CONTROLLING
WEEDS in CORN
with 2,4-D

UNIVERSITY OF ILLINOIS
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Controlling Weeds in Corn With 2,4-D

By F. W. SLIFE, R. F. FUELLEMAN, G. E. McKIBBEN, and W. O. SCOTT

During 1949 more than 500,000 acres of corn in Illinois were sprayed with 2,4-D for the control of weeds. Other states in the North-Central region are likewise spraying large acreages of corn with 2,4-D. Results have been generally satisfactory, but with this wide use have come some disappointments. Many of these unsatisfactory results can be explained by unfavorable climate, wrong soil type, miscalculation of material or sprayer, and too little knowledge of the types of weeds 2,4-D will control.

The purpose of this circular is to give the best available information on how to use 2,4-D so that it will control weeds most effectively without damaging the corn crop. Although 2,4-D is undoubtedly the best chemical aid the farmer has yet had in his fight with weeds, it is not recommended as a complete substitute for cultivation or other cultural practices.

Pre-Emergence Spraying of Weeds

Pre-emergence spraying usually refers to treatment of the soil after the corn has been planted but before the first weeds have come up. The corn at this time either has not come up or is just beginning to appear. Sometimes pre-emergence spraying is done at lay-by to control late-germinating weeds.

Wide experience with pre-emergence spraying is lacking, and therefore it is desirable to try this method on a small scale. It is not recommended for large-scale treatment or as a standard method of weed control.

Advantages. Annual weeds are very quickly killed by 2,4-D while they are germinating (Fig. 1). This is true both of the annual broad-leaf plants such as velvet weed and cocklebur, and of the annual grasses such as foxtail and crabgrass. The effectiveness of pre-emergence spraying on the annual grasses is particularly important, since they are not affected by 2,4-D after they have come up.

If pre-emergence treatment works satisfactorily, one to three cultivations can be omitted. On most soil types, however, at least one cultivation is needed for best growth of corn.

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A pre-emergence spray, at the rate of 2 pounds of acid per acre in the amine form, was applied to this field in 1949. Plenty of rainfall made weeds germinate promptly, so that they were killed by the 2,4-D upon emergence. The corn was not cultivated. (Fig. 1)

Disadvantages. Pre-emergence treatment is relatively expensive. It has little effect on Canada thistle, bindweed, quack grass, and other perennial weeds; and it is ineffective against annual weeds in a dry season. For 2,4-D to kill annual weeds the soil must be moist enough to insure prompt generation of the weed seeds in the top layer of soil. If the top layer is dry when the corn is planted and no rain falls for several weeks, the chemical will have lost much of its effectiveness before the weeds come up.

This type of treatment should not be used on sandy soils or on light, porous soils because of possible injury to the corn.

Types and rates of 2,4-D to use. Esters, amines, and sodium salts of 2,4-D (see page 15), when used at equal rates, have been about equally effective for pre-emergence spraying in corn up to 3 inches tall. Two pounds of the acid should be used to the acre, although if conditions are favorable 1 1/2 pounds will give excellent results. More than 2 pounds gives little added weed-control and is likely to injure the corn (Fig. 2). For pre-emergence spraying at lay-by, it is safest to cut the amount of acid to 1 pound, although in some years heavier treatments have resulted in good corn yields.

The problem of how much 2,4-D can be safely applied to young corn needs further investigation. However, tests at Urbana in 1949
Corn may be damaged by heavy rates of 2,4-D applied as a pre-emergence treatment. The corn on the left received 4 pounds of 2,4-D acid per acre. Note how much lower it is than the corn on the right, which was cultivated three times without chemical treatment. (Fig. 2)

indicate that corn up to 3 inches tall is quite resistant to 2,4-D. Applications of $1\frac{1}{2}$ pounds of acid in the amine form have had no effect on corn 2 inches high. In trials in eastern states corn up to 3 inches tall was not injured by treatment with $1\frac{1}{2}$ pounds of 2,4-D acid. Corn taller than 3 inches has been injured by this rate.

**When to apply.** Weed control is usually much better if treatment is made 3 to 7 days after corn planting rather than immediately afterward. This is indicated by experiments both in Illinois and in some eastern states. Delaying the treatment until 3 days to one week after corn planting gives the weeds time to start germinating, provided the ground is moist.

While treatment at this time will destroy early-germinating weeds if conditions are favorable, the effects will not last long enough to destroy late-germinating weeds. Two possible ways of getting rid of these weeds are suggested. One is to make one pre-emergence treatment within a week after planting, and then to cultivate once, when the third cultivation would normally occur. If the pre-emergence treatment is successful the first two cultivations can be omitted.
The other possibility is to delay pre-emergence treatment and make it in place of or after the third cultivation. As already mentioned, 1 pound of acid to the acre is less likely to damage the corn than 2 pounds; and this rate will usually give satisfactory control of the late-germinating weeds. There is still possibility of damage to the corn, however. To keep damage to a minimum, a nozzle extension (Fig. 9) that will keep the spray down between the corn rows is necessary.

Neither of these two plans can be positively recommended until more information is available.

**Experimental results.** Results of pre-emergence spraying of corn at Urbana have been erratic, mainly because of varying weather conditions. Excellent weed control was obtained in 1947 and 1949. In 1948, however, results were very poor because of a three-week drought at planting time. Corn was not injured by treatments made at recommended rates.

Results of pre-emergence trials at Urbana in 1949 are given in the table below. The corn was drilled in a black silt loam and pre-emergence treatments were made three days afterward. A moderate rain fell ten days after the corn was planted.

Judged by corn yields and number of weeds present six weeks after treatment, 2 pounds of 2,4-D was the most effective rate to use. Although the 3-pound rate gave better weed control, it reduced the yield of corn somewhat. One cultivation at lay-by stage, in addition to pre-emergence treatments of 1 and 2 pounds an acre, slightly increased corn yields because it destroyed late-germinating weeds and also probably because it stirred the soil.

In pre-emergence trials at the Dixon Springs Experiment Station

**EFFECTS OF PRE-EMERGENCE TREATMENTS ON CORN YIELDS AND WEEDS**

**Urbana, 1949**

<table>
<thead>
<tr>
<th>Rate of 2,4-D acid per acre</th>
<th>No cultivations</th>
<th>Corn yield</th>
<th>Number of weeds per 9 square feet 6 weeks after treatment</th>
<th>Corn yield with 1 cultivation at lay-by</th>
<th>Corn yield with 2 cultivations, no treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>bu.</td>
<td>62.0</td>
<td>108</td>
<td>71.0</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>85.0</td>
<td>32</td>
<td>86.5</td>
</tr>
<tr>
<td>1 pound</td>
<td></td>
<td></td>
<td>84.5</td>
<td>13</td>
<td>86.5</td>
</tr>
<tr>
<td>2 pounds</td>
<td></td>
<td></td>
<td>79.5</td>
<td>0</td>
<td>79.0</td>
</tr>
</tbody>
</table>

*Applications of both amine and ester types were made at each rate. Data are given as averages of the results obtained.*
This corn was given three cultivations during the growing season of 1949, but summer rains favored the germination of weed seeds after the last cultivation. A late pre-emergence treatment would have helped to keep these weeds down.

in southern Illinois, highest corn yields have been obtained by three normal cultivations followed by a pre-emergence treatment down between the rows. This late-season treatment has killed many of the annual grasses and broadleaf weeds germinating after the last cultivation.

Post-Emergence Spraying of Weeds

More definite benefits have been obtained from post-emergence spraying (spraying after weeds and corn are up) than from pre-emergence spraying. Post-emergence spraying is past the experimental stage, and it is now recommended for weed control in corn when normal cultural practices are not controlling weeds that are susceptible to 2,4-D.

Advantages. This type of spraying is relatively cheap and it may eliminate one or more cultivations. Weeds susceptible to 2,4-D can usually be controlled, regardless of weather, if they are thoroughly covered with the material.

Disadvantages. Grasses and a number of other weeds are not affected by post-emergence spraying (page 13). Nor does post-emergence spraying control weeds germinating at a later date. Another disadvantage is that this type of spraying may injure corn.
Types and rates of 2,4-D to use. Amines and esters are used in cornfields much more than the sodium salts. While both types have given satisfactory results, the esters are more likely to damage the corn if used at rates higher than recommended.

In the ester form, \( \frac{1}{4} \) pound of acid can be used to the acre with little damage to the corn. One-half pound of acid in the amine form may be used with reasonable safety. Applications at these rates will control most of the common annual broadleaf weeds that infest cornfields. (For list of weeds see page 13.)

To control Canada thistle, field bindweed, and a few other weeds the above rates have to be doubled. These heavier rates may cause some damage to the corn. They should not be used unless nozzle extensions (Fig. 9) are attached to the sprayer.

When to apply. Time for spraying the corn should be determined primarily by amount and growth of the weeds. Experimental results indicate that corn can be sprayed with \( \frac{1}{4} \) to \( \frac{1}{2} \) pound of 2,4-D acid per acre at any time from emergence to maturity, with little or no damage to the crop (Fig. 4). However, corn should not be sprayed just before, during, or after silking or at pollination time.

In many years, such as 1949, late summer rains are favorable for weed growth after the corn has received its last cultivation. As mentioned on page 6, a pre-emergence treatment, applied either in place of or after the last cultivation, will give good control of germinating annual weeds in wet seasons. Sometimes spot treatments are necessary to control late-appearing perennial weeds.
Use 2,4-D on bottomland corn. Post-emergence spraying will be most important in bottomland areas or in wet years when normal cultivation has been interrupted.

Corn is perhaps the most important crop in the bottomlands of Illinois. These areas have the good soil and ample moisture that are needed for large yields. However, under these conditions weeds also flourish and often the corn crop is lost because weeds take over. This is particularly true in years when the soil is too wet to cultivate. Bottomland soils are full of weed seeds and each overflow brings in a new supply. For the most part these weeds are broadleaf annuals such as horseweed, smartweed, pigweed, velvet weed, and cocklebur. These can be effectively controlled with light applications of 2,4-D. Crops of bottomland corn have been saved by 2,4-D during the last few years and many farmers consider 2,4-D as valuable as cultivation in some of the bottomland areas.

Injuries to corn from 2,4-D are reported most commonly from bottomland fields. Corn is often growing rapidly when applications are made. Also, the chemical usually has to be applied over the tops of the corn because the weeds are as tall as the crop. The damage to the corn, however, is seldom as serious as it would be if the weeds were allowed to grow unchecked. If the weeds are not stopped in these areas, little or no corn will be produced.

2,4-D Can Damage Corn in Four Ways

2,4-D is most effective against weeds when soil, moisture, and temperature conditions are favorable for rapid growth. It is under these same conditions that corn is most likely to be injured by 2,4-D. Four general types of injury may occur. They are onion leafing, abnormal growth of brace roots, stalk bending, and brittleness.

Onion leafing (Fig. 5). This symptom may be found in unsprayed fields of corn, but it is more common in sprayed fields. Leaves at the top of the plant remain rolled tightly together for an abnormally long time. Often this hinders the emergence of the tassel. This symptom of injury is not serious and should have no effect on the yield of corn, unless it is unusually severe.

Abnormal growth of brace roots (Fig. 6). This is perhaps the most common injury caused by spraying with 2,4-D. The chemical affects the brace roots in several different ways. They may fuse together to form an enclosed ring around the plant; they may not be produced at all; they may turn upward instead of downward; or they may be stimulated to form many smaller roots. Occasionally they grow abnormally large and burst. Brace-root injury is usually found in fields sprayed any time after the corn has emerged. There is no evidence to indicate that this type of injury reduces the yield.
Onion leafing (Fig. 5)

Brace-root injury (Fig. 6) Stalk bending (Fig. 7)

These injury symptoms may or may not occur in sprayed fields. They are most likely to occur if the corn is growing rapidly. When recommended rates and precautions are followed, corn is seldom injured severely.

Brittleness (Fig. 8)
Stalk bending (Fig. 7). Stalk bending usually occurs when corn is growing rapidly and when a heavier-than-recommended rate of 2,4-D has been used. Several days later upright growth is resumed but the lower part of the stalk may remain curved or elbowed. In a few fields this curvature has been so severe that the plants would not feed into the corn picker properly. This results in a more expensive harvesting operation because it is necessary to follow the mechanical picker with hand picking.

Brittleness (Fig. 8). Brittleness usually occurs within 24 hours after spraying and may persist for 2 to 7 days. At the end of this time it disappears. The danger here is that a wind storm or cultivation may break the corn while the stalks are brittle, thereby causing a reduction in yield.

Ways to avoid damage. These three precautions will cut down the danger of damage to corn from 2,4-D sprays:

1. Use recommended rates of 2,4-D.
2. Use nozzle extensions on sprayers (Fig. 9) when spraying corn more than 3 inches tall. These extensions are most effective after corn is 6 to 8 inches tall. By keeping most of the 2,4-D off the corn, they greatly reduce the possibility of injury. Also they give better coverage on weeds. Extensions are less effective on corn 3 to 6 inches tall, but they do protect the upper part of the plant.
3. Do not spray corn when it is growing rapidly. Avoid spraying when the weather is hot and the soil is wet. These conditions stimulate corn to grow faster than normal.

Nozzle extensions are being attached to spray boom for post-emergence spraying. These will keep much of the 2,4-D off the corn. (Fig. 9)
It is best not to cultivate corn for one week after spraying. Cultivation may break cornstalks made brittle by the chemical. If it is necessary to cultivate soon after spraying, test the corn first for brittleness. To do this, bend stalks over. If brittle, they will break off at the lower nodes.

**Hybrid Tolerance to 2,4-D**

For several years experiments by stations in the corn belt have indicated that corn hybrids vary in their tolerance to 2,4-D. The Illinois Agricultural Experiment Station has found considerable variation in inbred lines and crosses tested for two seasons. A few inbred lines are apparently seriously damaged by 2,4-D, while others are almost completely resistant. Most hybrids, however, fall in between these extremes. If more than one of the susceptible inbreds should occur in double-cross hybrids, the hybrid may be injured more than hybrids that have only one or none of these inbreds in their pedigree.

When $\frac{1}{4}$ to $\frac{1}{2}$ pound of 2,4-D acid is used per acre and precautions are taken to place this material down between the rows instead of over the top of the corn, there is little danger of damage to any of the double-cross hybrids used in Illinois.

2,4-D should be used with especial caution in seed-production fields because susceptible inbreds or crosses may be present which could be severely injured (Figs. 10 and 11).

A seed-production field of inbred corn in central Illinois, as it appeared before being sprayed with 2,4-D. (Fig. 10)
The same seed-production field shown in Fig. 10, after spraying with 2,4-D. The female parent strain (left) has been severely damaged, while the male parent strain has suffered no injury. (Fig. 11)

Effect of 2,4-D on Weeds Common in Cornfields

Annual weeds should be treated with 2,4-D when they are young and growing rapidly. As they approach maturity they are much harder to control and some become quite resistant to 2,4-D sprays.

Perennial weeds should also be treated in the rapid-growth stage, preferably as they are approaching the bud stage. They should be retreated when they begin to grow again later in the season. Hand sprayers are good for this late-season spot treatment.

Following is a list of some of the common weeds in Illinois, and the applications of 2,4-D that are needed in post-emergence spraying (A stands for annual weeds, P for perennials):

Can be killed with $\frac{1}{4}$ to $\frac{1}{2}$ pound of 2,4-D an acre

- Common ragweed (A)
- Horseweed (A)
- Morning glories (A)
- Cocklebur (A)
- Smartweed (A)
- Pigweeds (A)
- Mustards (A)
- Velvet weed (A)
- Flower-of-the-hour (A)
- Hedge bindweed (P)

Can be controlled with $\frac{1}{2}$ to 1 pound of 2,4-D an acre

- Canada thistle (P)
- Field bindweed (P)
- Perennial sow thistle (P)
- Wild sweet potato (P)
- Lambsquarter (A)
- Jimson weed (A)

Not affected by post-emergence spraying with 2,4-D

- Grasses (P)
- Bull nettle (P)
- Ground cherry (P)
- Common milkweed (P)
- Climbing milkweed (P)
- Devil's shoe-strings (P)
- Grasses (A)
- Purslane (A)
- Nightshades (A)
- Buffalo bur (A)
Equipment for Applying 2,4-D in Corn

Various types of equipment can be used to apply 2,4-D in corn. Treatments are most effective when uniform coverage is obtained.

**Ground equipment.** Ground spraying is on the whole better than plane spraying. There are many different types of sprayers for use on the ground and no attempt will be made here to evaluate them. A sprayer that delivers 10 or more gallons per acre is most desirable. The amount of water applied per acre is determined by the size of nozzle, amount of pressure used, and speed of travel. Results definitely indicate a better control of weeds in corn when 10 gallons are applied per acre rather than 5. The drift hazard is also somewhat less.

Sprayers should have nozzle extensions as standard equipment for treating corn (Fig. 9).

**Plane application.** Applying 2,4-D from airplanes has the advantage of being much faster than other methods of application, and it may be cheaper. However, the drift hazard is greater, and the chemical is applied over the top of the corn rather than between the rows, where it should be placed.

In areas where the soil is too wet for ground equipment and the weeds are smothering the corn, plane application may be the answer. Also, little apparent damage has been done to corn in several fields which were sprayed by plane in late summer, when the corn was nearing maturity. These applications have done an excellent job of killing late-germinating cockleburs and morning glories.

*In general, however, plane application is not recommended for Illinois.* Most Illinois cornfields are somewhat small for efficient use of planes for applying 2,4-D, and these fields are often bordered by crops such as soybeans and clovers, which are damaged by this chemical. In regions where fields are large and there is little danger of drift to susceptible crops, airplane application is used extensively.

Effect of 2,4-D on Other Crops

**Small grains.** Wheat, oats, rye, barley, and other small grains can be sprayed with 2,4-D in the spring for weed control, if no legume has been seeded. Treatment should be made after the plants are fully tillered and before the stems begin to joint. One-fourth pound of acid in the ester form, or \( \frac{1}{2} \) pound in the amine or sodium salt form, can be used with little danger of damage to the small grain. Applications at these rates will control annual weeds. If perennial weeds are present, heavier rates will be needed, and some decrease in yield can be expected.

Fall applications to winter grains should not be made. The 2,4-D will severely damage the crop.
Legumes. Legume seedlings are easily killed by 2,4-D. It should therefore not be applied to small grains early in the season if a legume has been seeded. As the small grain grows taller, it gives more protection to the legume, and 2,4-D may not reduce the legume stand excessively.

Pastures. White and Ladino clover have shown some resistance to 2,4-D and will not be injured by light applications. Where good stands of alfalfa, red clover, alsike clover, and birdsfoot trefoil are present, 2,4-D should be used only for spot treatment of noxious weeds.

Types of 2,4-D Available

Three principal types of 2,4-D can be purchased for weed control. They are made by treating the pure acid of 2,4-D (dichlorophenoxyacetic acid) in ways to make it soluble in water. The three types are:

- **Esters** of 2,4-D, made by treating the pure acid with alcohol.
- **Amines** of 2,4-D, made by treating the pure acid with amines.
- **Sodium salts** of 2,4-D, made by treating the pure acid with sodium salts.

The esters are somewhat more effective against weeds than the amines or sodium salts when used at equal rates. However, they are also more apt to damage corn that is more than 3 inches tall if they are used at rates greater than 1/4 pound of acid to the acre. A recent survey shows that amines and esters have been used in cornfields much more than the sodium salts. The amine and ester types are completely soluble in any amount of water, but the sodium salt should be dissolved in 12 to 20 gallons of water per acre to avoid clogging of sprayer screens.

Commercial preparations of 2,4-D vary in the amount of acid they contain. The acid content is usually given on the container labels in pounds of 2,4-D acid per gallon, or as percent of acid in the material. If the acid content is stated in pounds per gallon, the amount of acid in a pint can be found by dividing the pounds in a gallon by 8 (the number of pints per gallon). If the acid content is stated in percent, multiply the percent by the weight in pounds of a gallon of the material and divide the product by 8 to get the fractional part of a pound of acid in a pint of the material. 2,4-D may vary in weight from 8 to 10 pounds per gallon.
WHEN SPRAYING CORN WITH 2,4-D

Use recommended rates of 2,4-D.

Use with special caution in seed-production fields.

Use nozzle extensions on sprayers when treating corn more than 3 inches high.

Do not use pre-emergence sprays in corn growing on sandy or light porous soils.

Be cautious of drift. Many crops, including tomatoes, cotton, soybeans, and clovers, are injured by 2,4-D.

If sprayer is to be used for other chemicals and on crops that will be injured by 2,4-D, thoroughly clean it with a 2-percent solution of household ammonia, leaving the solution in the tank and boom overnight.

Remember that 2,4-D is not a complete substitute for cultivation or other cultural practices.