BENAZOLIN FOR SELECTIVE WEED CONTROL IN WHEAT AND
OILSEED CROPS

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ABSTRACT

In field tests conducted between 1963 and 1969, wheat, *Triticum aestivum* L., flax, *Linum
usitatissimum* L., Argentine rape, *B. assica
napus* L., and Polish rape, *B. campestris* L.,
were tolerant to benazolin (4-chloro-2-oxo-3-
benzothiazolineacetic acid). Wild mustard,
*Sinapia arvensis* L., and redroot pigweed,
*Amaranthus retroflexus* L., were controlled.
Control of other weeds encountered in these
tests was usually unsatisfactory. There was
sufficient difference in tolerance of wild mus­
tard and both species of rape to make selec-
tive control possible. In years when growing
conditions were favorable, benazolin gave
good control of wild mustard in rape at 0.56
kg/ha. When crop stands were poor due to
dry, unfavorable weather a rate of 0.84 kg/ha
was required. This sometimes caused light but
visible injury to the rape, although crop yields
were not significantly reduced. The selective
properties of benazolin may make it possible
to grow rape on land infested with wild musta:d.

INTRODUCTION

In 1970, over 1.5 million hectares of rape were grown on the Canadian prairies. Rapeseed is not extensively grown on the fine textured soils (Downey and Bolton, 1961) of the Dark Brown and Brown soil zones of the prairie provinces. Part of the reason for this is that wild mustard is a common weed on these soils. The seeds of wild mustard cannot be separated from rapeseed, and adversely affect the quality of the rapeseed oil. Commercial rape will grade “Rejected” if it contains 1% wild mustard. A method of controlling wild mustard in rape would remove one of the hazards of extending the rape production area.

Benazolin (4-chloro-2-oxo-3-benzothiazolineacetic acid) is extremely active against certain weeds such as chickweed [*Stellaria media* (L.) Cyrill.] and cleavers (*Galium aparine* L.) (Brooks and Leafe, 1963; Leafe, 1964). In England the kale and clover crops are relatively tolerant.

In 1963, the tolerance of wheat (*Triticum aestivum* L.) and flax (*Linum
usitatissimum* L.) to benazolin was tested at Regina. A few wild mustard plants
in the plots were killed. This observation, and the knowledge that kale was quite
tolerant, suggested that it might be a useful herbicide in western Canada, particularly
if it could be used to control wild mustard in rape.

This paper reports on experiments on control of weeds in oilseed crops and
in wheat with benazolin. The tests were conducted in Saskatchewan, Manitoba
and Alberta under a wide range of growing conditions.

MATERIALS AND METHODS

Five experiments were conducted at Regina from 1963 to 1967 on Regina heavy
clay soil which has been described previously (Ellis et al., 1965). Treatments in
the field tests were replicated four times on plots 2 x 5 m arranged in a randomized
block design. The benazolin was mixed with water and applied as a foliage spray.
Spray volumes in the Regina field tests were 47 liters/ha (5 gal/acre) in 1963,
and 94 liters/ha (10 gal/acre) in succeeding years.

Two experiments were conducted in Manitoba, one at Starbuck in 1965 and
another at Westbourne in 1969. Both were on clay loam soil on plots 2 x 5 meters

Table 1. Yield of Pembina wheat, Marine flax and control of wild mustard after treatment with benazolin, Regina, 1963

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Control of wild mustard 0-9*</th>
<th>Crop yields, g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wheat</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>244</td>
</tr>
<tr>
<td>0.28</td>
<td>9</td>
<td>257</td>
</tr>
<tr>
<td>0.56</td>
<td>9</td>
<td>248</td>
</tr>
</tbody>
</table>

*0 = no control, 9 = complete kill.

in size and treatments were not replicated. The spray volume for these trials was 47 liters/ha.

Eleven other demonstration trials, scattered throughout Manitoba, Saskatchewan and Alberta, were conducted in 1969. These trials were on plots 0.4 hectares in size and treatments were not replicated. The spray volume for these trials was 47 liters per hectare.

The weed control and crop tolerance scores (0-9) used in some of the tables are based on both stand reduction and suppression of growth. Crop cultivars, rates of herbicide application, weed growth, and growing conditions varied from year to year and are given with the results.

RESULTS

Plot trials

TEST 1. The tolerance of Pembina wheat and Marine flax to benazolin was tested at Regina in 1963. Benazolin was applied at 0, 0.28 and 0.56 kg/ha to the wheat and flax on relatively weed-free land, to determine their tolerance to the herbicide when the wheat was in the tillering stage and the flax was 5 to 9 cm tall. The weather was favorable for good crop growth. There were a few wild mustard plants in the plots in the small rosette stage, and these were killed by the treatments (Table 1). No injury due to the herbicides was observed on either crop.

TEST 2. Benazolin was tested for control of weeds in Selkirk wheat and Redwood flax at Regina in 1964. The wheat and flax were sown on land containing natural infestations of various weeds including wild mustard, wild buckwheat (*Polygonum convolvulus* L.), redroot pigweed (*Amaranthus retroflexus* L.) and lamb's-quarters (*Chenopodium album* L.), in order to confirm crop tolerance and to observe susceptibility of the weeds. Growing conditions were favorable for crop growth.

Table 2. Control of weeds and yield of Selkirk wheat treated with benazolin, Regina, 1964

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Control of wild buckwheat 0-9*</th>
<th>Dry weight all weeds g/m²</th>
<th>Yield of wheat g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July 6</td>
<td>Aug. 12</td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>0</td>
<td>4.5 a</td>
</tr>
<tr>
<td>0.56</td>
<td>4</td>
<td>0</td>
<td>3.27 ab</td>
</tr>
<tr>
<td>0.84</td>
<td>6</td>
<td>3</td>
<td>1.85 b</td>
</tr>
</tbody>
</table>

*a = no control, 9 = complete kill.

a-b Means followed by the same letter are not significantly different (P = 0.05).
Table 3. Control of weeds and yields of Redwood flax treated with benazolin, Regina, 1964

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Number of weeds/m²</th>
<th>Yield of flax g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild mustard</td>
<td>Redroot pigweed</td>
</tr>
<tr>
<td>0.00</td>
<td>32.2 a</td>
<td>61.2 a</td>
</tr>
<tr>
<td>0.56</td>
<td>2.7 b</td>
<td>8.8 b</td>
</tr>
<tr>
<td>0.84</td>
<td>0.7 b</td>
<td>11.0 b</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not significantly different (P = 0.05).

There were too few weeds in the wheat to have a significant effect on crop yields. The wheat was sprayed at the five-leaf stage when the weeds had from three to six leaves. Weed counts were not taken, but dry weight of the weeds was determined at maturity. Visual appraisals indicated that wild buckwheat, the predominant weed, recovered considerably from initial injury and the control was not considered to be satisfactory (Table 2). There was a significant reduction in dry weight of all weed species from the high rate of application. Differences in wheat yields were not significant.

Weeds were more numerous in the flax plots than in the wheat plots. The flax was 7 to 8 cm high when sprayed. The wild mustard and stinkweed were in the rosette stage, and most of the wild buckwheat and redroot pigweed plants were at the four-leaf stage. Plant counts at maturity indicated that satisfactory control of wild mustard and redroot pigweed was obtained with 0.56 kg/ha, and wild buckwheat with 0.84 kg/ha. Stinkweed (Thlaspi arvense L.) and lamb's-quarters were not controlled. The increases in yields of flax were not significant (Table 3).

TEST 3. At Regina, in 1964, benazolin was applied at 0.56 and 0.84 kg/ha to the Arlo cultivar of Polish rape (Brassica campestris L.) at the four- to six-leaf stage in a test for tolerance. No crop injury was apparent. There were too few weeds in this test to give information on weed control. Rapeseed yields for the plots receiving 0, 0.56 and 0.84 kg/ha were 139, 146 and 144 g/m², respectively.

TEST 4. Control of weeds in Tanka rape with benazolin was examined at one Manitoba site, Starbuck, in 1965. Benazolin was applied at 0.56 and 0.84 kg/ha when this cultivar of Argentine rape (Brassica napus L.) was 20 to 25 cm high and the weeds were 13 to 15 cm high. Growing conditions were favorable. Control of wild mustard and stinkweed was satisfactory, but control of wild buckwheat and lady's-thumb (Polygonum persicaria L.) was not. The rape was tolerant to benazolin at both rates (Table 4).

Table 4. Control of weeds in Tanka rape with benazolin, Starbuck, 1965

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Weed control, 0-9*</th>
<th>Crop tolerance 0-9†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild mustard and stinkweed</td>
<td>Wild buckwheat and lady's-thumb</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.56</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>0.84</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

*0 = no control, 9 = complete kill.
†0 = no tolerance, 9 = complete tolerance.
Table 5. Tolerance, heights and yields of rape treated with benazolin in field trials, Regina, 1966

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Echo rape</th>
<th>Tanka rape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tolerance 0-9*</td>
<td>Height cm</td>
</tr>
<tr>
<td>0.00</td>
<td>9.0</td>
<td>58 a</td>
</tr>
<tr>
<td>0.56</td>
<td>8.5</td>
<td>53 ab</td>
</tr>
<tr>
<td>0.84</td>
<td>8.0</td>
<td>50 b</td>
</tr>
</tbody>
</table>

*0 = no tolerance, 9 = complete tolerance.
a–b Means followed by the same letter are not significantly different (P = 0.05).

TEST 5. Echo and Tanka rape were tested for tolerance to benazolin in field trials at Regina in 1966. The rape cultivars were sprayed with benazolin at 0, 0.56 and 0.84 kg/ha to get additional information on crop tolerance. The rape was in the three- to five-leaf stage when sprayed. The growing season was drier than usual, and yields were relatively low. There was light initial injury to both cultivars, evident mainly in retardation of growth. Blossoming was delayed about a day with the highest rate of application, and this treatment also reduced the height of Echo rape by 8 cm. Dry spring weather gave an uneven stand of rape, and although average yield reductions were quite large from the high rate of herbicide application, they were not statistically significant (Table 5).

TEST 6. In 1967, at Regina, wild mustard was mixed with Echo and Tanka rape before seeding in order to ensure a weed infestation in the crops. Due to dry weather for several weeks after seeding, emergence of the rape was only about 50%, and crop yields were low. Wild mustard emergence was also relatively light and uneven. Benazolin was applied at 0, 0.56 and 0.84 kg/ha when the wild mustard had four leaves, the Tanka rape had five leaves and the Echo rape was slightly further advanced. Visual estimates of wild mustard control, based on both kill and suppression, were 52% from the light rate and 87% from the heavy rate of application. Echo rape appeared to be a little more susceptible to injury than Tanka, as indicated by a delay in blossoming and reduction in seed yields. However, these differences were small and not significant (Table 6).

TEST 7. Control of broad-leaved weeds in rape with benazolin was tested at the other Manitoba site, Westbourne, in 1969. Benazolin was applied to Target Argentine rape infested with wild mustard, lamb's-quarters and stinkweed. The rape was in the five- to six-leaf stage and the weeds had four to six leaves. The herbicide was applied at 0, 0.56 and 0.84 kg/ha. Growing conditions were good.

Table 6. Control of wild mustard and yields of rape treated with benazolin, Regina, 1967

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Control of wild mustard 0-9*</th>
<th>Echo rape</th>
<th>Tanka rape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days to blossom</td>
<td>Yield g/m²</td>
<td>Days to blossom</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>42.5</td>
<td>16.6</td>
</tr>
<tr>
<td>0.56</td>
<td>5</td>
<td>44.0</td>
<td>16.2</td>
</tr>
<tr>
<td>0.84</td>
<td>8</td>
<td>46.0</td>
<td>12.8</td>
</tr>
</tbody>
</table>

*0 = no control, 9 = complete kill.
Table 7. Control of weeds and yields of Target rape treated with benazolin, Westbourne, 1969

<table>
<thead>
<tr>
<th>Rate of application kg/ha</th>
<th>Wild mustard</th>
<th>Lamb's-quarters</th>
<th>Stinkweed</th>
<th>Yield of rapeseed g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00·</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>103</td>
</tr>
<tr>
<td>0.56·</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>129</td>
</tr>
<tr>
<td>0.84·</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>103</td>
</tr>
</tbody>
</table>

*0 = no control, 9 = complete kill.

The treatments gave good control of wild mustard at both rates, but not of lamb's-quarters and stinkweed (Table 7).

Field trials

Field trials with benazolin for weed control in Argentine and Polish rape were made on farmers' fields at 11 locations in the rape-growing areas of Manitoba, Saskatchewan and Alberta in 1969. Rates of 0, 0.56 and 0.84 kg/ha were applied to unreplicated plots, 0.4 hectare in size. Observations on crop tolerance and weed susceptibility were made.

In general, rape was tolerant at both rates of application. There was no appreciable delay in maturity. However, at three locations, benazolin at 0.84 kg/ha caused some reduction in the height of the crop. This injury was associated with drought, uneven germination and unfavorable growing conditions.

Control of lamb's-quarters and stinkweed which were present in all locations was not satisfactory. Control of redroot pigweed, which was also present in all locations, was fair. Of the less frequently encountered weeds, ball mustard [*Neslia paniculata* (L.) Desv.] and green foxtail [*Setaria viridis* (L.) Beauv.] were not controlled. Control of wild buckwheat (*Polygonum convolvulus* L.) and topgrowth of dandelion (*Taraxacum officinale* Weber) was fair.

In two field trials, wild mustard and Canada thistle [*Cirsium arvense* (L.) Scop.] were predominant weeds, and control was 90 to 100% for wild mustard and 77 to 90% of topgrowth for Canada thistle.

DISCUSSION

Wheat, flax and rape were tolerant to benazolin at rates required to control certain weeds. Wild mustard and redroot pigweed were present in most tests and these were consistently controlled. Stinkweed and lamb's-quarters were also present in most tests, but control of these and other annual weeds was generally unsatisfactory. The susceptibility of Canada thistle to the herbicide should be confirmed with additional experiments. The possibility of mixing benazolin with other herbicides to broaden the spectrum of weeds controlled should also be explored.

The difference in susceptibility of wild mustard and rape to benazolin was enough to make selective control possible. In years when growing conditions were favorable for rape, 0.56 kg/ha gave good control (Tables 1, 3, 4, 7). When crop stands were poor, due to dry, unfavorable weather conditions, 0.84 kg/ha was required (Table 6).

The control of wild mustard in rape is important from the standpoint of the quality of the rapeseed oil produced, as well as from its competitive effects on
crop yields. This makes it doubly important to control wild mustard even at the expense of some crop injury. These tests indicate that under good growing conditions the wild mustard could be controlled with 0.56 kg/ha.

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LITERATURE CITED