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WEED CONTROL IN CORN



Weed-free corn fields such as this one are possible with modern up-to-date pre-emergence herbicides.

**Cooperative Extension Service
South Dakota State University
United States Department of Agriculture**

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WEED CONTROL IN CORN

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South Dakota farmers annually plant approximately 4 million acres of corn that produce a gross annual income of around \$100 million. Weeds often reduce the crop yield by 25% and even more under adverse conditions.

In one test, a wet spring prevented early cultivation and a dry summer allowed the weeds to exert abnormal competition. Weedfree corn yielded 51 bushels per acre and weedy corn produced only 12 bushels. The weedy corn was cultivated three times, but weeds were not killed by the first cultivation because the soil was too wet. The weeds got too big to be controlled by later cultivations. Annual weeds reduced the yield 77%.

CULTIVATION

For many years the conventional method of planting corn was to check it. Excellent weed control could be obtained by cultivating lengthwise the first and third cultivations and crosswise the second time through. In recent years most corn is drilled, power checked, or hill-dropped, making it impossible to cultivate crosswise. Good weed control is more difficult to obtain by cultivation. However, several systems have proved to be effective.

A good cultivation system for a crop planted in furrows is to use disks for the inside shovels and "throw out" as soon as the operation can be performed without covering the crop, and "throw in" during the second cultivation as soon as new weeds emerge. Many small weeds in the row are covered by the second operation.

The annual weed control problem is greatly reduced in wheel track planted crops, by planting within 24 hours after plowing. Delayed planting frequently allows weeds in the tracks to emerge earlier than the crop. Cultivation may cover the crop while attempting to kill the weeds.

Rotary Hoe

The rotary hoe controls annual weeds early in the season, but its efficiency depends on several factors. Use it when the weeds are just emerging. Travel at a speed of 8 to 10 miles per hour and use a shield over the hoe or behind the tractor driver's head as a protection from flying clods and stones. It is most effective if the soil is crusted as a result of drying

after a rain, but is also effective on moist soil. It may cover small plants growing in furrows, wheel tracks, or loose soil. If crop plants are large, use the rotary hoe during the heat of the day to prevent breaking the plants.

A much larger acreage can be rotary hoed than can be row-crop cultivated in the same length of time. However, several hoeings are generally required to replace one row-crop cultivation. The rotary hoe is generally not effective if weed seedlings are big enough to develop a green color.

Flextine Harrow

The flextine harrow can be used in much the same way as the rotary hoe except that it can be operated at slower speeds. The rotating action of the flexible tines makes it an effective implement for killing weed seedlings. As with the rotary hoe, a much larger acreage can be covered than with the row-crop cultivator; several harrowings are generally required to replace one row-crop cultivation and it is not effective if weed seedlings are taller than one-fourth inch.

Costs of Cultivation

If labor is not considered, the cost of rotary hoeing is about 45 cents per acre, while the flextine harrow costs 21 to 24 cents per acre, and row-crop cultivation costs about 66 cents. If labor is worth \$1.25 per hour, the costs increase to 67 cents, 35 cents, and 91 cents per acre, respectively. The first row-crop cultivation takes longer than others and the cost would be some higher than the 66 or 91 cents quoted here. Consequently, two rotary hoeings or three harrowings can be done for approximately the same cost as the first row-crop cultivation.

SPRAYING WITH 2,4-D

Many broad-leaved annual weeds and some perennials can be killed with 2,4-D in corn. Some hybrids are more susceptible to 2,4-D than others. However, corn is usually tolerant to $\frac{1}{4}$ pound of 2,4-D acid in an ester form or $\frac{1}{2}$ pound in an amine form at any growth stage except the week before silking.

Use drop nozzles for 2,4-D application after the corn is knee high. The spray does not touch the upper leaves of the corn, but must hit the tops of the weeds. The risk of injury to the crop is reduced and better

coverage of weeds is often obtained. Use a high clearance sprayer with drop nozzles for application made after tasseling.

Stalks often become brittle after treatment with 2,4-D and a strong wind or careless cultivation may break many of them (the larger the corn at time of treatment, the greater the chance of breakage). Sometimes brace roots are damaged and severe injury will allow the corn to lodge.

Environmental conditions influence the degree of injury more than stage of growth at the time of treatment (except for the week before silking). Corn is more susceptible when growing rapidly. The temperature during the period before treatment is more important than the temperature at time of treatment. Corn is more susceptible after several days at 85°F. than it is after several days at 65°F.

Noxious Weeds

Use 3/4 to 1 pound of 2,4-D per acre to control broad-leaved noxious weeds. Although there is some chance of injuring the corn, numerous applications at these rates have been made near the time of the second cultivation without causing damage. Apply a second treatment after tasseling with high clearance sprayer equipped with drop nozzles.

For more details on noxious weed control see the Fact Sheet that discusses the weed you have in question.

Annual Weeds

Apply the amount of 2,4-D required to kill the weed. The quantity of herbicide required for control varies with the weed species. The same rate of herbicide is usually less effective as the weed matures. The amount of 2,4-D required to control numerous weeds at different stages of growth is listed below:

1/4 lb./A.	1/3 lb./A.	1/2 lb./A.
Kochia, 2-4 in.	Kochia, 4-8 in.	Kochia, over 8 in.
Marsh elder, 2-4 in.	Marsh elder, over 4 in.	Cinquefoil
Ragweed, 2-4 in.	Ragweed, over 4 in.	Gumweed, 6-12 in.
Pennycress, 4-6 in.	Pennycress, over 6 in.	Mare's tail
Pigweed, 2-4 in.	Pigweed, over 4 in.	Puncture vine
Mustard, 3-6 in.	Mustard, over 6 in.	Plantain
Lamb's quarters, 4-6 in.	Lamb's quarters over 6 in.	Cocklebur, over 6 in.
	Sowthistle, annual, 2-6 in.	Sowthistle, annual, over 6 in.
	Sunflower, 2-6 in.	Sunflower, over 6 in.

1/4 lb./A.	1/3 lb./A.	1/2 lb./A.
	Lady's thumb, 2-6 in.	Lady's thumb, over 6 in.
	Velvet leaf, 4-6 in.	Velvet leaf, over 6 in.
	Wild lettuce, 4-6 in.	Wild lettuce, over 6 in.
	Russian thistle, 2-4 in.	Russian thistle, 4-6 in.
	Wild buckwheat, 2 leaves	
	Morning glory, annual	
	Peppergrass, annual	

The cost of 2,4-D is about 90 cents a pound and the cost of application is about 75 cents per acre.

PRE-EMERGENCE SPRAYING

Atrazine, atrazine plus linuron, CDAA, CDAA-T and Ramrod are useful for controlling weeds in corn when applied before the weeds emerge. They are absorbed by the roots of the weeds; consequently, they must be moved into the root zone in the soil. Rain will leach them into the soil and mechanical incorporation with rotary hoe or harrow will help if too little rain is received to do the leaching.



Figure 1. Carry-over effect from band application of atrazine killed bands of small grain seeded 1 year after treatment.

Atrazine

This herbicide controls most annual grasses, numerous broad-leaved annuals, and quackgrass. Good control is obtained if applied to wet soil or if $\frac{1}{2}$ to $\frac{3}{4}$ inch of rain falls within 2 weeks after application. Poor control can be expected if the rain is not received until the third week. If less than $\frac{1}{2}$ inch of rain falls within 2 weeks after application, rotary hoeing or harrowing helps activate the herbicide and kills weed seedlings that may have started to emerge. To get effective weed control, higher rates of atrazine are needed on heavy soils or high organic matter soils than on light soils or low organic matter soils.

Residues from over 1 pound per acre of this herbicide applied pre-emergence in corn one year generally damage the crop planted the next year (figure 1). Damage from residues is reduced if the herbicide is applied in bands over the rows. Less area is covered and tillage the following spring dilutes the residue by mixing treated soil with untreated soil. In one test, plowing reduced residual effect more than disking did.

Rainfall records during the 10-year period, 1952-61, indicate that rainfall at corn planting time would have been adequate to activate atrazine and give good weed control in eastern South Dakota 8 of the 10 years. There was almost enough rainfall on the ninth year and mechanical incorporation with a harrow or rotary hoe would have improved results that year to give good weed control 9 of 10 years.

Use 2 to 3 pounds of active ingredient per acre to control foxtails, barnyard grass, pigweeds, mustard, lamb's quarters, Russian thistle, kochia, and other annuals. Use the lower rate on light soils and the higher rate on heavy soils. Treat 8- to 14-inch bands over the rows. Rotary hoe or harrow 2 weeks later if less than $\frac{1}{2}$ inch of rain falls during the 2-week period. Cultivate twice with a row-crop cultivator.

Although an over-all application will replace one and sometimes two cultivations, the cost of the herbicide and the carry-over effect from chemical residues generally make it impractical to use such a treatment. Since two cultivations will generally be needed anyway, they will kill weeds between the rows.

See Table 1.

Atrazine has also some post-emergence action on young weeds. This herbicide can be used up to 3 weeks after planting. Use 2 to 3 pounds active ingredient per acre before the weeds are $1\frac{1}{2}$ inches tall. Early post-emergence treatments may be more effective in years when rainfall is short. The atrazine spray will control the weeds that have emerged by foliage contact irregardless of rainfall and still leave some soil residual for later growing weeds.

Recent studies have shown that reduced rates of atrazine, applied early post-emergence, can be com-

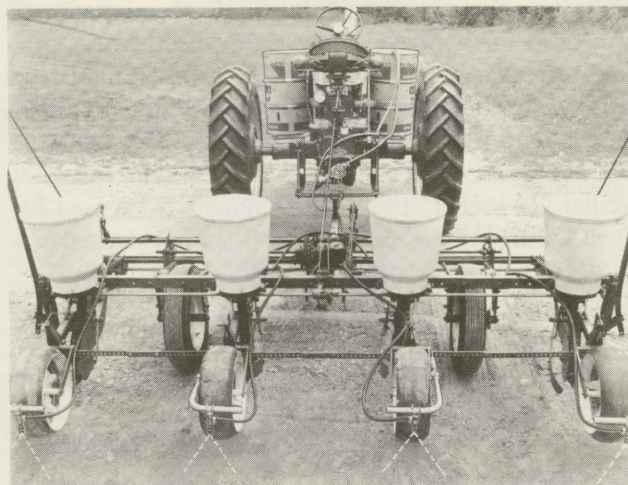


Figure 2. Corn planter equipped with sprayer attachment for band application of pre-emergence herbicides.
Photo courtesy of Century Engineering Company

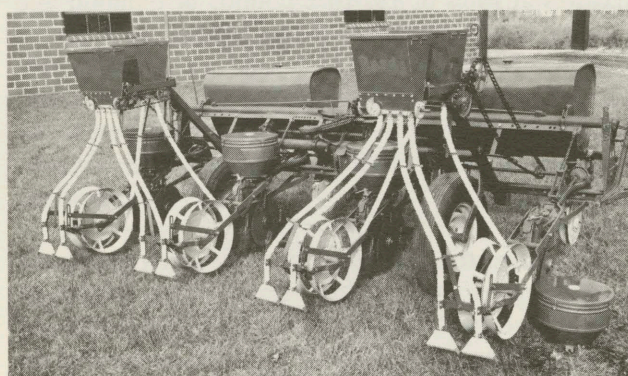


Figure 3. Corn planter equipped with attachments for application of granules of fertilizer, insecticide, and pre-emergence herbicides. Note different placement in soil for each chemical.
Photo courtesy of Gandy Company Inc.

bined with an emulsifiable dormant spray oil (non toxic to plants) to give weed control results equal to normal dosages of atrazine. At 9 locations in 1965 one pound active ingredient of atrazine plus oil and water or $2\frac{1}{2}$ pounds active and water gave 90% control as compared to 95% control for a normal $2\frac{1}{2}$ pounds active ingredient pre-emergence application. Applications have been made with 1 to 2 gallons of oil plus 18 gallons of water per acre. More testing of atrazine plus oil combinations is needed.

Sprays may be applied with an applicator similar to the one shown in figure 2 or with a regular field sprayer that has nozzles spaced the same width as the rows. Be sure that you have good agitation in the sprayer tank to keep atrazine in suspension. Agitation is best accomplished by mechanical means. However, liquid pressure agitation is the type of agitation found on most corn belt sprayers and will do a good job if modified to some extent. The bypass line from the pressure regulator can be outfitted with a jet agitation which will create more turbulence than the normal

outlet. However, for best results a separate agitator line should be installed between the pump and the pressure regulator. This new line can then be outfitted with a jet agitator. The pump should have at least the capacity of 10 gallons per minute to give good operating pressure and agitation. Use 15 to 20 gallons of water per acre on the area treated. Use special nozzles that give uniform coverage over the entire width of the band and use nozzle screens 50 mesh or larger in size. Nozzles on regular field sprayers are designed to overlap and deliver low volumes of water. Consequently, they do not give uniform coverage over the swath of any one nozzle and are equipped with fine screens.

Atrazine Plus Linuron

A mixture of atrazine plus linuron (sold under the tradename Lorox) applied at the rate of one pound active ingredient of each will reduce or minimize the problem of carry-over to susceptible crops grown the following year. Linuron is an effective corn herbicide with a short residual life in the soil.

Linuron when used as a pre-emergence weed killer by itself at 2 to 3 pounds active ingredient per acre has damaged corn. If used at lower rates in combination with other pre-emergence herbicides such as atrazine, good weed control results without crop injury. At the same time the rate of atrazine can be reduced to 1 pound active ingredient per acre minimizing the chance of carry-over. See Table 1 for results with this mixture in 1965 trials. Do not apply atrazine plus linuron mixtures to corn after the crop has emerged.

Atrazine is formulated as an 80% wettable powder while linuron is formulated as a 50% wettable powder. To obtain a 1 pound plus 1 pound active ingredient mixture applied to each acre you must add $1\frac{1}{4}$ pounds of atrazine product (Atrazine 80W) plus 2 pounds of linuron product (Lorox, 50% active) to each volume of water that will treat one acre. For example if a 200 gallon sprayer treats at the rate of 20 gallons per acre then add enough chemical to treat 10 acres or $12\frac{1}{2}$ pounds of atrazine product (Atrazine 80W) and 20 pounds of linuron product, Lorox, 50% active).

The same precautions in spraying this mixture should be observed as with atrazine alone. Use large 50 mesh screens in the suction strainer, line strainer and nozzle strainers of the sprayer. Be sure to have sufficient agitation of the spray mixture.

CDA and CDA-T

Both chemicals control most annual grasses and CDA-T controls several broad-leaved annuals. Sprays of either herbicide give good control if applied to warm soil (60° to 65° F.) and if a minimum of $\frac{1}{2}$ to $\frac{3}{4}$ inch of rain falls during the first week after appli-



Figures 4, 5, 6. Good annual weed control is viewed in corn with treatments of atrazine (figure 4) and Ramrod (figure 5) when compared with the weedy, but cultivated, untreated check plot (figure 6). Cultivation cannot yet be eliminated, but can be minimized to some extent with good chemical weed control as shown here.

cation. CDAA and CDAA-T generally give better weed control on heavy soils high in organic matter than on light soils low in organic matter. Both herbicides are relatively volatile and relatively emulsifiable in water. Therefore, they must be leached into the soil before they volatilize, but heavy rain (2½ inches) may leach sprays beyond the root zone of weed seedlings.

Granules are effective over a wider range of conditions. They are effective if applied to cool soil, they are not rendered ineffective by heavy rains, and they are effective if rain is not received for 10 days or 2 weeks.

CDAA and CDAA-T sprays have a repulsive odor and are highly irritating to the skin. The fumes easily irritate the eyes. Because of the foregoing, granule formulations of either CDAA or CDAA-T are much preferred for use over the liquid formulations. Granules are much less irritable to handle. If you do decide to use a spray, wear goggles and protective clothing.

Rainfall records during 1952-1961, indicate that the rainfall at corn planting time would have been adequate to activate CDAA and CDAA-T sprays and give good weed control in eastern South Dakota 5 out of the 10 years. Granules would have been effective 7 or 8 years.

CDAA and CDAA-T give weed control for a shorter time than atrazine and do not give good weed control as often as atrazine, but they do not leave a chemical residue that will damage next year's crop.

Use 4 pounds of active ingredient per acre of CDAA to control annual grassy weeds or 3 pounds of CDAA-T to control most grassy annuals and some broad-leaved annual weeds. Apply in 14-inch bands over the rows. Use a row-crop cultivator twice. An over-all application seldom replaces more than the first row-crop cultivation. Since two cultivations are generally required to give good weed control, they will control weeds between rows and there is no point in making over-all treatments. Band applicators are shown in figures 2 and 3.

Ramrod

Ramrod is the tradename for a new pre-emergence herbicide that is closely related to CDAA. Recent tests have shown Ramrod to be very effective in controlling

grassy weeds in corn. See Table 1 and figure 5. However, like CDAA, Ramrod doesn't control broad-leaved weeds as effectively as other pre-emergence herbicides used in corn.

Use 4 pounds of active ingredient per acre at planting time to control grassy weeds. Apply in 14 inch bands over the rows. Use a row-crop cultivator twice. An over-all application usually replaces the first row-crop cultivation and occasionally the second cultivation with optimum conditions.

Cost of Herbicides

The cost of application is very small if applied with a corn planter attachment; however, it is about 75 cents per acre if a field sprayer is used after planting.

Read Table 1 for pre-emergence herbicide costs.

Herbicide-Insecticide-Fertilizer Mixtures

You generally need separate applicators for each chemical. When applied with corn planter attachments, fertilizer is applied 2 inches to one side and 2 inches below the seed so that it will not damage the corn. The fertilizer applicator is mounted near the planter shoe. Herbicides applied pre-emergence are applied in 8- to 14-inch bands behind the packer wheel. Insecticides composed of chlorinated hydrocarbons, such as aldrin and heptachlor, may be applied as a liquid in a stream directly on the seed to control corn rootworm with an attachment that is mounted behind the planter shoe. Insecticides composed of phosphates, such as diazinon, thiamet, and parathion (stabilized), used to control western rootworm are applied as granules in 7-inch bands ahead of the packer wheel on the planter. The hydrocarbon insecticides may be applied as sprays or granules in the same manner. Figure 3 illustrates that three attachments are required to apply the three types of chemicals.

Some commercial firms have formulated and packaged herbicide-insecticide granular mixtures for

Table 1. Chemical Costs

Herbicide Treatment*	Cost of Product**\$	Cost per lb. active \$	Cost of Treatment***\$	
			14" band	overall
Atrazine	\$2.45 pp	\$3.00	\$2.00 to 3.00	\$6.00-9.00
Atrazine + linuron	2.45 + 2.95 pp	3.00 + 5.90	2.77	8.90
Ramrod (WP)	1.56 pp	2.40	3.20	9.60
Ramrod (granules)	0.51 pp	2.55	3.40	10.20
CDAA-T (EC)	8.90 pg	2.85	2.94	8.84
CDAA-T (granules)	0.39 pp	3.30	3.41	10.23
CDAA (EC)	7.80 pg	1.95	2.60	7.80
CDAA (granules)	0.44 pp	2.20	2.93	8.80

*WP=wettable powder, EC=emulsifiable concentrate. Atrazine is formulated as an 80% wettable powder. Linuron is formulated as a 50% wettable powder. Ramrod is formulated as a 65% wettable powder or a 20% granule. CDAA-T is formulated as a 3.1 pounds per gallon emulsifiable concentrate or 11.7% granule. CDAA is formulated as a 4 pounds per gallon emulsifiable concentrate.

**pp = price per pound, pg = price per gallon.

***Treatment cost based on suggested retail prices and recommended herbicide rates in this publication. For 7 inch bands divide cost for 14 inch bands by 2. Seven inch bands may be desirable for use in listed corn.

application through one applicator. Such mixtures are advertised for both weed control and soil insect control. If the placement of the granular material satisfies both weed and insect control needs without endangering the crop plant, then such mixtures may be desirable. For good weed control purposes a wider band is needed (14 inches) than would normally be used for insect control purposes (7 inches). However, narrow bands may be more suited for lister-planted corn.

DIRECTED-SPRAYS

Herbicides that would ordinarily damage corn if applied to the foliage may be applied as directed-sprays. Apply them with special spraying equipment to the base of the corn plant for controlling annual weeds in the row. A directed-spray applicator is shown in figures 4 and 5.

Carefully apply directed-sprays of dalapon-2,4-D mixtures at rates of 1½ to 2 pounds of dalapon and ¾ pound of 2,4-D per acre of area treated when corn is from 8 to 16 inches tall. This mixture stunts or kills most annual weeds in the row. Do not allow excessive amounts of dalapon to contact the corn leaves, as the plants will become stunted and deformed. Twisted leaves and undeveloped ear husks are typical injury symptoms.

Use a directed-spray applicator. Attach it directly to the tractor or mount it with a cultivator. It must have attachments that lift the corn leaves and special nozzles that direct the spray to the base of the corn plant and the weeds in the row. Calibrate the sprayer to apply 10 to 15 gallons of spray per acre in a 12- to 14-inch band in the row.

A directed-spray of linuron (trade name Lorox) at

2 pounds active per acre of area treated, applied when the corn is at least 15 inches tall, has shown promise. It is more effective if 0.5% of surfactant is added. Linuron will kill leaf tissue it contacts and yields may be reduced if leaf kill is extensive. Apply with a directed-spray applicator.

Since directed sprays cannot be applied to small corn, use rotary hoe, harrow, pre-emergence herbicide, or row-crop cultivator to control early weed growth and to prevent yield reduction from weed competition. You may replace the second cultivation with directed sprays, but you will probably use it as an emergency measure for controlling heavy stands of annual weeds in the corn row.

Application cost is about the same as a first row-crop cultivation (90 cents per acre). Most applicators cover four rows at a time and a relatively slow speed of travel must be used. The cost of herbicide is about \$3.00 per acre treated for a dalapon-2,4-D mixture and \$12.60 per acre for linuron. However, only ½ of the field is treated so costs are reduced to \$1.00 per acre of field for dalapon-2,4-D mixture and \$4.20 for linuron.

Table 2. 1965 Weed Control in Corn Demonstration

Herbicide	Rate/Acre	Annual Weed Control*	
		Grass	Broad-leaved
Atrazine	2½	93	98
Atrazine + linuron .	1 + 1	83	96
Ramrod	4	79	51
Ramrod**	4	70	44
CDAAT**	3	53	56
Check	---	0	0

*Average per cent weed control in August 1965 of 9 counties.

**Granules