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THE USE OF 2,4-D IN RICE FIELDS FOR THE CONTROL OF WEEDS

By

T. C. Ryker and Clair A. Brown

Rice being dusted for weed control on farm of Robert Bros., Burnside, Louisiana

LOUISIANA STATE UNIVERSITY

AND

AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATION
W. G. Taggart, Director
The Use of 2,4-D in Rice Fields for the Control of Weeds

T. C. Ryker and Clair A. Brown

Weeds in rice fields cost growers thousands of dollars each year. This loss results from the cost of labor to pull certain of the weeds by hand, from the lower yields resulting when these weeds are not removed, and from the lower quality of the product when weed seeds are present. The cost of removing indigo and curly or frizzly indigo by hand may vary from one to as much as ten dollars per acre, depending upon the density of the weeds. The problem has been further complicated in recent years by lack of sufficient labor to pull weeds. This will probably continue since the industry is becoming geared to a more complete mechanization in the growing and harvesting of rice. Furthermore, the control by hand methods is limited to two of the three principal broad-leaf weeds, indigo and curly indigo. The third weed, Mexican weed or birdeye, together with certain other weeds of lesser importance, cannot economically be removed from rice fields by hand.

The recent discovery that 2,4-dichlorophenoxyacetic acid, commonly referred to as 2,4-D, will control certain broad-leaf plants without at the same time materially injuring most true grasses has aroused considerable interest on the part of rice growers. Sufficient information has accumulated during the last two years both from experimental tests and from commercial applications to show that 2,4-D will control certain rice weeds at a relatively low cost per acre.

The purpose of the present investigations was to determine the effectiveness of these new compounds in controlling certain broad-leaf weeds in rice fields and to determine the best means of application. Following several tests made late in the season of 1945 by S. J. P. Chilton and Clair A. Brown of the Louisiana Agricultural Experiment Station, a rather large number of tests under various conditions were made in 1946. The outcome of these tests was of such a promising nature and the demand for information was so great that a preliminary report was made before the final results were obtained. The present report summarizes the results to date, and gives recommendations on the use of 2,4-D in rice weed control.

1 Acknowledgment is made to the following companies who kindly furnished materials used in the investigations: American Chemical Paint Co., Bartlett Chemical Co., Chapman Chemical Co., Dow Chemical Co., General Agricultural Chemicals, Niagara Sprayer & Chemical Co., Sherwin-Williams Co., and Water Weed Exterminating Co.

Experimental Methods

For most of the tests, paired 1/50-acre plots were selected for uniformity of growth of the rice and of weed infestation. One plot was treated and the other was left untreated to serve as a control. For the most part, two of the various formulations were used, (1) the acid plus soda ash, and (2) the sodium salt of 2,4-D. They were applied either as a spray or as a dust. A 1,000 parts per million concentration of 2,4-D in water was applied at the rate of 100 gallons per acre with a knapsack sprayer. The dusts consisted for the most part of material containing 10 per cent or 15 per cent of the acid. The dusts were applied with a small Root hand duster early in the morning or late in the evening, while the air was relatively quiet. With this hand duster it took approximately 20 pounds of material per acre for good coverage.

Weed counts were made from 4 to 8 weeks after treatment. Counts were made of all surviving weeds and did not evaluate the size of the weeds remaining in the plots. The counts were obtained by dropping a one-foot-square frame at nine fixed points in each plot and counting all weeds within the frame.

Yields were obtained by cutting two samples 3½ by 12 feet in each plot. As far as possible the samples were taken to include the same drill rows in the treated plots as in the untreated ones. The samples were air dried and threshed separately. The yields were computed in barrels per acre.

There were also several tests in which the dust was applied by airplane. These were supplemented by observations made in fields commercially dusted by plane.

The Effect of 2,4-D on Rice Weeds

While the manner in which 2,4-D compounds kill weeds is not clear, the growth processes of the plants are severely disturbed. Within a few hours after treatment the plants wilt slightly, and the stems become bent and twisted. In time, various malformations develop, including root and bud proliferations. The leaves slowly lose their green color, and in time, die and become dry. The stems and roots gradually die. It may take from two to four weeks for the plants to die. Weeds affected but not killed may either recover in two or three weeks and show apparently normal growth thereafter, or upon recovery may show an abnormal type of growth. The sensitivity of different broad-leaf plants to 2,4-D varies considerably. Indigo has been one of the most sensitive, while Mexican weed has been quite resistant except during the seedling stage.

Experiments showed that the younger and more vigorously growing plants were the most easily killed. In addition to volume and concentration of the material, other factors such as season and temperature were also found to be important.
The rice weeds controlled with 2,4-D include:

Bladder pod or old fashion coffee bean, *Glottidium vesicarium* (Jacq.) Harper.
Cocklebur, *Xanthium americanum* Walt.
Curly indigo (frizzly or silvery), *Aeschynomene virginica* (L.) B.S.P.
Goose weed, *Sphenoclea zeylanica* Gaerth.
Mexican weed or birdeye, *Caperonia castaneaefolia* (L.) St. Hil.
Mule ear, *Heteranthera limosa* (Sw.) Willd.
Redweed, *Melochia corchorifolia* L.
Sagittaria, *Sagittaria* spp.
Sedges: yellow sedge, *Cyperus iria* L.
   tadpole sedge, *Rynchospora corniculata* (Lam.) Gray.
   *Fimbristylis miliaea* Vahl.
Toothcups or redstem, *Ammania coccinea* Rottb.
Turtle back, dayflower, or batwing, *Commelina* spp.
Water hyacinth, *Piaropus crassipes* (Mart.) Britton
Water primrose, *Jussiaeae* sp.

**The Effect of 2,4-D on the Rice Plant**

Young rice seedlings treated with 2,4-D developed a noticeably darker green color and showed a definite retardation in growth for a period of about two weeks. The base of the plants became swollen and

![Figure 1](image)
large stubby roots emerged. This was especially noticeable when plants were treated before flooding. Shortly after flooding the treated plants made a marked recovery and developed a normal root system within two to three weeks. This is shown in Figure 1. Plants treated after their water root system had developed, showed less of the stunting effect, but did turn a noticeably darker green color, which was evident throughout the growing period. Plants treated at heading time showed a blasting of many of the florets. The hulls remained open and frequently a small abnormal grain developed within the open hulls (Fig. 2). In addition, they usually showed a reddish brown discoloration. Heavy dosages at this time sometimes induced bending of the stems at the upper nodes. There were also indications that tillering had been inhibited to some degree in several of the tests. Plants treated prior to heading, headed normally and produced viable seed.

The Effect of Time of Treatment on Weed Control

The most effective control of Mexican weed or birdeye was obtained by treatment before flooding, followed within two days by a good water coverage. In ten tests an average of 75 per cent of the Mexican weed plants were killed (Table 1). However, treatments made from one to two weeks after the initial flooding were also effective, an average of 68 per cent of the plants being killed in the four tests made. In tests made

Figure 2.—Zenith rice dusted at heading time on farm of E. Hebert, Kaplan, Louisiana, showing injured panicles on the right as compared to normal panicle on the left.
Figure 3.—The effect of 2,4-D on Mexican weed three weeks after treatment. Plots on farm of N. Zaunbrecher treated previous to flooding. Treated plot on the right.

Figure 4.—The effect of 2,4-D on Mexican weed six weeks after treatment. Plot on farm of P. J. Thevis treated shortly after flooding. Untreated area to left and in background.
Figure 5.—The effect of one application of 2,4-D on indigo on farm of Robert Bros., Burnside, Louisiana. Treated area in center.

three weeks or more after flooding, the Mexican weed was not killed by the treatments, even when the dosage was doubled. Typical plots treated before flooding and others treated after flooding are shown in Figures 3 and 4.

TABLE 1. Effect of time of application of 2,4-D on control of Mexican weed in 1946
(Tests on 12 farms in 6 parishes)

<table>
<thead>
<tr>
<th>Location of test</th>
<th>Parish</th>
<th>No. weeds per square yard</th>
<th>Per cent killed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>control</td>
<td>treated</td>
</tr>
<tr>
<td>Treated before flooding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. Andrus</td>
<td>Acadia</td>
<td>146</td>
<td>18</td>
</tr>
<tr>
<td>J. Heinen</td>
<td>Acadia</td>
<td>108</td>
<td>16</td>
</tr>
<tr>
<td>L.B. Lawson</td>
<td>Acadia</td>
<td>587</td>
<td>247</td>
</tr>
<tr>
<td>Pierce</td>
<td>Acadia</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>N. Zaunbrecher</td>
<td>Acadia</td>
<td>168</td>
<td>11</td>
</tr>
<tr>
<td>R. Robert</td>
<td>Ascension</td>
<td>60</td>
<td>43</td>
</tr>
<tr>
<td>G. Lyons</td>
<td>Jefferson Davis</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>C.P. Dugal</td>
<td>St. Landry</td>
<td>142</td>
<td>11</td>
</tr>
<tr>
<td>O.L. Pollangue</td>
<td>St. Landry</td>
<td>155</td>
<td>44</td>
</tr>
<tr>
<td>J. Zaunbrecher</td>
<td>Vermilion</td>
<td>69</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>147</td>
<td>45</td>
</tr>
</tbody>
</table>

Treated one to two weeks after flooding

<table>
<thead>
<tr>
<th>Location of test</th>
<th>Parish</th>
<th>No. weeds per square yard</th>
<th>Per cent killed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>control</td>
<td>treated</td>
</tr>
<tr>
<td>P. Andrus</td>
<td>Acadia</td>
<td>202</td>
<td>130</td>
</tr>
<tr>
<td>R.J. Thevis</td>
<td>Acadia</td>
<td>142</td>
<td>13</td>
</tr>
<tr>
<td>R. Robert</td>
<td>Ascension</td>
<td>63</td>
<td>14</td>
</tr>
<tr>
<td>L.E. Fontenot</td>
<td>Evangeline</td>
<td>118</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>131</td>
<td>50</td>
</tr>
</tbody>
</table>
Experiments with indigo showed that it could be killed at any stage of development. A portion of an experimental plot is shown in Figure 5. However, less 2,4-D was necessary to kill the plants when they were small.

Tests on curly indigo made previous to or shortly after flooding gave somewhat erratic results, but for the most part very few plants were killed. Dust treatments were more effective than the spray treatments. Dust treatments made at the usual weeding time killed back the tips of the plants, but the plants in most cases recovered in about three weeks. A second application made at this time did give satisfactory control in the two tests in which it was tried. Results in one of the tests are shown in Figure 6.

Very little dust was available during the early part of the growing season, and a careful comparison of dusts and sprays could not be made. In one test on Mexican weed made before flooding, where 2,4-D was sprayed on the plants, 88 per cent were killed as compared to only 75 per cent with the dust. On the other hand, in another test made two weeks after flooding, only 36 per cent of the plants were killed with the spray as compared to 75 per cent with a dust with an acid content of 10 per cent. In each of these tests, however, approximately twice as much 2,4-D was applied in the dust as in the spray.

Both sprays and dusts gave satisfactory control, but in the limited number of tests made, dusts were more effective than sprays in the control of curly indigo.

Yield data were not secured in most plots in which indigo and curly indigo were the principal weeds, since these weeds were eventually pulled or treated in the control plots in order to prevent seeding. However, in one test on the Daughenbaugh farm near Lake Charles, in which indigo

Figure 6.—Effect on curly indigo of two applications of 2,4-D dust made three weeks apart on Pierce farm at Morse, Louisiana. Untreated area in background.

Comparative Effectiveness of Sprays and Dusts
was relatively abundant, in plots treated June 7 with a 10 per cent dust all plants were killed. The entire field was dusted by plane the middle of August and most of the indigo in the field was killed. Yield data gave an average of 14.9 barrels per acre for the plots treated June 7, and 9.0 barrels for the control plots. Since growers are well aware of the damage that indigo may cause in rice fields, yield data on the effect of this weed did not seem as important to obtain as with Mexican weed.

The increase in yields that may be expected from the control of Mexican weed is of vital importance to the grower, since in the past he has been unable to evaluate the damage that it caused. This is because rice is able to compete to some degree with this weed. The results of yield tests carried out on nine farms are given in Table 2. The increases in yield from the control of Mexican weed varied from 1.4 barrels per acre on the Lyons farm, where the weed infestation was very light, to 12.0 barrels per acre on the Thevis farm, where the weed infestation was heavy. In several tests made late in the season, the weeds were not killed but their growth was retarded somewhat by the 2,4-D treatment. Small increases in the yields of the treated plots were secured, but the increases were not sufficient to justify a late treatment. In one test in which there was both heavy grass and Mexican weed infestation, the control of the Mexican weed with 2,4-D actually resulted in a decrease in yield. In this case the temporary stunting induced in rice by the 2,4-D probably enabled the grass to outgrow the rice.

**Airplane Applications of 2,4-D**

The first application of 2,4-D on rice by plane in Louisiana was made May 28, 1946, on the farm of M. O. Marquette, Jeanerette. This consisted of two tests. In test one, a field of the Bluebonnet variety was dusted three days prior to flooding with a dust containing 2 1/2 per cent of the 2,4-D acid at the rate of approximately 15 pounds per acre. The second test was made in a field of the Zenith variety about two weeks after flooding. In this test a 23 per cent dust was applied at the rate of

<table>
<thead>
<tr>
<th>Location of test</th>
<th>Parish</th>
<th>Variety</th>
<th>Yield in bbls. (^1) per acre</th>
<th>Difference in bbls. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Zaunbrecher</td>
<td>Acadia</td>
<td>Zenith</td>
<td>7.6</td>
<td>+ 6.8</td>
</tr>
<tr>
<td>J. Heinen</td>
<td>Acadia</td>
<td>Fortuna</td>
<td>9.5</td>
<td>+ 1.8</td>
</tr>
<tr>
<td>O. L. Pollangue</td>
<td>St. Landry</td>
<td>Fortuna</td>
<td>10.0</td>
<td>+ 2.7</td>
</tr>
<tr>
<td>G. Lyons</td>
<td>Jefferson Davis</td>
<td>Blue Rose</td>
<td>11.7</td>
<td>+ 1.4</td>
</tr>
<tr>
<td>P. J. Thevis</td>
<td>Acadia</td>
<td>Texas Patna</td>
<td>5.9</td>
<td>+ 12.0</td>
</tr>
<tr>
<td>L. B. Lawson</td>
<td>Acadia</td>
<td>Rexoro</td>
<td>10.7</td>
<td>+ 4.8</td>
</tr>
<tr>
<td>R. Andrus</td>
<td>Acadia</td>
<td>Rexoro</td>
<td>9.5</td>
<td>+ 3.9</td>
</tr>
<tr>
<td>C. P. Dugal</td>
<td>St. Landry</td>
<td>Rexoro</td>
<td>10.3</td>
<td>+ 6.4</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td><strong>9.4</strong></td>
<td><strong>5.0</strong></td>
</tr>
</tbody>
</table>

\(^1\)One barrel is 162 pounds of rough rice, or 3.6 bushels.
10 pounds per acre. The weed control was determined by staking off four one-square-yard plots in each test and making weed counts in these blocks at the time of treatment and approximately four weeks later.

The results showed that in the test with the $2\frac{1}{4}$ per cent dust applied prior to flooding, the alligator weed was not controlled, but Mexican weed and curly indigo were controlled in areas in which there was good water coverage. In the test with the 23 per cent dust applied after flooding, there was excellent control of alligator weed, Mexican weed and indigo. On the other hand, only about 50 per cent of the curly indigo plants were killed. It should be pointed out that in the test made prior to flooding there was less than half a pound of 2,4-D dust in the 15 pounds of $2\frac{1}{4}$ per cent dust applied per acre. This is probably the reason for the poor results on the alligator weed.

Additional tests were made June 5 and June 27 on Mexican weed in the Crowley area. In these tests a 10 per cent dust applied at the rate of 10 pounds per acre was used. The weeds were 12 to 15 inches in height at the time of treatment. The results showed that Mexican weed could not be controlled when treated at this stage of development.

Following the success of the initial dusting, approximately 3,000 acres of rice were treated in Louisiana by plane. In most applications a 10 per cent dust was applied at the rate of 10 pounds per acre. However, some 15 per cent dust was used. Most fields were treated at a time when the indigo was quite large and during a period of very frequent rains. In a number of instances rain followed a few hours after treatment.

Observations showed that indigo was killed in most fields, but that Mexican weed and curly indigo were not. Instances of poor kill of indigo could be accounted for either from poor coverage with the dust or from rain following too closely after treatment. Mexican weed and curly indigo, while severely affected, usually recovered in about three weeks. Several fields were treated shortly after flooding and in these fields relatively good control of Mexican weed and curly indigo was obtained.

**Means of Application**

The most economical means of treating fields is by plane, and agencies equipped to treat considerable acreage are now available in the area. The cost of application usually runs around six cents per pound. With an application of ten pounds to the acre the cost would be 60 cents. The present planes are equipped to apply dust, but should sprays be found more suitable they could easily be changed over. However, there are areas of localized weed infestation that will not justify application by plane. Also, there are fields in which the drift from planes would endanger nearby cotton, sweet potatoes, vegetables and shrubs.

A small hand duster is suitable for small areas and for the control of weeds on levees, ditches and canals. Hand sprayers may be used also but are much more laborious to use than hand dusters.

There are a number of different power dusters and sprayers that can be adapted for use in rice fields. However the power sprayer that
uses the conventional rate of 100 gallons of spray per acre does not seem suitable because of its size, weight and the amount of water that is required. One of the newer developments in power sprayer equipment is a machine from which one may get good coverage with only 5 to 6 gallons of spray per acre. A spray concentrate could be used in such a machine, and while it has not been tried on rice, there seems no reason why it should not be effective.

**Discussion**

While there is little question concerning the effectiveness of 2,4-D in the control of certain rice weeds, further investigations are necessary to determine the comparative effectiveness of the various 2,4-D compounds and the best means of applying them. Further information on the injurious effect of 2,4-D on rice and on possible means of lessening this injury must be obtained. It should be pointed out that flooding still remains the basic method for the control of grasses and other weeds, and that adequate water coverage is essential to good control of weeds with 2,4-D.

In order to control Mexican weed it is necessary that the weeds be treated when the plants are quite small. This is either before flooding or within one to two weeks after flooding. At this stage rice is injured to some degree and hence care should be exercised that an overdose of the chemical is not applied. This is especially true in treating before the initial flooding. Heavier dosages may be used after the rice plant has developed a good water root system. In spite of some injury to seedling rice the increases in yield obtained from the control of such weeds as Mexican weed are so marked as to make 2,4-D treatments advisable. On the other hand, it is questionable if treatment should be made where a heavy growth of grass is present which has not been controlled by flooding. There is also the possibility that the weed infestations may be cleaned up following several years of treatment. It is not known how long the seed of the various weeds will stay viable in the soil, but with no new crops of seed being produced it may be possible to reduce the weed infestation to the point where treatment would no longer be necessary.

The ease of control of indigo is such that the principal question is whether or not it can be treated with 2,4-D more economically than it can be pulled by hand. Curly indigo, on the other hand, presents more of a problem. The initial tests indicate that it is best treated when small and that two applications of 2,4-D are necessary for effective control. It may be found that a heavier dosage or that some 2,4-D compound other than the ones tried will prove more effective in the control of this pest. Since indigo is a legume, there is the possibility that nitrogen is made available to the rice plants when it is killed.

The cost of 2,4-D treatments, to a large degree, is the cost of the materials. The price of 2,4-D will probably decrease as the production increases.

The minimum dosage for most weeds is one pound of 80 per cent
2,4-D per acre. This dissolved in 100 gallons of water gives a concentration of 1,000 parts per million. Since the materials available for the most part vary between 60 and 80 per cent of 2,4-D, proportionately increased amounts will have to be used with materials containing less than 80 per cent to get the above equivalent. In the case of dusts the 2,4-D content is usually given in terms of percentage of 2,4-D by weight.

There are additional problems in weed control that hold promise for the future. One of these is to find a material at low cost that can be applied to the soil and will kill all weed seeds, including those of the grasses and red rice, and that will be dissipated in time to permit planting rice a short time after treatment. This may be possible with 2,4-D since it is very lethal to all germinating seed and does not show the differential action on germinating seed that it does when applied to growing plants. Another possibility is the promise of a general herbicide that will control all weeds and grasses in canals and drainage ditches.

**Recommendations**

**Dust.** Use 10 pounds of a 10 per cent dust per acre 1 to 3 days before flooding. After rice has been flooded or after a maximum emergence of weeds in non-flooded areas, such as on levees, use 10 to 15 pounds of a 10 per cent dust or 10 pounds of a 15 per cent dust.

**Spray.** Use at the rate of 14 ounces of pure 2,4-D per 100 gallons of water per acre. This requires one pound of an 80 per cent, 1 1/4 pounds of a 70 per cent and 1 1/2 pounds of a 60 per cent material. Because of the injury to rice, the minimum rate should be used in treatments before flooding; but the rate may be increased in treatments made after flooding.

**Caution.** Equipment used with 2,4-D should not be used later for applying insecticides and fungicides on vegetables. It is almost impossible to clean equipment sufficiently for that purpose. Care also must be taken to see that the spray or dust does not drift to fields where extremely sensitive plants such as cotton, sweet potatoes, beans and tomatoes are growing. However, 2,4-D is not toxic to man, livestock or fish.

Do not treat after rice has headed.

**Mexican weed.** Treat previous to flooding or within two weeks after flooding. If treated before flooding, follow within 1 to 3 days with a good coverage of water. If treated after flooding, the water should be shallow in order to permit coverage by the herbicide of the weeds that are too short to stick out of a deep flooding. Follow with good water coverage. If this is not possible, treat when maximum weed emergence has occurred. The same procedure should be followed in treating weeds on levees. Do not treat if there is a heavy growth of grass that cannot be controlled by the water.

**Indigo.** Treat at any time, but preferably while the plants are still relatively small.

**Curly indigo.** Treat preferably when plants are small. Make a sec-
ond application 3 to 4 weeks after the first one when plants begin to recover.

**Other weeds and sedges.** The same as for Mexican weed.

**Summary**

The results of tests with 2,4-D in the control of certain broad-leaf rice weeds are reported.

A spray at a concentration of 1,000 parts per million applied at the rate of 100 gallons per acre and both a 10 per cent and a 15 per cent dust applied at the rate of 10 to 20 pounds per acre gave effective control.

Mexican weed was controlled and the yield of rice substantially increased when treatments were made just before or within two weeks after flooding.

Indigo was effectively controlled at all stages of development.

Curly indigo was best controlled when young and usually required two applications about 3 weeks apart. Dusts were more effective than sprays.

Recommendations for the control of the various weeds are given.