteland, and government program land) operated by the sampled farmer/grower.
** Total acres planted with corn for the 2004 crop year by the sampled farmer/grower.
*** The acres planted with genetically modified (GM) corn by the sampled farmer/grower. Please note that GM_Corn refers to all biologically engineered corn including Bt-corn, herbicide resistant corn, and etc.

Approximately 22.5% sampled acres were planted with corn and over half of them were GM-corn including Bt-corn in this region. South Dakota led these states in GM-corn production in 2004.

Survey data showed that approximate 24% sampled acres were treated with insecticides, 140% sampled acres were treated with herbicides for various weeds at different times, and less 1% sampled acres were treated with fungicides. Overall, weed management was one of important practices in corn production in the Northern and Central Plains. Certain areas were obviously treated multiple times with herbicides against weeds. Plant disease was a relatively minor problem in comparison with insects and weeds in pest management, as measured by pesticide use.

Survey responses indicated that overall 60% of the pesticide applications were undertaken directly by farmers/growers against various pests while 40% were applied by commercial entities.

Cultural Practices

Corn planting dates range from late March in Kansas to late-May in North Dakota. Corn is ideally planted when soil temperature reaches 55^{o}F at 2-inch depth. Most irrigated corn plant populations range from 24,000 to 30,000 plants/acre, if irrigation is limited, plant population range is from 16,000 to 25,000 plants/acre depending on soil type and amount of water available. In Nebraska, corn is recommended 30 inches apart in rows and a population of 25,000 to 30,000 plants per acre. Planters usually are equipped for herbicide banding, starter fertilizer, and soil insecticide application. Corn produced for grain under irrigation represented about 60% of the total harvested corn acreage. Irrigated corn production was the most dominant cultural practice in this region. Irrigated corn requires 24 to 30 inches of water use for full season hybrids grown in this region.

A number of different tillage and planting systems are used in corn production, including primary and/or secondary tillage, or no pre-plant tillage operations. Conservation tillage includes reduced till, mulch-till, eco-fallow, strip-till, ridge-till, zero-till, and no-till. In Kansas, about 30 percent of the harvested corn acres will have less than 15 percent ground cover. 46% percent of the corn acres are in reduced tillage, no-tillage or ridge-till, leaving more than 30 percent ground cover at all times. Corn can be successfully grown in conservation tillage system if rotated with other crops such as wheat and soybeans, which will reduce some of the problems encountered with conservation tillage.

Worker Activities

Corn production in the Northern and Central Plains is primarily mechanized. Worker activities for Corn production involve field preparation, planting, fertilizer and pesticide application, pest scouting, and harvesting. Most of these activities are conducted by growers, family members, their employees, or consultants with machines.

The primary worker activities in the early season involve seed treatment with insecticides, fungicides, and herbicides against certain soil insects, plant diseases, and broadleaf weeds. The major activities during the summer involve pest monitoring, and fungicide applications against several potential plant diseases**.** Field scouting is done normally prior to any pesticide application and therefore causes minimal risk of exposure. Farmers/growers may occasionally harvest fresh sweet corn by hand during early summer. Overall activities that bring workers in direct contact with corn during the whole growing season are limited.

Insect Pests

Corn as a major crop in the Northern and Central Plains, like all others major crops, suffers from pests including various insects, the occurrences of pest infestation may change from year to year and from state to state. Chemical insecticide application is still one major component in insect management during corn production in this region even though the proportion of genetically modified corn increased dramatically in this region. Survey showed that at least 39 insecticide products were applied against 17 insect pests in this region during 2004. Although seed treatment is primarily for disease control, recent

developments in seed treatments have emphasized the efforts toward insect control. Products such as Gaucho and Prescribe offer various levels of protection against different insects in soil.

Insects

Following are major corn insect pests that were treated with insecticides in the Northern and Central Plains in 2004.

Cutworms Various cutworm species can attack corn seedling. **Sandhills** and **Black Cutworms** may be the most frequent pests. The moths of all species but the **Black Cutworm** (*Agrotis ipsilon*) lay their eggs in the fall and generally are partly to full grown by the time corn sprouts. (**Black Cutworm**, Image courtesy of http://www.pdis.org). **Black Cutworm** (*Agrotis ipsilon* (Hufnagel)) damage is restricted to corn fields within the first two weeks after emergence in this region. Spots in the field with transparent or notched leaves may indicate small cutworm larvae are present. Large cutworm larvae cause the plant to wilt, and damage to the growing point reduces plant stands. Fields should be scouted frequently from the start of plant emergence until the corn is 6-8 inches high. Post-emergence treatments are almost always preferred over preventative treatments because of the uncertain nature of the infestations.

Billbug Billbugs are early-season seedling corn pests that can kill seedling plants and significantly reduce stands if their populations are large. These insects are weevils and several species are known in this region including **maize billbug**, **southern corn billbug** and **claycolored billbug**. The maize billbug is 5/16-inch long and is the most common of the three species. The **southern corn billbug** and **claycolored billbug** are much less common. All three species are characterized by a very hard body and a long, downward curved beak. **Maize Billbug** (*Sphenophorus maidis**)*** damage occurs early and adult billbugs destroy the growing point in the stalks just below or above the soil surface. The larva tunnels into the lower stem and roots. (*Sphenophorus parvulus*, image courtesy of http://www.pdis.org), all unspecified insect images were courtesy of Insect and Damage Photo Album of Department of Entomology, Kansas State University).

Webworms Webworms are caterpillars that feed protected by webs; these caterpillars primarily feed on corn leaves and cause injury to corn seedlings early in the spring. They vary in size from 1/2 to nearly 1 and 1/2 inches in length. Webworms include several species. (Sod webworm (*Crambus lechellus*), image courtesy of http://www.pdis.org).

Webworms that attack corn overwinter as larvae inside cocoons spun the previous summer. Larvae become active in the spring and feed on corn until they are full-grown during summer. Pupation occurs next to corn plants and a short distance underground. Injury caused by webworm larvae may resemble cutworm injury. Larvae defoliate plants, feed on leaf margins, cut plants near ground level, or feed just below the soil surface. Larval tunneling in furled leaves results in straight rows of shot holes across the leaves. The most severe injury occurs when plants are cut below ground or when larvae chew holes into underground portions of the stem and injure the meristem, which may result in wilting or tillering of the plant (http://www.ag.uiuc.edu/cespubs/pest/articles/v979e.html).

Corn Rootworm (Western and Northern species) Larvae (*Diabrotica virgifera* and *Diabrotica longicornis,* respectively) damage may be not a problem if corn is rotated with another crop on an annual basis in this region.

Adult corn rootworm beetles lay eggs in cornfields from late summer through early fall. The larvae feed on the roots of corn (field corn, popcorn, or sweet corn). By rotating corn annually, the expense of planting-time corn rootworm insecticides can be avoided. In areas that produce continuous corn planting-time insecticides against corn rootworm larvae or aerially applied products directed against egg-laying adults have been used in Kansas. **Northern rootworm** adults are about 0.25 inch long and have a uniform pale green to yellow coloration. **Western corn rootworm** adults are about the same size as northerns or are slightly larger. Westerns are generally yellow with a black stripe running around the margin of each wing cover. The wing covers of southern corn rootworms have 11 black spots on a yellow-green background. Larvae tunnel into and feed on corn roots causing significant lodging, reducing plant ability to take up nutrients and water, which collectively reduces grain yield.

Seed Corn Beetle (*Stenolophus lecontel)* **and Seed Corn Maggot** (*Hylemya platura)*. **Seed corn beetles** are about 1/3 inch long. Their overall coloration is dark brown with a light-brown to tan border stripes on the wing covers. Gaps in the crop stand may result from destruction of seed germ or completely hollowed seed. The **seed corn maggot** is a slender, pale yellowish-white larva. Full-grown maggots are legless, tapering. Feeding maggots damage the seed so that establishment of the plant is not successful. Non-use of planting-time insecticides increases the opportunity for damage from seed-attacking insects. Seed treatments should be used where planting-time soil insecticides are not used (bottom, Seed corn beetle, image courtesy of http://www.pdis.org; top, Seed corn maggot adult, image courtesy of http://fciig.ifas.ufl.edu/fracind.htm).

Southern Corn Leaf Beetle. Adults are drab in color, grayish to brownish, and may be covered with soil particles. Feeding damage reduces plants to fragments and the cause of the injury can be easily mistaken as cutworms. Healthy stands can disappear in a few days if large numbers of beetles descend on a field. Several pyrethroid insecticides should provide suppression of southern corn leaf beetle adults when applied as a foliar spray. (Image courtesy of http://entomology.unl.edu/fldcrops/cornpestkey/scornleafb.htm).

Wireworms (*Elateridae***)** are hard-shelled, smooth, cylindrical, yellowish worms. They eat into the germinating seed or burrow into the underground part of the stem. Two to six years may be required for some species to complete their life cycle. Damage in row crop fields generally is highest during the first or second year after a sod or forage was last grown.

White Grubs (*Scarabaeidae***)** are white, C-shaped worms with three pairs of legs, a tan to brown head, and a dark, subsurface zone near the rear of the body. White grubs may cause concern in the same rotations where wireworms are found. Planting time insecticides may give some reduction in grub numbers. Better degree of control will be realized with in-furrow rather than as over-the-row bands. (Image courtesy of http://www.pdis.org).

Armyworm (*Pseudaletia unipuncta*) larvae are between 1.5 and 2 inches in length. The head capsules have honeycomb-like markings and the body lacks hairs. Adults deposit their eggs where grassy growth is very lush, often in low lying areas on wheat or pasture ground. The larvae consume the grasses or they dry down (wheat matures) and the larvae move to corn to survive. Problems from this insect are expected to increase as more reduced tillage is practiced. Later season damage is caused when the larvae remove all the leaf tissue except the midrib and work their way up the plant, defoliating as they go. (Image courtesy of http://www.pdis.org).

Fall Armyworm (*Spodoptera frugiperda*) damage occurs at midsummer. Larvae cut large holes in whorl-stage leaves. Later, large holes may be cut in the stalks at the nodes. Treatments should be applied to silking stage corn if small larvae are detected before they have tunneled into the shanks and ears.

Corn Earworm (*Helicoverpa zea***)** infestation during the silking period results in damage to the tip of the ear. Early planted corn often escapes heavy infestations. Although a majority of ears may contain an earworm, the use of insecticides to control ear damage is impractical in field corn. The rapid growth of silks provides unprotected areas for moths to land and lay eggs. Even if the field was sprayed recently, newly hatched larvae would be able to penetrate into the tip of the ear beneath the husk without contacting insecticides unless sprays were applied every 2-3 days.

Corn flea beetles (*Chaetocnema pulicaria*) are very small, shiny jumping beetles that strip the upper surface from seedling corn leaves. More injury is likely to occur at two- to four-leaf stage corn when cool temperatures slow corn growth. The amount of injury must be assessed carefully before control methods are applied. Frequently, satisfactory results can be obtained by spot treatment or border treatment. Favorable growing conditions would eliminate or reduce the effect of this insect if the growing point has not been killed. Treatments are needed when four or more beetles per plant are found on two-leaf corn plants. In addition to their direct effects from feeding, corn flea beetles transmit the bacterium responsible for Stewart's wilt disease(Image courtesy of http://www.pdis.org).

European corn borer (ECB) (*Ostrinia nubilalis*) may produce multiple generations in this region. For instance, in Kansas, ECB can complete at least 2 generations. How ever, the ECB dynamics and management change dramatically with adoption of transgenic corn. Transgenic corn is a genetically engineered corn plant that contains an insect-suppressing gene adapted from a naturally occurring soil bacterium, *Bacillus thuringiensis* (Bt). Plants possessing this gene produce an internal toxic protein that kills certain species of insects after they have fed on the plant. Several companies are marketing Bt-corn hybrids. Some Bt-corn hybrids are extremely effective, providing almost complete protection against ECB, southwestern corn borers, or other Lepidoptera species. Resistance management strategies are believed to be essential to delay or prevent loss of this control option. Approximately, over 60% of the corn acreage is currently (2004) being planted with GM-corn in the Northern and Central Plains.

Stalk Borer (*Papaipema nebris*) **(**common**)** damage occurs in early summer and the growing point of the corn plant may be killed (deadheart). (Image courtesy of http://www.pdis.org).

Western Bean Cutworm (***Striacosta*** *albicosta*) Eggs are laid in groups on the upper surface of the upper leaves. When the eggs hatch, the larvae first feed on pollen and then move to the corn ears or bean pods. The larvae will feed there for several weeks before they drop to the soil to form a subterranean overwintering chamber. By the end of the five larval instars, considerable feeding damage can occur. In corn, one larva per plant usually will not cause severe damage but the ears may contain several larvae, which can significantly reduce yield. This is because western bean cutworms are not cannibalistic, as compared to corn earworms. Scouting generally should be most intensive during late July or early August.

Insecticide control

Overall, approximately 24% of corn acreages were treated with insecticides. At least 14 insecticides (ingredients) were applied in the control of 17 primary insect pests on corn in the Northern and Central Plains.

Adoption of Genetically Modified (GM) Corn and Insecticide Treatment

STATE	Sampled (Acre)	CORN (Acre)	GM-CORN		Insecticide Treatment	
			Acre	Proportion (%)	Acre	Proportion (%)
KS	87611	18903	6885	36.42	10217	54.05
NE	100935	34491	17169	49.78	11624	33.70
ND	131799	25600	15973	62.39	282	01.10
SD	179433	33588	30148	89.76	4766	14.19
Total	499778	112582	70175	59.59	26889	23.88

In addition to North Dakota, there was a negative relationship between insecticide treatment acreages and GM-corn adoption. The more the GM-corn was grown, the less likely the corn was treated with insecticides during corn production. For instance, approximate 90% of corn acreages were planted with GM_corn in South Dakota and only 14% of them were treated with insecticides. In contrast, over 54% corn acreages were treated with insecticides in Kansas since only 36.4% acreages were planted with GM-corn.

Insect Pests Targeted

No	Insect Pest	Kansas	Nebraska	North Dakota	South Dakota
1	Armyworm	X			
2	Billbug	X	X	X	X
3	Corn earworm	X			
4	Corn flea beetle	X			
5	Corn rootworms	X	X	X	X
6	Cutworms	X	X	X	X
7	European corn borer	X	X	X	X
8	Fall armyworm				X
9	Maize billbug	X	X	X	X
10	Seed beetles	X	X	X	X
11	Seed maggot	X	X	X	X
12	Southern corn leaf beetle	X	X	X	X
13	Stalk borer	X	X	X	X
14	Webworms	X	X	X	X
15	Western bean cutworm	X	X	X	X
16	White Grubs	X	X	X	X
17	Wireworms		X		

Insecticides Used and Targeted Insect Pests

Insecticide (Ingredients)	Insect Pest Targeted
Bt.	1, 5, 6, 7, 9, 10, 12, 13, 14, 15
terbufos	1, 5, 6, 9, 11, 12, 14, 15, 16
bifenthrin	1, 3, 6, 9, 11, 12, 14, 15, 16
propargite	5, 6
methyl parathion	5, 7
permethrin	1, 15
cyhalothrin-lambda	13, 14, 15
chlorpyrifos	2, 4, 5, 6, 7, 8, 13, 14, 15
phorate	5, 6, 10, 14, 15
malathion	
cyfluthrin	6
phostebupirim	6
parathion	5, 15
fipronil	2, 3, 5, 6, 7, 9, 10, 13, 14, 15

One insecticide may target on several insect pests across this region. The number of insect pest targeted in the table above refers to Table '**Insect Pest Targeted'**.
Please note that one pesticide product may contain up to 3 ingredients and target several pests at the same time. Each ingredient in a pesticide was considered sharing the targeted pests with others. Thus, even though corn rootworms, seed beetles, and Western bean cutworm (No 5, 10, and 15 in the table above) were not listed on the Bt label, they were still regarded as the targeted pests of Bt.

The following table displays the insecticide trade names, acres treated, percentage of area treated, and application rate.

Insecticide usage on corn

Insecticide (Ingredient)	Trade name	Acres Treated	Percent Treated*	Rate (lb a.i./a)
Bt-related	Javelin WG, Dipel ES, Lepinox WDG, DiPel DF, Ketch DF	5360	14.08	2.21
terbufos	Counter 15-G	6768	17.78	0.30
bifenthrin	Capture			
propargite	Comite	250	0.66	4.40
methyl parathion	Penncap M, Methyl parathion	815	2.14	1.04
permethrin	Ambush	700	1.84	0.19
cyhalothrin-lambda	Warrior 1EC, Warrior	4452	11.70	1.08
chlorpyrifos	Nufos 4E, Lorsban 15G, Nufos 15G	3919	10.30	20.59
phorate	Thimet 15G, Thimet 20G	2134	5.61	0.13
malathion				
cyfluthrin	Aztec 4.67 G	855	2.25	0.34
phostebupirim	Aztec 4.67 G	854	2.24	0.34
parathion	parathion	155	0.41	4.02
fipronil	Regent 4SC, Regent 80WG	11795	30.99	1.29
Total		38057	100.00	

* Percent Treated = (acreage treated with a given insecticide / the total acreage treated) * 100.

Fipronil is the most frequently applied one among insecticides targeted on several important insect pests on corn in the Northern and Central Plains, up to 31% of the sampled treated areas did so at a rate of 1.29lb/a, followed by Bt-related pesticide products at a rate of 2.21 lb/a.

Measurement of IPM Adoption in ECB

European corn borer (ECB) is a significant corn pest throughout the northern half of the United States. Even though prevalence and economics of corn borer infestation may vary greatly from year to year and from region to region, this pest has been recognized as a serious problem in the Northern and Central Plains on corn production. Pest management on ECB was identified particularly to measure IPM adoption on both Bt-corn and non-Bt corn using survey data.

Various cultural practices have been adopted in the control of ECB in this region such as stalk shredding, plowing, grazing, or burning stalks, which are used to reduce overwintering corn borer populations in individual fields, but do not significantly result in reduced damage the next year since eggs are laid by the winged adult and fields may be repopulated by moths moving in from other fields. Certain selected corn varieties are resistant to whorl feeding by ECB larvae, depressing the first ECB generation population. An early maturity group hybrid flowering before peak moth flight may have significantly fewer corn borers. Planting date is also critical because the height of the corn relative to surrounding corn during the first brood moth flight and the maturity of the plants relative to surrounding corn during second moth flight will

help to determine the vulnerability of the hybrid to an ECB infestation. Early harvest is always a better choice in corn production since the longer corn remains in the field after maturity, the greater the amount of stalk lodging, breakage, and ear drop.

IPM adoption may significantly reduce pesticide use on corn production. Especially in recent decades, GM-corn, which was designed to control ECB, southwestern corn borer and corn earworm, provides a novel management tool for all corn producers. It has been declared that GM-corn has a great potential to improve ECB control significantly, compared with other IPM practices (http://www.lgseeds.com/LG_Tech2/ecb.asp). Performance of GM-corn can be dramatic compared with non-GM-corn of the same hybrid. GM-corn hybrids may provide more than 99% control of first generation ECB larvae in whorl-stage corn. In contrast, chemical insecticides, if timed properly, could provide control from 60 to 95% of the first generation larvae and about 40 to 80% of second generation larvae. Following tables illustrated IPM adoption measurement on ECB management based upon 2005 survey.

Measurement of IPM Adoption on ECB Management

No	IPM Approach	Kansas	Nebraska	North Dakota	South Dakota	Total	Proportion* %
1	Switching to Bt or other genetically modified Corn	19	38	16	31	104	26.26
2	Biological Control (releasing natural enemies)	2	2	0	1	5	1.26
3	Chopping Stalks	7	14	7	5	33	8.33
4	Clean Plowing	2		4	3	9	2.27
5	Adjusting Planting Dates	5	4	2	4	15	3.79
6	Adjusting Harvesting Dates	1	5	1	3	10	2.53
7	Field Scouting	22	24	13	18	77	19.44
8	Applying Pesticides	8	13	5	5	31	7.83
9	Rotating Chemicals to Reduce Chances of Resistance	19	23	4	16	62	15.66
10	Using Economic Thresholds before Applying Insecticides	17	16	7	10	50	12.63

*Proportion = Total / 396 * 100.

Non-chemical and cultural practices were extensively adopted in the Northern and Central Plains for corn protection. The leading approach for ECB management was the adoption of Bt-corn and other genetically modified corn or varieties, followed by field scouting and chemical insecticide rotations. At least four chemical pesticides were used in 2004 against ECB. Survey data demonstrated that the insecticide usages were significantly reduced following an adoption Bt-corn and other genetically modified corn in this region.

Weed and Management

Weedy plants and corn require the same resources for growth and development. Use of these resources by weeds makes them unavailable for corn growth. Corn is vulnerable to weed competition for about the first few weeks, a time span that coincides with cold spring temperatures. Thus, a successful weed control strategy should assure weed-free conditions for about a month after planting. Weed germination after that time may only pose minor threat to yield reduction.

Weed management
Several methods are available for weed management in corn:

- Crop rotation with soybeans, forage crops, or cereal grains.
- Row-crop cultivation.
- Early planting of corn.

No-till and low-tillage corn
Corn may be planted into undisturbed crop residue from previous year, as well as directly into killed alfalfa or smooth brome sods. Before planting, winter annual weeds must be controlled with tillage or with foliar-absorbed herbicides. Weed and volunteer wheat control is necessary during the 9-month period between wheat harvest and corn planting the following spring, to enhance the soil moisture storage required for successful dryland crop production. Some corn growers elect to perform some tillage to control weeds prior to planting corn. Pre-plant incorporated herbicides may then be used. Some herbicides should not be incorporated because serious corn injury may occur.

Post-emergence weed control in corn
In the Northern and Central Plains, many corn producers cultivate their corn to control weeds that have escaped previous treatments. Significant herbicide savings result from banding residual herbicides over the row at planting, and then controlling inter-row weeds with cultivation. In furrow-irrigated fields ridge-tilled corn is managed with very low herbicide inputs.

Weeds and Herbicide Usage in 2004

Various weeds may potentially compete for resources in corn production across the region; a few of them required treatment with herbicides based on the 2005 survey. In 2004, over 140% corn planting areas were treated with herbicides, suggesting certain areas may be treated multiple times across the corn production year and therefore weed control was one of the important practices in corn production in the Northern and Central Plains. At least 36 herbicides (ingredients) were applied in the control of at least 33 different weed species. Following tables illustrate the herbicides used and weeds targeted. Certain non-chemical methods (e. g., cultural practices) may also be applied in weed control.

Targeted Weeds

No	WEED	Kansas	Nebraska	North Dakota	South Dakota
1	Atex	X	X		
2	Barnyard	X	X	X	X
3	Black Nightshade	X	X	X	X
4	Broad Leaf		X	X	X
5	Buttonweed		X		
6	Canada Thistle	X	X	X	X
7	Chickweed	X			
8	Cocklebur	X	X	X	X
9	Crabgrass	X	X	X	X
10	Creepery Jenny	X	X	X	X
11	Field Bindweed	X	X	X	X

12	Foxtails	X	X	X	X
13	Hedge Bindweed	X	X	X	X
14	Hemp Dogbane	X	X	X	X
15	Honeyvine Milkweed	X	X	X	X
16	Johnson grass	X	X	X	X
17	Kochia	X	X	X	X
18	Lambsquarter	X	X	X	X
19	Milkweed	X	X	X	X
20	Pigeon Grass	X	X	X	X
21	Pigweed	X	X	X	X
22	Quack grass	X	X	X	X
23	Russia Thistle	X	X	X	X
24	Sandbur	X	X	X	X
25	Shattercane	X	X	X	X
26	Smartweed	X	X	X	X
27	Sunflower	X	X	X	X
28	Velvetleaf	X	X	X	X
29	Waterhemp	X	X	X	X
30	Waterhoop	X	X	X	X
31	Wild oats	X	X	X	X
32	Wildbuck	X	X	X	X
33	Wooly cupgrass	X	X	X	X

Herbicides Used and Weeds Targeted

Herbicide	Weeds Targeted*
2,4-D	6 11 12 16 17 18 19 21 22 24 26 27 28 34
Foramsulfuron	12 18 21 27 31
acetochlor	4 6 9 11 12 15 16 17 18 19 20 21 22 24 25 26 27 28 29 31 33 34
alachlor	12 21 27 28
atrazine	1 2 4 6 9 11 12 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 34
bromacil	12 21
bromoxynil octanoate	2 9 12 17 21 22 26 27 28 34
carfentrazone-ethyl	17 18 21 27 28 29
chlorpyrifos	12 16 21 28 34
clopyralid	4 9 12 15 16 17 18 20 21 22 25 26 27 28 34
cyanazine	N/A
dicamba	6 9 10 11 12 16 17 18 19 20 21 22 23 24 27 28 29 34
diflufenzopyr	17 18 19 20 21 22
diflufenzopyr-sodium	9 11 12 16 17 18 20 21 22 24 27 28
flufenacet	27 28
flumetsulam	4 9 12 15 16 17 18 20 21 22 25 26 27 28 34
folpet	9 12 21 22 25 28
glufosinate-ammonium	9 11 12 17 18 21 24 25 26 27 28
glyphosate	5 6 7 9 11 12 15 16 17 18 19 20 21 22 23 24 25 27 28 29 30 31 32 33 34

imazapyr	12	18	21																	
imazethapyr	12	18	21																	
isoxaflutole	4	9	12	17	18	19	21	24	25	27	28	31								
mesotrione	4	6	9	11	12	16	17	18	19	20	21	22	23	25	26	27	28	29	30	34
metolachlor	6	9	11	12	16	17	18	19	20	21	24	25	27	28	29	34				
metribuzin	27	28																		
nicosulfuron	6	9	10	11	12	16	17	18	20	21	22	23	24	25	26	27	28	30	34	
pendimethalin	N/A																			
primisulfuron-methyl	4	6	12	17	18	25	27	28	29											
prosulfuron	4	17	18	25	27	28														
pyridate	12	21	27																	
rimsulfuron	6	9	10	11	12	16	17	18	20	21	22	23	24	25	26	27	28	30	34	
s-Dimethenamid	9	12	17	18	21	24	26	28	34											
s-metolachor	12	27																		
simazine	18	21																		
thifensulfuron-methyl	12	17	21	26	27	28	34													
tribenuron methyl	12	17	21																	

* Number of Weed Targeted in the table refers to Table '**Targeted Weeds**'.

Herbicide Ingredient and Trade Name

Herbicide (Ingredient)	Trade Name
2,4-D	2,4-D ester, Double Play, Curtail, 2,4-D amine, Banvel
Foramsulfuron	Option
acetochlor	Surpass EC, Degree Xtra, Surpass 20G, Harness, Keystone
alachlor	Lariat, Bullet, Lasso
atrazine	Aatrex 4L, Atrazine 4F, Atrazine 4L, Degree Xtra, Lumax, Steadfast ATZ, Basis gold, Lariat, Guardsman Max, Liberty ATZ, Marksman, Bicep II Magnum, Bullet, G-Max Lite, Buctril + Atrazine, Extrazine 110DF, Keystone
bromacil	Double Play
bromoxynil octanoate	Buctril, Buctril + Atrazine
carfentrazone-ethyl	Aim 40WP
chlorpyrifos	RUP
clopyralid	Hornet, Stinger, Hornet WDG, Curtail, Accent Gold
cyanazine	Extrazine 110DF
dicamba	NorthStar, Celebrity Plus, Sedagri, Clarity, Marksman, Banvel, Distinct
diflufenzopyr	Distinct
diflufenzopyr-sodium	Celebrity Plus
flufenacet	Axiom DF
flumetsulam	Hornet, Hornet WDG, Accent Gold

folpet	Permit
glufosinate-ammonium	Liberty, Liberty ATZ
glyphosate	Roundup, Buccaneer, Touchdown CF, Glystar Plus, Roundup UltraMax II, Glyphomax, Roundup UltraMax
imazapyr	Lightning
imazethapyr	Lightning
isoxaflutole	Balance, Balance Pro
mesotrione	Callisto, Lumax
metolachlor	Dual IIG Magnum, Dual Magnum, Lumax, Bicep II Magnum, Dual II, Dual II Magnum
metribuzin	Axiom DF
nicosulfuron	Steadfast ATZ, Basis gold, Celebrity Plus, Accent Gold, Steadfast
pendimethalin	Prowl 3.3 EC
primisulfuron-methyl	NorthStar, Spirit, Exceed
prosulfuron	Spirit, Exceed
pyridate	Tough 5 EC
rimsulfuron	Basis, Steadfast ATZ, Basis gold, Accent Gold, Steadfast
s-Dimethenamid	Outlook, Guardsman Max, G-Max Lite
s-metolachor	Cinch
simazine	Princep 4L
thifensulfuron-methyl	Basis, Harmony Extra
tribenuron methyl	Harmony Extra

The next table displays acres treated, percentage of area treated, and application rate for each herbicide (ingredient).

Herbicide Usage on Corn

Herbicide (Ingredient)	Acres Treated	Percent Treated*	Rate (lb a.i./a)
2,4-D	19118	3.42	2.47
Foramsulfuron	0	0.00	0.00
acetochlor	41267	7.37	6.06
alachlor	1953	0.35	4.58
atrazine	120516	21.53	4.71
bromacil	100	0.02	5.21
bromoxynil octanoate	4497	0.80	3.16
carfentrazone-ethyl	1782	0.32	0.31
chlorpyrifos	490	0.09	0.77
clopyralid	20417	3.65	0.71
cyanazine	572	0.10	1.66
dicamba	26989	4.82	0.28
diflufenzopyr	6600	1.18	0.10
diflufenzopyr-sodium	3480	0.62	0.10
flufenacet	1220	0.22	0.24
flumetsulam	19593	3.50	0.29

folpet	1239	0.22	0.21
glufosinate-ammonium	9365	1.67	1.62
glyphosate	60599	10.83	1.82
imazapyr	650	0.12	0.27
imazethapyr	650	0.12	0.27
isoxaflutole	25176	4.50	0.28
mesotrione	44173	7.89	0.59
metolachlor	40105	7.16	2.46
metribuzin	1220	0.22	0.24
nicosulfuron	39392	7.04	0.15
pendimethalin	0	0.00	0.00
primisulfuron-methyl	12826	2.29	0.11
prosulfuron	6826	1.22	0.07
pyridate	450	0.08	0.67
rimsulfuron	38552	6.89	0.15
s-Dimethenamid	2355	0.42	31.24
s-metolachor	2150	0.38	4.31
simazine	425	0.08	2.08
thifensulfuron-methyl	3840	0.69	0.08
tribenuron methyl	1200	0.21	0.05
Total	559787	100.00	

*: Percent Treated = (acreage treated with a given herbicide / the total treated acreage with herbicide)*100.

Weeds

Followings are brief descriptions of the major weeds that were treated with herbicides in 2004:

Barnyard grass (*Echinochloa crusgalli*), member of the Grass family, is an annual that prefers wet sites. It is not usually a problem in well-drained cultivated fields but can grow heavily around irrigation pipe leaks and other wet spots in the field. It is a vigorous, warm season annual grass reaching 1 - 5' in height. Many stem bases are reddish to dark purple. Leaf blades are flat, broad, smooth, and without a ligule or auricle at the junction of sheath and blade. Seed are the only source of reproduction. It flourishes in warm conditions. Barnyard grass was treated with various herbicide products across the region based on the 2004 survey. (Image courtesy of http://alfalfa.okstate.edu/weeds/sumanngrass/barnyardgr-516.htm).

Black nightshade (*Solanum ptycanthum*) **(Eastern black nightshade)** is a native weed. Flowering season is from May to October. A berry has a smooth surface that is initially green, but later becomes black as it matures. Seeds are the only source of reproduction. Found in roadsides, open woodland, stream banks, gardens row crops, and waste places. (Image of Courtesy of http://www.illinoiswildflowers.info/weeds/plants/black_nightshade.htm**).**

Broadleaf signalgrass (*Brachiaria platyphylla*) is annual, warm season grass, and native to the southeastern US, however, it has become more popular in this region. This plant varies in height from 0.2 to 0.9 m. The ligule is a narrow membrane fringed with hairs. It has a decumbent growth habit and will commonly root at the lower nodes. The leaf blade is glabrous, however the sheath may have a pubescent margin. (Image of Courtesy of http://www.illinoiswildflowers.info/weeds/plants/black_nightshade.htm**).**

Buttonweed (*Diodia virginiana*) is a warm season perennial with a sprawling, widely branched growth habit. Leaves are opposite, margins slightly serrated, oblong or nearly linear, generally 2 to 3 inches long and leathery in texture. Leaves often develop a purplish color. The plant has an extensive root system and develops underground rhizomes. The plant produces small, white flowers during the summer and fall. Fruit develop along the stolons, or stems, in summer and fall. Fruit are oval shaped with vertical ridges and usually 6 to 10 mm long. The fruit develops into leathery pods in rows along the stolons and give the plant its name, buttonweed. (Image of Courtesy of http://www.floridaplants.com/Eflora/diodia.htm).

Canada Thistle (*Cirsium arvense*), **(Field thistle)** is a native of Eurasia and North Africa, and flowers from June to August. Seeds and rhizomes are the source of reproduction. Found on cropland, ditch banks, roadsides, mud flats, stream and lake bank, and in moist soils. Treatments on this weed using herbicides were reported across the region based on 2004 survey. (Image courtesy of http://www.funet.fi/pub/sci/bio/life/plants/magnoliophyta/magnoliophytina/magnoliopsida/asteraceae/cirsium/vulgare-5.jpg).

Common Chickweed (*Stellaria media*) is an annual belonging to the pink family (Caryophyllaceae). Light green mat-forming plant with shallow fibrous root system. Multiple branches can form roots at the nodes and cover large areas. Leaves are shiny green, rounded and taper to a point. The flowers in clusters at the ends of stems are white with five petals. It reproduces by seed. Usually found in moist, compacted sites in autumn and spring. It will persist longer in cool shaded areas. (Image of Courtesy of http://www.agry.purdue.edu/turf/weeds/chick/chick.htm).

Cocklebur (*Xanthium strumarium*) is a coarse, somewhat thick-stemmed annual growing to about 5' tall with alternate, thick and sandpapery leaves that are long-petioled, deltoid to ovate, 4" to 6" long, irregularly-toothed to lobed, green both above and below, and cordate at the base. It usually inhabits sandy or grassy areas in moist or dry streambeds, next to water courses, or in other disturbed locations. The staminate heads are many-flowered with subglobose involucres, fused filaments, free anthers, and slender ovaries. The bur is 3/4" to 1-1/2" long, is covered with many stout prickles, and has two incurved hooks at the end.

Crabgrass (*Digitaria sanguinalis* L.) **(hairy crabgrass, purple crabgrass)** native of Europe**; smooth** (*Digitaria ischaemum*) native of Europe. Seeds are the only source of reproduction. Both flourish in warm conditions. Both are common in lawns, cultivated fields, gardens, roadsides, pastures, and waste

places. (Large crabgrass, image courtesy of http://alfalfa.okstate.edu/weeds/sumanngrass/crabgrass/crabgrass-12.htm).

Field bindweed (*Convolvulus arvensis* L.) **(creeping Jenny, small-flower bindweed, small bindweed, European bindweed, greenvine)** is a perennial weed originated from Eurasia. Flowering season is in late summer. Rhizomes and seeds are the source of reproduction. Found on both cultivated and uncultivated land. It is most common in small grain fields, waste places, gardens, and roadsides. (Image courtesy of http://tncweeds.ucdavis.edu/photos/conar02.jpg).

Foxtail includes giant (*Setaria faberi*) (giant bristlegrass, Chinese foxtail, Chinese millet, noddingfoxtail) native of Asia; green (*Setaria viridis* L.) (green bristlegrass, pigeongrass, wild millet) native of Eurasia; and yellow (*Setaria glauca* L.*)* (yellow bristlegrass, pigeongras, wild millet) native of Europe. Seeds are the only source of reproduction. Common on cultivated grounds, waste places, roadsides and degraded rangeland and pastures.

Hedge Bindweed (*Calystegia macounii*) also called hedge glorybind, lady's nightcap, wild morningglory, and large-flower morningglory. Found in thickets, fence rows, waste areas, and cultivated fields. This member of the Morning Glory Family has an extensive root system. The flowers bloom white or pink. Hedge bindweed has larger flowers and bracts than field bindweed Convolvulus arvensis, and leaf blades that curve at right angles to their petioles. (Image courtesy of http://www.lib.ksu.edu/wildflower/hedgebindweed.html).

Hemp Dogbane (*Apocynum cannabinum*) is from 2 to 4 feet high, with erect branches and sharp-pointed, short-stalked leaves from 2 to 6 inches long. The small greenish white flowers which appear from June to August are borne in dense heads followed later by the slender, pointed pods which are about 4 inches in length. The plant contains a milky juice. (Image courtesy of http://www.primitiveways.com/hemp_dogbane.html).

Honeyvine Milkweed *(Cynanchum leave)* stem is vine, slender, twining, trailing or climbing on other plants and trees, simple or branched, glabrous or with lines of pubescence; sap milky, sticky. The leaves are Opposite, simple, triangular to ovate, 1 to 5 inches long, 1 to 4 inches wide, glabrous; margins entire; tip pointed; base heart-shaped; stalk 0.5 to 3 inches long. Flower has Calyx lobes lanceolate, green or purplish; corolla fragrant, white to cream, up to 0.25 inch long; lobes 5, petal-like, oblong to lance-oblong. The fruit has pod, narrowly lanceolate or spindle-shaped, 3 to 6 inches long, 0.6 to 1.2 inch thick, minutely hairy to glabrous, tubercles absent; seeds many, ovate, flattened, pale brown, tufted with white silky hairs.

Johnsongrass (*Sorghum halepense* L.), is a tall up to 6 feet, rhizomatous perennial grass that invades open areas throughout the United States. The long (up to 2 feet), lanceolate leaves are arranged alternately along a stout, hairless, somewhat upward branching stem. Flowers occur in a loose, spreading, purplish panicle. Johnsongrass is adapted to a wide variety of habitats including open forests, old fields, ditches, and wetlands. It spreads aggressively and can form dense colonies, displacing native vegetation and restricting tree seedling establishment. (Image courtesy of http://plants.usda.gov/cgi_bin/plant_profile.cgi?earl=plant_profile.cgi&symbol=SOHA).

Kochia (*Kochia scoparia* L.) **(summer cypress, fireweed, belvedere, mock cypress, Mexican firebush) is** native of Eurasia, much branched erect annual growing from 0.3 to 2 metres in height; main stem often tinged with red; stalkless narrow leaves with entire margins often turn purple in autumn; inconspicuous flowers usually surrounded by cluster of long hairs. Flowering season is from July to October. Seeds are the only source of reproduction. Found on rangeland, pastures, fields and disturbed sites. (Image courtesy of http://el.erdc.usace.army.mil/pmis/plants/html/kochia_0.html).

Lambsquarter (*Chenopodium album***)** is an annual weed found in cultivated and waste areas throughout the United States. This weed grows upright 1 to 4 feet tall with many branches. The leaves have a wavy or coarsely toothed margin with a soft gray or white mealy coating on young leaves and underside of mature leaves. The flowers are inconspicuous gray-green in dense clusters in leaf axils and branch tips. This weed acts as a host for beet leafhopper, which transmits curly top virus to beets. (Image courtesy of http://mint.ippc.orst.edu/lambsquarter.htm).

Milkweed (*Asclepias syrica*) is thick-stemmed and upright. It grows to be 3-5 feet tall. Its leaves are elliptical and opposite; they are velvety on their upper surface, and downy underneath. They are 4-9 inches long and quite wide. The pinkish-purple flower buds look like loose broccoli; the flower itself is large and made up of individual florets gathered in an umbrella shaped globe that droops from the stem. The stem is hairy. The seed pods are the most recognizable feature of the common milkweed; they are green, elliptical shaped and about 1-4 inches in length with a pointed tip; inside, they contain myriad seeds with silky parachute-like attachments. Another easily recognizable characteristic of the common milkweed is the profuse, milky white sap that flows from any broken part.

Pigeon grass (*Setaria incrassata cv. Inverell*) (**Purple pigeon grass**) is a perennial summer-growing tussock grass for areas with an annual rainfall of more than 500 mm. It is tolerant of drought, cool conditions, but is sensitive to frost. A valuable characteristic is its ability to germinate and establish more reliably than most other tropical grasses on medium and heavy cracking clay soils of the Darling Downs, the Brigalow lands, and the Maranoa, where establishment of other tropical grasses has been poor. Purple pigeon grass is suitable for permanent or ley pastures in a crop—pasture rotation. It will seed throughout the growing season, and can establish freely from fallen seed.

Pigweeds (*Amaranthus spp*.), members of the Amaranth family are a problem in several cropping systems. *A. hybridus*, smooth pigweed, was the first triazine resistant plant documented. *A. retroflexus*, redroot pigweed is probably the

most common species in this region. *A. lividus*, is a prostrate species with a notch in the tip of the leaf. *A. spinosus*, spiny amaranth, has sharp, strong spines on the stem. *A. graecizans*, breaks off at the ground line and being round is blown around by the wind. Treatments on this weed using herbicides were reported across the region based on 2004 survey. (*A. retroflexus*, image courtesy of http://wisplants.uwsp.edu/scripts/detail.asp?SpCode=AMARET).

Quackgrass (*Elytrigia repens*), a member of the Grass family, is an aggressive perennial reproducing by seed or spreading by a shallow mass of long, slender, branching rhizomes. Rhizomes are usually yellowish-white, sharp-pointed, some what fleshy. Stems are erect and usually 1 - 3' tall. Leaf blades are 0.25 - 0.5" wide, flat pointed and have small auricles at the junction of blade and sheath. Leaf sheaths and upper leaf blade surfaces are thinly covered with soft hairs. Tillage is an effective control by depleting food reserves and bringing rhizomes to the surface. Treatments on quackgrass using herbicides were reported across the region based on 2004 survey. (Image courtesy of http://www.invasive.org/images/768x512/1357002.jpg).

Russian thistle (*Salsola iberica*), **(tumbleweed, tumbling thistle)** is native of Europe. Flowering can be seen during summer and early fall. Seeds are the only source of reproduction. Found on small grain fields, cultivated dryland fields, and waste areas. There is confirmed resistance to triazine and ALS inhibiting herbicides. Treatments for this weed using herbicides were reported across the region based on 2004 survey. (Image courtesy of http://extension.usu.edu/rangeplants/forbs/russianthistle.htm) .

Sandbur (*Cenchrus pauciflorus*), member of the Grass family, is a warm season annual with tufted stems. It grows 8"- 3' tall, occasionally erect, but usually spreading horizontally and forming dense mats. Leaf sheaths are flattened, very loose, and smooth with hairy margins. Burs are thickly set with stiff, sharp, spreading spines. They usually contain two light brown, oval to oblong seed. Sandbur was treated using herbicides across the region based on the 2004 survey. (Image courtesy of http://www.vettorpisani.net/dune/galleria/cenchrus.frutti.jpg).

Shattercane (*Sorghum bicolor* L.) **(black amber, chicken corn, wild cane)** native of Africa. Seeds are the only source of reproduction. It is a major problem in corn and sorghum because seeds are several inches deep and keep coming up through the soil throughout the summer. Flourish in warm conditions. Grown in cultivated fields of corn, grain sorghum, and soybeans. Usually requires postemergence herbicides for control. (Image courtesy of http://www.plantsci.missouri.edu/fishel/shattercane.htm).

Smartweed (*Polygonum pensylvanicum* L.) (Pennsylvania knotweed, pinweed) is a native weed. Flowering season is from July to October. Seeds are the only source of reproduction. Found in wet soils or sometimes flooded soil of roadsides, ditches, cultivated ground, waste ground, waste places, and pond banks. (Image courtesy of http://www.ppws.vt.edu/scott/weed_id/polcc.htm).

Common sunflower (*Helianthus annuus* L.) **(annual sunflower)** is a native weed. Flowering season is from July to September. Seeds are the only source of reproduction. Found in cultivated fields, pastures, gardens, roadsides, waste ground, and disturbed sites. (Image courtesy of http://plants.usda.gov/cgi_bin/plant_profile.cgi?symbol=HEAN3&photoID=hean3_005_avp.tif).

Velvetleaf (*Abutilon theophrasti*), **(Indian mallow, butter print, elephantear, buttonweed)** originated from India. Flowering seasons vary with state in this region, normally during summer and early fall. Seeds are the only source of reproduction. Found in summer crop fields such as sorghum, corn, and soybeans, in waste places, roadsides, and fence rows. Velvetleaf was treated using herbicides across the region based on the 2004 survey. (Image courtesy of http://www.nwcb.wa.gov/weed_info/Written_findings/Abutilon_theophrasti.html).

Waterhemp (*Amaranthus rudis*), **(common waterhemp)** is a native weed. Flowering season lasts from June to October in the south region. Seeds are the only source of reproduction. Found in cultivated fields, roadsides, marshes, sandbars, riverbanks, and waste places. Waterhemp stems and leaves are hairless with narrower leaves than Redroot pigweed or Palmer amaranth. Confirmed resistance to triazine and ALS inhibiting herbicides. Waterhemp was treated using herbicides region widely based on 2004 survey. (Image courtesy of http://www.weedscience.org/Case/Case.asp?ResistID=333).

Wild Oat (*Avena fatua*), is a cool season annual, one to four feet tall. It is native to Europe but is common throughout much of western North America, including all of North Dakota. Wild oat is one of the most serious weed problems in small grains. It germinates quickly in the spring and can out-compete small grains resulting in severe yield losses. It is difficult to eradicate because the plants drop their seed prior to the crop being harvested. Seed dormancy results in delayed germination. (Image courtesy of http://plants.usda.gov/cgi_bin/topics.cgi?earl=plant_profile.cgi&symbol=AVFA).

Wild Buckwheat (*Polygonum convolvulus)*, a member of the Buckwheat family, is an annual weed with arrowhead-shaped leaves. It has trailing stems that wind around other plants and is often mistaken for field bindweed. Its leaves are heart shaped, alternate and more pointed than those of field bindweed. The leaves have an inconspicuous papery sheath that encircles the stem at the base of each petiole. Stems can be 8 - 40" long. In contrast to field bindweed, wild buckwheat has small, green flowers in the leaf axils. Seeds are triangular, black and slightly roughened. Seeds are the sole source of reproduction. Treatments for this weed using herbicides were reported region wide based on 2004 survey. (Image courtesy of http://oregonstate.edu/dept/nursery-weeds/weedspeciespage/wild_buckwheat/habit_750.jpg).

Woolly cupgrass (*Eriochloa villosa*) has plump, oval seeds that are pointed at one end and blunt at the other. The large seeds are about 3/16 inch long and about half as wide. The color of the seed can vary from light green to purple to tarnish-brown. After seeds have weathered in the soil they become dull tan in color. (Image courtesy of http://www.eeob.iastate.edu/research/iowagrasses/speciespages/EriocVillo/EriocVillo.html).

Plant Diseases

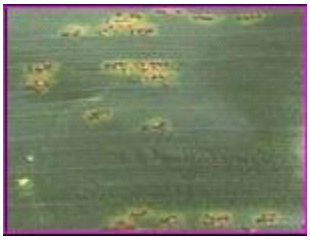
Corn in the Northern and Central Plains is susceptible to a number of diseases that may reduce corn yield and quality significantly, depending on the presence of the pathogen, weather and soil conditions, and the relative resistance or susceptibility of the corn. **Ear and kernel rots** decrease yields, quality, and feeding value of the grain. **Stalk rotting diseases** may minimally lower corn yield and quality, but can make harvesting difficult. **Leaf diseases** may cause reductions in photosynthesis that in turn reduces carbohydrate accumulation, and consequently results in yield reduction.

Most parasitic diseases of corn are caused by fungi, but a few are caused by bacteria, viruses, and nematodes. Non-parasitic diseases result from unfavorable climatic and soil conditions. Corn diseases, in contrast to other crops, seldom become severe over wide areas.

Many corn diseases are controlled by the use of disease-resistant hybrids and the application of fungicides to seeds. Using resistant hybrids is the most efficient and permanent means of controlling corn diseases. No hybrid is resistant to all diseases, and much remains to be done in developing disease-resistant hybrids.

The treatment of corn seed with fungicides may control seed rots and seedling diseases, but not other diseases. Crop rotation and destruction of diseased plant parts have been suggested as control measures for certain plant diseases. Such practices are most effective where the crop is growing in limited areas or if the specific disease-production agents are soilborne.

Following are the plant diseases that were treated with fungicides in 2004.



Common and Southern Rust, **common rust** is most abundant in this region, while southern rust is confined to late season infections that cause little or no damage. Losses to rust are usually negligible. Cool temperatures and high relative humidity increase common rust, whereas high temperatures and high relative humidity favor southern rust.

Cinnamon-brown pustules on the leaves are the common symptoms of rust in corn. Common rust pustules are often elliptical in shape and found on both sides of the leaf. On the other hand, southern rust pustules are found only on the upper side of the leaf. Late in the season, southern rust pustules turn black as the overwintering spores develop. Death of leaves and leaf sheaths may occur if infestation is severe. Management practices include use resistant hybrids and use fungicides during severe infestation. (Image courtesy, common rust on corn, http://www.ag.uiuc.edu/cespubs/pest/articles/200015d.html).

Corn Smut losses may range from a trace to 40 percent. The number, size, and location of smut galls on the plant affect the amount of yield loss. Large galls on or above the ear are more destructive than galls below the ear or on the leaf. Corn plants in fields with high nitrogen from barnyard manure show

more smut infestation. In addition, injuries, due to hail, insects, cultivation, or spraying increase smut incidence.

Galls are initially covered with a glistening, white membrane and, upon maturing, will burst to release millions of powdery black spores. Galls on leaves do not develop larger than pea size and become hard and dry without rupturing. The fungus overwinters as spores in crop refuse, manure, and soil. Dry conditions and temperatures between 78 and 94 ^{o}F favor corn smut. Feeding quality of corn is not affected by corn smut. Management practices include use of resistant hybrids and reducing mechanical damage to the plant. (Image courtesy of http://www.oznet.ksu.edu/dp_hfrr/includes/header.htm**).**

Seed Rots and Seedling Blights can be a problem during early planting of corn. Weather conditions determine the severity of the infection. Seedling diseases are most prevalent in cold, wet soil. Deep planting of corn, incorrect rates or placement of herbicides, and old seed can all lead to increases in the amount of disease. Even seeds treated with fungicides cannot always overcome the effects of poor germination conditions that result in delayed emergence. If seedlings survive the attack, they may be less vigorous than plants produced from healthy seedlings.

Seeds attacked by seed rot diseases often rot before germination. Above ground symptoms of seedling blight include a general lack of vigor, yellowing, wilting, and death. Several management practices were adopted against this type of diseases including using seed protectant fungicides and using healthy corn seed of high germination.

Gray leaf spot of corn, caused by the fungus *Cercospora zea-maydis,* is the most serious foliar corn disease in this region. Yield losses between 20 and 30 percent are not uncommon on susceptible hybrids. Temperatures of 70 to 85^{o}F are considered ideal for disease development. Symptoms include necrotic lesions that can range from as little as 1/16 inch in width to as much as 2 inches in length. They may be oval, oblong or rectangular depending on the pathogen. The lesions often have a distinct border, which can vary in color from tan to red depending upon the disease. (Image courtesy of http://ipm.ncsu.edu/corn/diseases/cornfig7.gif).

Fungicide Treatment

Only a few plant diseases were treated with fungicides by corn farmers/producers in the Northern and Central Plains during 2004. Approximately 1% of planted corn areas were treated with fungicides, indicating plant diseases may be a minor problem during corn production in this region. The survey shows three fungicides (ingredients) were applied for the control of four different plant diseases on corn. The following table lists the fungicides used and plant diseases controlled explicitly. Certain cultural practices may also be adopted for the control of plant diseases.

Targeted Plant Disease

No	Plant Disease	**Kansas**	**Nebraska**	**North Dakota**	**South Dakota**
1	Common and Southern Rust	X			
2	Corn Smut	X	X	X	X
3	Gray leaf spot	X	X	X	X
4	Seed Rots and Seedling Blights			X	

Fungicide Used and Plant Disease Targeted

Fungicide (Ingredients)	Plant Disease Targeted
fludioxonil	Seed Rots and Seedling Blights
mefenoxam	Seed Rots and Seedling Blights
propiconazole	Common and Southern Rust, Corn Smut, Gray leaf spot

Fungicide Usage on Corn

Fungicide (Ingredient)	Trade Name	Acres Treated	Percent Treated*	Rate (lb a.i./a)
fludioxonil	Maxim XL	700	43.75	N/A
mefenoxam	Maxim XL	700	43.75	N/A
propiconazole	Tilt 4	200	12.50	0.25
Total		1600	100.00	

* Percent Treated = (acreage treated with a given fungicide / the total acreage treated)*100.

Non-chemical Control Practices

Non-chemical (e. g., cultural practice) control may be one of the most important approaches for pest control during corn production in the Northern and Central Plains. The following table '**Cultural Practices Adopted in Pest Control**' lists 12 common cultural approaches that were adopted by farmers/producers for corn pest (including weeds, insects, and diseases) control.

Cultural Practices Adopted in Pest Control

No	Cultural Practice	Kansas	Nebraska	North Dakota	South Dakota	Total	Proportion* (%)
1	Releasing any beneficial organisms		1	1		2	0.28
2	Mowing, burning, or tilling around the fields	12	13	5	14	44	6.21
3	Cultivating during growing season	11	36	14	15	76	10.72
4	Adjusting planting/harvesting dates	7	5	5	10	27	3.81
5	Alternating chemical usage to minimize resistance	19	24	6	18	67	9.45
6	Rotating crops planted	42	60	24	64	190	26.80
7	Utilizing any water management practices	3	12		6	21	2.96
8	Cleaning field equipment between uses	7	15	8	10	40	5.64
9	Utilizing treated seed	23	42	22	38	125	17.63
10	Utilizing soil analysis	18	28	8	26	80	11.28

11	Adjusting row spacing or plant density	8	15	2	7	32	4.51
12	Other#	1	3		1	5	0.71

Unspecified targeted pests (weeds, insect pests, or diseases) in this survey.
* The proportion of growers who adopted a given cultural approach to pest control (Proportion = Total / 709 *100).

The leading cultural practice for pest control in the Northern and Central Plains was crop rotation, followed by seed treatment and soil analysis.

IPM adoption on corn

Various IPM practices including cultural control and Bt-corn have been adopted by producers and growers in recent years to manage pests on corn, which significantly reduces the usage of chemical pesticides in corn production. A promising IPM program on corn production may include one or several of the following operations:

- Selecting proper corn varieties such as Bt-corn hybrids.
- Applying proper cultural practices such as plowing, grazing, or burning stalks.
- Adjusting corn planting and harvesting timing.
- Maintaining corn health with proper irrigation and fertilization.
- Detecting and monitoring soil pests and seed attacking pests such as wireworms and grubs.
- Monitoring early season pests such as cutworms, stalk borer, armyworms, flea beetles and slugs.
- Detecting weed development early and assessing predominant weeds to determine the forthcoming weed management program.
- Scouting and monitoring whorl and tassel stage pests such as European corn borer that may require rescue treatment.
- Measuring adult corn rootworm beetle and silk feeding abundance to determine the need for a soil insecticide.
- Detecting late season infestations of corn borer or stalk diseases.
- Assessing and adjusting timing for pesticide applications.
- Applying biological and ecological means.

(http://ohioline.osu.edu/icm-fact/fc-11.html).

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Key References

- Agricultural Research Service. 1966. Corn diseases in the United States and their control. Handbook No. 199.
- Bauernfeind R.J. 1990. The chinch bug: questions and answers about its biology, development and methods of control. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. AF-134 Revised (2006) (http://www.oznet.ksu.edu/library/entml2/AF134.pdf).
- Brooks, L.H. and R.A. Higgins. 1998. Southern corn leaf beetle: notes on reappearance of a rare corn pest. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. LD02.
- Corn production handbook. 1994. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. C-560 Revised (http://www.oznet.ksu.edu/library/crpsl2/c560.pdf).
- Higgins, R. A., P.E. Sloderbeck, and R. J. Whitworth. 2006. Insect management for field corn in 1999. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-810 Revised (http://www.oznet.ksu.edu/library/entml2/MF810.pdf).
- Higgins, R.A. and G.E. Wilde. 1995. Corn rootworm management in Kansas field corn Kansas State University Agricultural Experiment Station and Cooperative Extension Service. 1995. MF-845 Revised (http://www.oznet.ksu.edu/library/entml2/MF845.PDF).
- Jardine, D.J. 1998. Gray leaf spot of corn. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2341 (http://www.oznet.ksu.edu/library/plant2/mf2341.pdf).
- Jardine, D.J. and T.C. Todd. 1992. Nematode management in Kansas: chemical and biological control. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-1038 (http://www.oznet.ksu.edu/library/plant2/mf1038.pdf).
- Kadir, S. 1999. Crop Profile for Corn in Kansas. (http://www.ipmcenters.org/cropprofiles/docs/KScorn.html).
- U.S. Department of Agriculture (USDA)/National Agricultural Statistics Service (NASS). 2005. (http://www.nass.usda.gov:8080/QuickStats/PullData_US).
- Regehr, D.L., D.E. Peterson, W.H. Fick, P.W. Stahlman, and R. E. Wolf. 2004. Chemical weed control for field crops, pastures, rangeland, and noncropland. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. SRP 917.
- Raun, E. 2000. Crop Profile for Corn in Nebraska (http://www.ipmcenters.org/cropprofiles/docs/necorn.html).

- Sloderbeck, P.E., R.A. Higgins, L. Buschman, and R. Bowling. 1995. Corn borer management using B*t* corn. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2175.
- Sloderbeck, P.E., R.A. Higgins, and L.L. Buschman. 1996. Southwestern corn borer. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-845. (http://www.oznet.ksu.edu/library/entml2/MF845.PDF).
- Stubbendieck, J., G. Friisoe, and M.R. Bolick. 1994. Weeds of Nebraska and the Great Plains. Nebraska Department of Agriculture, Lincolin, Nebraska.
- Weed Control Manual. 1996. Meister Publishing Company, volume 30.