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Title: EFFECT OF TIMING AND RATE OF METRIBUZIN ON WHEAT AND BARLEY CULTIVARS AND ON ITALIAN RYEGRASS

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A field study was conducted in 1973 and 1974 to determine optimum timing of metribuzin (4-amino-6-*tert*-butyl-3(methylthio) *as*-triazine-5(4*H*)one) on winter wheat (*Triticum aestivum* L. 'Hyslop') for control of Italian ryegrass (*Lolium multiflorum* Lam.). Herbicide treatments were applied at 5 different stages of growth of winter wheat. Metribuzin at 0.56 kg/ha applied in December at the three to four tiller stage gave the best combination of high wheat yields and excellent ryegrass control. Preemergence and early postemergence treatments caused more wheat injury than later applications. Poor ryegrass control was obtained from April treatments.

The objective of the greenhouse experiments was to compare the responses of wheat and barley cultivars to metribuzin. Experiments were conducted either in the greenhouse or in growth chambers. Wheat cultivars were Hyslop, McDermid, Wanser, Paha, and Yamhill.

Kamiak and Hudson were the barley cultivars. Metribuzin was applied at the two-leaf stage at rates ranging from 0.11 kg/ha to 1.68 kg/ha.

Within barley cultivars, Kamiak tended to be more tolerant to metribuzin than Hudson.

The relative sensitivity of the five wheat cultivars varied between experiments but three of the cultivars, Paha, Wanser, and Yamhill tended to be less susceptible than Hyslop and McDermid.

Under the conditions of higher light intensity and higher temperature, barley cultivars were found to be significantly less susceptible to metribuzin injury than wheat cultivars.

Effect of Timing and Rate of Metribuzin on Wheat and Barley Cultivars and on Italian Ryegrass

by

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EFFECT OF TIMING AND RATE OF METRIBUZIN ON WHEAT AND BARLEY CULTIVARS AND ON ITALIAN RYEGRASS

INTRODUCTION

Italian ryegrass (*Lolium multiflorum* Lam.) is the most serious annual weed problem in winter wheat in western Oregon. Workers at Oregon State University have measured as many as 130 plants per square meter in research plots. Much higher densities are common in growers' fields.

Two chemicals are registered for ryegrass control in winter wheat; diuron and linuron. The main problems with these herbicides are:

1. If winter wheat is seeded in a dry seedbed, applications must be delayed until rain settles the soil.
2. Application to ryegrass beyond the tillering stage of growth, generally results in reduced ryegrass control or failure.
3. If ryegrass population is high these herbicides are not very effective.
4. The seedbed should be clean, smooth, firm, and clod-free.
5. Seeding depth is important for herbicide application. Wheat seeded less than 2.5 cm deep is more susceptible to injury.

The present method of controlling ryegrass in winter wheat has suppressed the ryegrass populations, but improved control is needed.

In the 1973 crop year, metribuzin showed excellent performance in controlling ryegrass in winter wheat in western Oregon. However, wheat injury has been reported from metribuzin treatments (5). With these results in mind, a field trial was established in 1973 to determine the effect of timing of metribuzin on yield of winter wheat and control of Italian ryegrass. Greenhouse and growth chamber studies were conducted to find out the differential response of wheat and barley cultivars to metribuzin injury.

LITERATURE REVIEW

Ryegrass - Winter Wheat Competition

Italian ryegrass (*Lolium multiflorum* Lam.), while an important seed crop, is also a serious weed in winter wheat fields in western Oregon and Washington. Any practices or treatments that can be made to reduce ryegrass populations are highly beneficial. Even if ryegrass control is not complete, reductions in populations are still highly advantageous (4).

If a field is known to be heavily infested with ryegrass seed, chances of yield loss are reduced by selecting a tall wheat variety. The addition of high levels of nitrogen fertilizer is not advisable under such conditions. The ryegrass responds to the nitrogen fertility as much or more than does the wheat (4).

Results of a competition study (3, 4) indicated that ryegrass populations of about 1 plant per square foot can reduce wheat grain yields by an average of 4.1 bushels per acre. So, extra costs may be feasible in striving toward complete ryegrass control.

Studies at Oregon State University showed a decrease in 1000 - seed weights of wheat as ryegrass density increased. The flour protein percentage increased as yields were reduced from competition (3). Both stand count data and yield data showed that failure to control a ryegrass problem one year can result in a continuing problem the following year unless control measures are applied (3).

Ryegrass Control in Winter Wheat

Diuron [3-(3,4-dichlorophenyl)-1,1-dimethylurea] and linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea] are standard herbicides used commercially for ryegrass control in winter wheat (8). Triallate [S-(2,3,3-trichloroallyl)diisopropylthiocarbamate]and barban [4 chloro-2-butynl m-chlorocarbanilate] are wild oat herbicides which are also effective against Italian ryegrass.

Wheat is tolerant of foliage applications of diuron and linuron made prior to the boot stage of growth. Application to ryegrass beyond the tillering stage of growth generally results in reduced ryegrass control or failure (8).

The standard treatment of 1.6 lbs a.i./A of diuron applied preemergence or early postemergence has proven to be highly beneficial to wheat yields over the past decade, but yield trials have shown that a considerable amount of yield is still lost because of incomplete ryegrass control from this treatment (5). It was found that the lower rates of diuron gave mediocre ryegrass control but grain yields were still 10 to 30 bu/A higher than the weedy check (5).

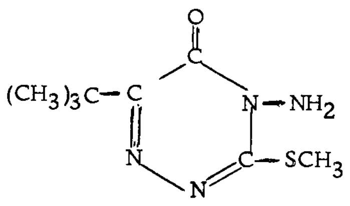
Aldridge, et al. (7) reported that the combination of diuron and CP 52223 for ryegrass control increased yields over either compound alone. Little difference was noted between the 0.8 lb a.i./A diuron plus 1.0 lb a.i./A CP 52223 treatment and the 1.5 lb a.i./A diuron plus 1.6 lb a.i./A CP 52223 treatment.

In a screening trial to evaluate new materials for control of weeds in winter wheat, promising results were seen from metribuzin applied postemergence at 0.5 lb a.i./A. This gave excellent ryegrass control. To keep the wheat injury to a minimum, 0.75 lb a.i./A of metribuzin appeared to be the maximum rate of application. Higher rates caused some severe thinning of the wheat (5).

Chemical Properties of Metribuzin

Metribuzin is a new asymmetrical triazine herbicide. It shows promise as a preemergence and postemergence herbicide for the control of many broadleaf and grass weeds in several crops.

Its chemical name is: 4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazine-5(4*H*) one. Its structural formula is:



Metribuzin is characterized by high water solubility (1200 ppm) (19).

It has been formulated as a 70% wettable powder, a 50% wettable powder, or various granules (15).

Agronomic Use of Metribuzin

Metribuzin is currently registered for use as a preemergence application to soybeans in the United States and as pre and postemergence applications to potatoes in Canada. Experimental uses, showing promise for early registration, are for selective weed control on sugarcane, tomatoes, corn, and alfalfa (15).

According to Velev and Elenkov (39), metribuzin applied to tomato at 0.5 kg/ha preemergence and at 0.5 to 0.75 kg/ha postemergence gave effective weed control without injuring the crop. It should be applied immediately after sowing. In transplants, metribuzin can be applied at 0.5 to 0.75 kg/ha before manual planting or after machine planting, depending on the soil type.

Fortino and Splittstoesser (16) reported that direct-seeded or transplanted tomatoes were more susceptible to injury when they were less than 10 cm tall. Metribuzin was more effective in controlling broadleaf weeds than grass weeds, but grass control was acceptable with higher rates. Ultraviolet light decomposed metribuzin and weed control was improved when it was incorporated into the soil after application.

Other metribuzin-tolerant crops include apple, citrus, grape, pear, and pineapple. Cole crops, cruciferous crops, onion, peas, strawberries, sugar beets, sunflower, sweet potatoes, cotton, and tobacco are sensitive (19).

Osgood (28) reported that metribuzin at 2 to 6 lb a.i./A has provided more effective broad spectrum weed control than standard treatments with ametryne in irrigated cane and diuron in non-irrigated cane.

A study (2) indicated that metribuzin can be used in winter wheat for control of both annual bluegrass (Poa annua) and Italian ryegrass. Both 5% a.i. granular and 70% a.i. wettable powder formulations resulted in 100 percent control of both weeds at rates of 0.50, 0.75, and 1.0 lbs a.i./A. Only the 1.0 lbs a.i./A rate of the granular formulation caused significant wheat injury.

Kukas, et al. (21) found that metribuzin at 3.0 lb a.i./A completely eliminated all weed species from winter wheat fallow ground, regardless of time of application.

Metribuzin is effective against annual grasses and numerous broadleaf weeds, including deep-rooted weeds such as cocklebur, velvetleaf, jimsonweed, coffeeweed, teaweed, and sickle pod (19).

Use of metribuzin as a combination treatment with a variety of other herbicides that are primarily effective against grass weeds resulted in broader spectrum weed control, more consistent weed control, and increased crop tolerance (11). Carter (11) found that combinations of metribuzin with alachlor and trifluralin gave good weed control in soybeans. Metribuzin (0.25 to 0.75 lb a.i./A) and alachlor (1.5 to 2.5 lb a.i./A) applied preemergence to the soil as a tank-mix combination provided control of 46 weed species - 12 more than alachlor alone, 7 more than metribuzin alone. In addition, crop tolerance was increased because of the reduced application rate of metribuzin.

Jones, et al. (20) studied combinations of trifluralin + metribuzin and found that weed control in soybeans was good to excellent at the rates of 0.5 + 0.25, 0.75 + 0.38, and 1 + 0.5 lb a.i./A on light, medium, and heavy soils, respectively. Minor soybean injury was observed at the seedling stage.

Addink, et al. (1) reported that trifluralin + metribuzin combinations did not affect emergence when applied preplant and soil incorporated. That application resulted in increased soybean yield compared to cultivated controls.

Metribuzin Behavior in Plants

Metribuzin is absorbed through the leaves when applied post-emergence to weeds but the major and significant route for uptake is via the root system. Uptake through the roots is best described as osmotic diffusion. Metribuzin is translocated upward and moves distally when applied at the base of leaves. Downward movement does not occur. It can be considered a systemic herbicide in terms of upward movement. The concentration of metribuzin is highest in roots, stems, and leaves and is lowest in fruits and seeds (19).

Blockage of the photosynthetic process may be the major mode through which metribuzin controls weed growth (19).

The major routes of detoxification are the action of sunlight, oxidation, and conversion to water-soluble conjugated products (33).

Metribuzin is used as a preemergence herbicide for soybeans. A study by Coble and Schrader (12) on tolerance of soybean to preemergence applications of metribuzin indicated that soybean tolerance to metribuzin is positional rather than physiological.

Soybean cultivars have been reported to range in tolerance to metribuzin from tolerant to susceptible (10,23). Smith and Wilkinson (37) indicated that the less susceptible variety metabolized more metribuzin in the root and stem tissue than the two more susceptible varieties.

Selective weed control with metribuzin has also been obtained on tomatoes. Phatak and Stephenson (31) found that metribuzin injury to tomatoes may be minimized if applications during or immediately after cloudy weather are avoided. In another study, Phatak (30) found that metribuzin caused severe injury to all plants shaded at different stages of growth. Yield reductions were commonly associated with severity of injury. There was no injury on nonshaded plants sprayed with metribuzin.

Many of the toxicity symptoms induced by metribuzin are similar to those induced by the s-triazine herbicides (17).

Fortino and Splittstoesser (17) reported that about 4 percent of the available metribuzin was absorbed by tomato leaves or roots and was translocated in the xylem. They also concluded that conditions which favored the absorption of metribuzin, such as high humidity or temperature damage to the leaf cuticle, or application of the chemical with a surfactant increased the susceptibility of tomato to metribuzin injury.

According to Stephenson, et al. (38), growth stage at the time of treatment is a major factor influencing the tolerance of tomato to metribuzin. Two varieties were very susceptible when treated at the sixth day but both were highly tolerant to metribuzin applied 24 days after germination. Fortino and Splittstoesser (17) reported that tomato plants 13 cm in height were less susceptible to metribuzin injury than plants 8 cm tall.

Similar to soybeans, tomato cultivars have also been reported to differ in their responses to metribuzin (6,9).

Metribuzin has shown promise for weed control in potatoes (25). According to Cohick (13), metribuzin is an excellent herbicide with a broad spectrum of activity for control of broadleaf weeds and some grasses. This activity is achieved with both preemergence and post-emergence applications. The application of metribuzin to potatoes generally shows excellent crop tolerance with both preemergence and postemergence treatment. However, some varietal differences have been noted. Varietal difference is most obvious from postemergence application and is dependent to a certain extent upon several factors including crop height, weather conditions, and soil type.

Freeman (18) reported that maturity and skin color are not necessarily correlated with tolerance to the herbicide. The weather conditions at the time of treatment appeared to have an effect on the amount of plant injury; spraying during cool, cloudy weather tended to increase foliage injury.

Phatak (32) observed that the most obvious visual symptoms of metribuzin injury were localized sunken areas in the leaves which turned chlorotic-necrotic with time. Symptoms were first evident 72 hours after spraying. Injury reached its maximum within 7-10 days after treatment. Plants shaded before and after treatment showed maximum foliar injury. Shading only after treatment also caused injury with slightly less injury from shading before treatment. In general, yields decreased with every increase in foliage injury. From a practical standpoint, Phatak's study indicates that metribuzin injury to potatoes from postemergence applications may be minimized if applications are made during sunny weather.

As with other crops, potato cultivars also differ in their responses to metribuzin (18).

According to Osgood and Hilton (29), metribuzin was selected in 1970 for outstanding preemergence and postemergence weed control in sugarcane. Crop resistance has been excellent with only the most sensitive varieties showing injury. Weed control results have been excellent in all climatic zones. In general, grasses were better controlled than broadleaves. Metribuzin appears to be absorbed easily through the roots of sugarcane but only with great difficulty through leaves. The herbicide appears to be metabolized in the plant to the non-phytotoxic DADK (deaminated diketo as-triazine). It is translocated with water mainly into the green leaves and is lost when the lower leaves drop off (26).

Nomura and Yauger (27) studied metribuzin on sugarcane. They found that 67% of the absorbed metribuzin from nutrient solution was translocated to the leaves, 2% remained in the seed, 26% was in roots, and 4% was in the stalk. The residue was concentrated in the leaves 1 month after application, but after 2 months, residues were lost with time by the abscission of old leaves.

Metribuzin Behavior in Soils

The persistence of metribuzin in soil is dependent upon several factors. The rate of breakdown of metribuzin has been shown to be altered by the soil type involved (24). Any soil condition which favors growth of soil microorganisms will increase rate of breakdown. Breakdown occurs fastest under aerobic conditions in the presence of sunlight (19).

Movement in runoff water does not contribute much to the loss of metribuzin but leaching loss can be of significance, especially in light-textured soils having little organic matter content (24).

In laboratory tests, 3.6 inches of water were required to leach metribuzin 1 inch in clay loam. With sandy loam, only 2.2 inches of water moved it 1 inch (19).

According to Savage (33), the relative movement of metribuzin in soil was not correlated significantly with soil organic matter content. On the other hand, Coble and Schrader (12) reported that soil organic matter, herbicide rate, and rainfall or irrigation after treatment greatly influenced tolerance of soybean to metribuzin. They also found that regardless of the rainfall regime, injury was more severe as herbicide rate increased and became less severe as organic matter level increased.

Sharom and Stephenson (35) reported that the addition of $CaCl_2$ increased the adsorption of metribuzin to all soils. Metribuzin was relatively mobile in mineral soils but was very immobile in the muck soils. Bioassay studies indicated that phytotoxicity of metribuzin also decreased with increasing organic matter content of the soil. Persistence of herbicidal activity in the field was shown to be dependent on leaching as well as on microbial degradation.

Nomura and Kameda (26) disagreed with several other workers. They concluded that adsorption of metribuzin was fairly low and did not vary much from soil to soil. Adsorption appeared not to be related to soil pH or organic matter content. Inexplicably, leaching was not excessive under high rainfall conditions.

In a study by Ladlie, et al. (22) metribuzin was applied at 0, 0.5, 0.75, and 1 lb a.i./A to sandy clay loam adjusted to the following pH ranges: 4.5 to 4.9, 5.0 to 5.4, 5.5 to 5.9, 6.4 to 6.9. Metribuzin at all rates reduced weed and corn population as pH increased. Both visual injury ratings and corn yields indicated an increase in corn injury as pH increased. Soybeans grown in the greenhouse at the same pH levels gave a similar response. Soybeans grown in soil and treated with metribuzin showed a pH-sensitive response with a reduction in dry weight per plant as pH increased. However, in sand culture there was no reduction in dry weight as pH increased. This study indicated that pH affects the binding or inactivation of metribuzin in the soil.

Waggoner, et al. (40) studied metribuzin degradation in mineral and muck soils under laboratory and field conditions. They reported that degradation metabolites are:

a) DA 6(1,1-dimethylethyl)-3-(methylthio)1,2,4-triazin-5-(4H)-one

b) DK 4-amino-6(1,1-dimethylethyl)-1,2,4-triazin-3,5(2H,4H)-dione, and

c) DADK 6-(1,1-dimethylethyl)-1,2,4-triazin-3,5-(2H,4H)-dione

Rates of degradation were increased by soil microorganisms, air, and light.

The biological activities of metribuzin and its DA, DK, and DADK metabolites were compared for cucumbers, corn, and cotton under greenhouse conditions. Metabolites were considerably less active than the parent compound, and can be considered biologically insignificant under field conditions.

According to Schmidt (34), the degradation of metribuzin is strongly influenced by photochemical processes but is not readily lost by vaporization. Chemical degradation is more rapid in light soils than in heavy soils.

Metribuzin would be expected to be lost rapidly from surface applications but not from soil where it is protected from light. Soil samples from fields treated with metribuzin at 20 lb/A contained 9 ppm on the day of application but only 0.05 ppm after 90 days. The losses were attributed to leaching, degradation, and possible volatilization (27).

Murphy, et al. (24) analyzed metribuzin-treated soils from the United States and Canada after the 1973 growing season. Only 7% showed bioassay detectable residues. High organic matter content and early sampling appeared to be the main determinants of these residues.

INFLUENCE OF TIMING OF METRIBUZIN ON WINTER WHEAT AND RYEGRASS

Materials and Methods

A field experiment was established at the Schmidt Research Farm near Corvallis in the fall of 1973. The objective of the trial was to determine effect of timing of metribuzin on winter wheat for control of Italian ryegrass (*Lolium multiflorum* Lam.).

The soil was a Woodburn silt loam (Table 1). A fine seedbed was prepared by conventional methods. The plot area was laid out in a split-plot design with five replications. Herbicide treatments were main plots and dates of application were subplots. Figure 1 shows the plot plan for this experiment. Individual plot size was 3.1 by 10 m. The experimental area was seeded to Hyslop winter wheat on October 10, 1973. Italian ryegrass was seeded separately from the wheat in a strip across the back of the plots on the same date.

Herbicide treatments were applied on October 10, October 25, November 20, December 10, and April 5 with a bicycle-wheel plot sprayer using water as the carrier. Table 2 shows the stages of growth of both wheat and ryegrass at the dates of application.

Visual evaluations of ryegrass control and crop injury were made prior to harvesting. A scale of 0 to 100% was used to estimate ryegrass control and crop injury. A zero rating indicated no visible

Table 1. Mechanical Analysis of a Woodburn Silt Loam, Schmidt Farm, Corvallis, Oregon.

Depth inches	Sand %	Silt %	Clay %	Organic Matter %	pH
0 - 7	8.96	69.99	21.05	3.00	5.4
7 - 13	8.56	64.24	27.20	1.85	5.7
13 - 19	8.40	62.79	28.81	----	5.8
19 - 26	6.16	56.81	37.03	----	5.9

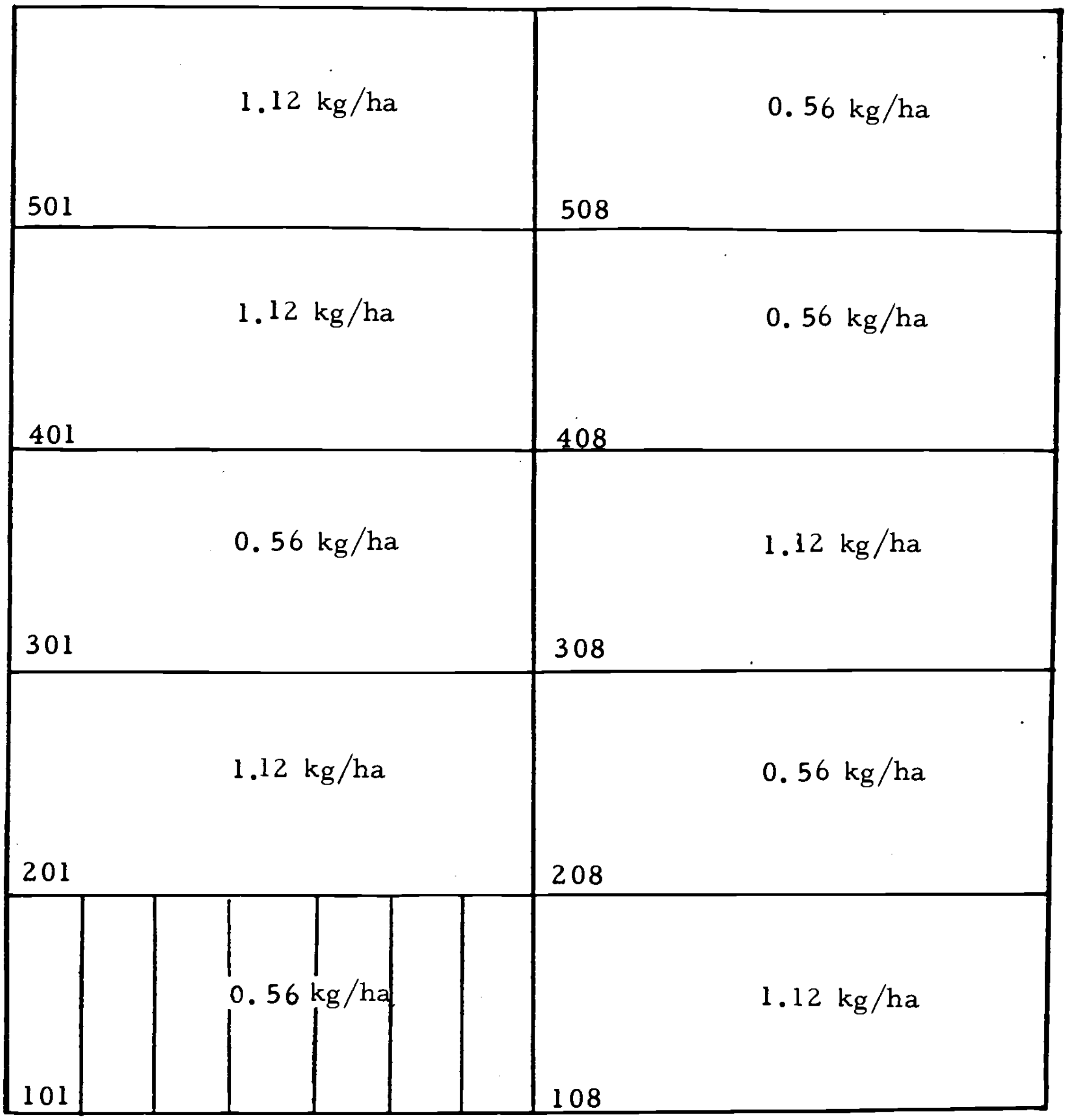


Figure 1. Plot diagram for Schmidt Farm experiment.

Table 2. Stages of Growth of Wheat and Ryegrass at the Dates of Application.

Dates of Application	Stages of Growth	
	Winter Wheat	Ryegrass
1. October 10, 1973	Preemergence	Preemergence
2. October 25, 1973	1 leaf, 5-10 cm tall	1 leaf, 2.5-7.5 cm tall
3. November 20, 1973	3 leaf-tillering	2-4 leaf, 5-10 cm tall
4. December 10, 1973	3-4 tillers	3 leaf-2 tillers, 10 cm tall
5. April 5, 1974	Early joint	Late tillering

reduction in stand or plant growth. A rating of 100 represents complete plant elimination. Fresh weights of ryegrass foliage were obtained by randomly placing a 0.84-sq meter quadrat and clipping the area with an electric hedge clipper on June 28, 1974. Winter wheat was harvested on July 29, 1974. Yield data were collected using a small plot combine with 1.2 m header. The harvested grain samples were cleaned and yield data were subjected to analysis of variance.

Results and Discussion

Metribuzin at 0.56 kg/ha applied in December at the three to four tiller stage (Figure 2) gave the best combination of high wheat yields and excellent ryegrass control (Figures 3, 4, 5, and 6). Yield results are presented in Table 3 and Appendix Tables 1 and 2. Grain yields from the 1.12 kg/ha metribuzin treatment were significantly lower than the yields from the 0.56 kg/ha rate of metribuzin (Figure 7).

Severe wheat injury was observed on March 22, at the higher rate, but the evaluation on June 26 generally showed less injury because of considerable crop recovery. Averages of visual evaluations of percent wheat injury are presented in Table 4 and Appendix Tables 3 and 4. Preemergence and first postemergence applications resulted in wheat injury varying from 15 to 37% at the June evaluation. The yields from 0.56 kg/ha at these two application dates were significantly different from the check but there were no statistically significant differences between yields from different application dates at the rate of 1.12 kg/ha.

In November, herbicide was applied to very wet soil. This was followed by extended heavy rainfall. Poor adsorption and leaching of the herbicide by heavy rainfall probably was the cause of poor ryegrass control from treatment at that date.

Winter Wheat   Italian Ryegrass

Figure 2. Stages of growth of wheat and ryegrass at the time of December application.

Figure 3. Check plot, Schmidt Farm - 1974.

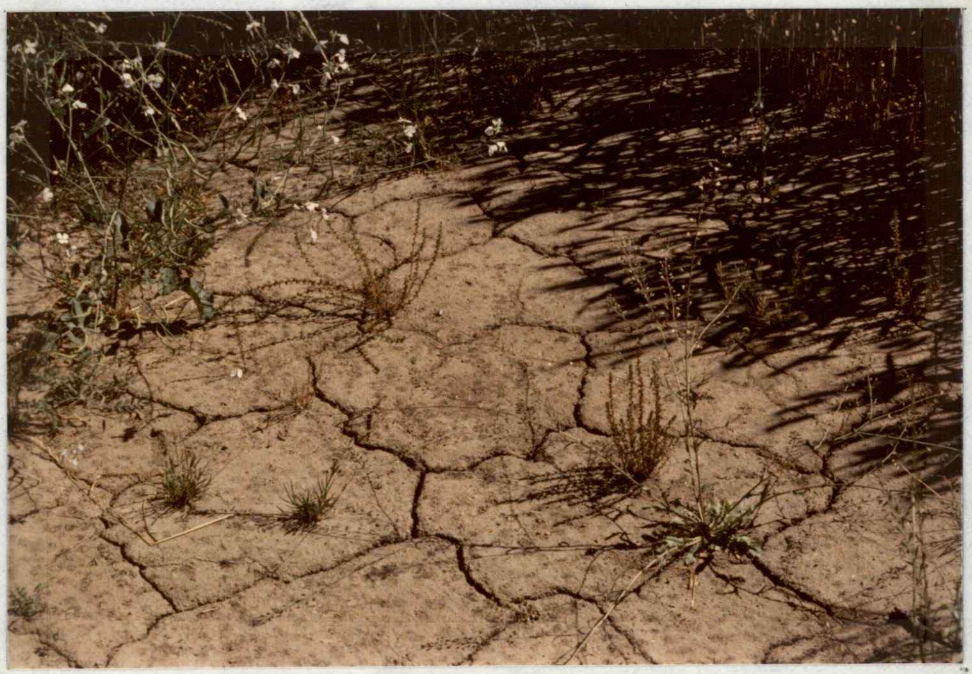


Figure 4. Italian ryegrass treated with 0.56 kg/ha metribuzin on December 10, Schmidt Farm - 1974.

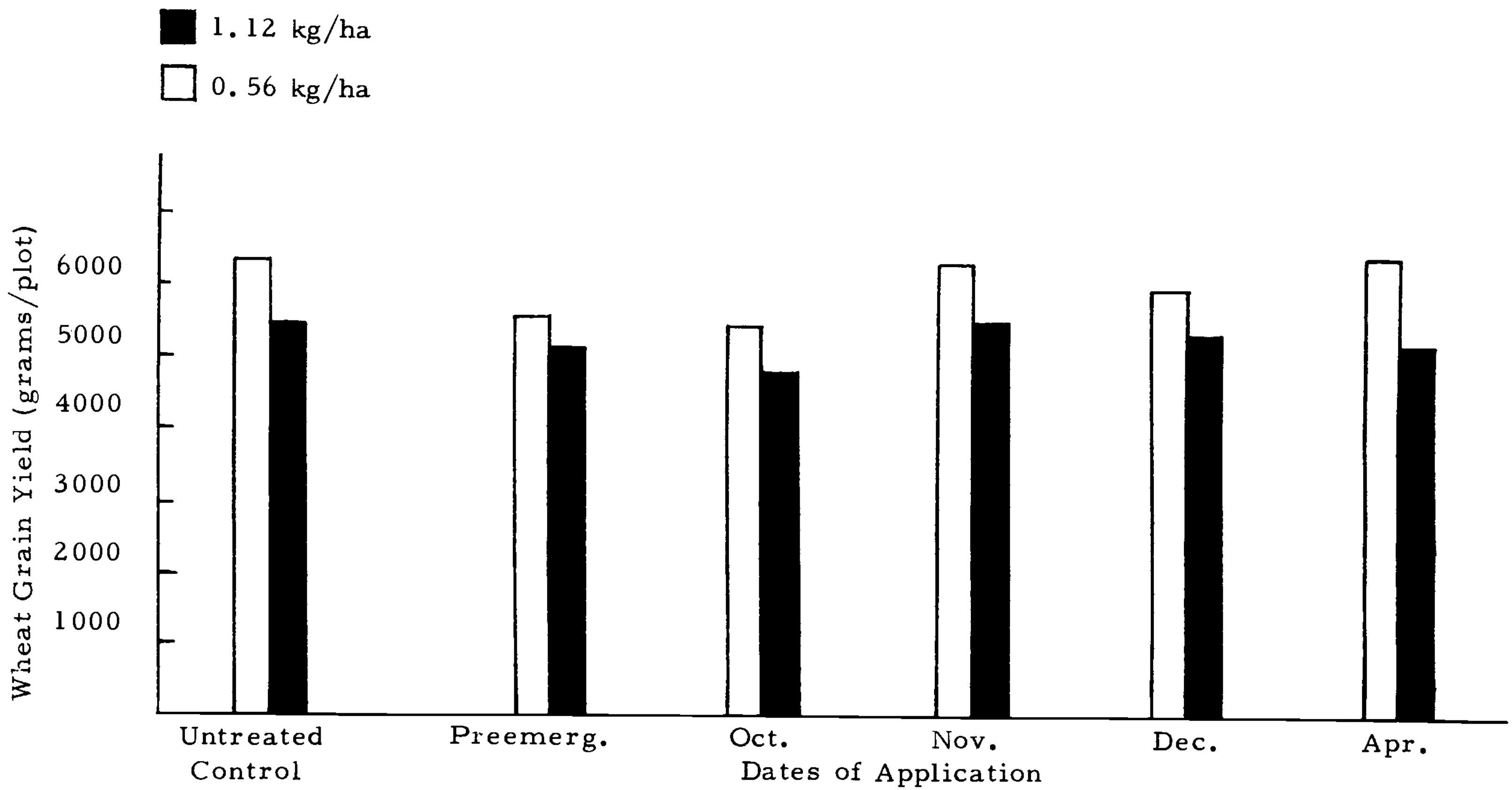
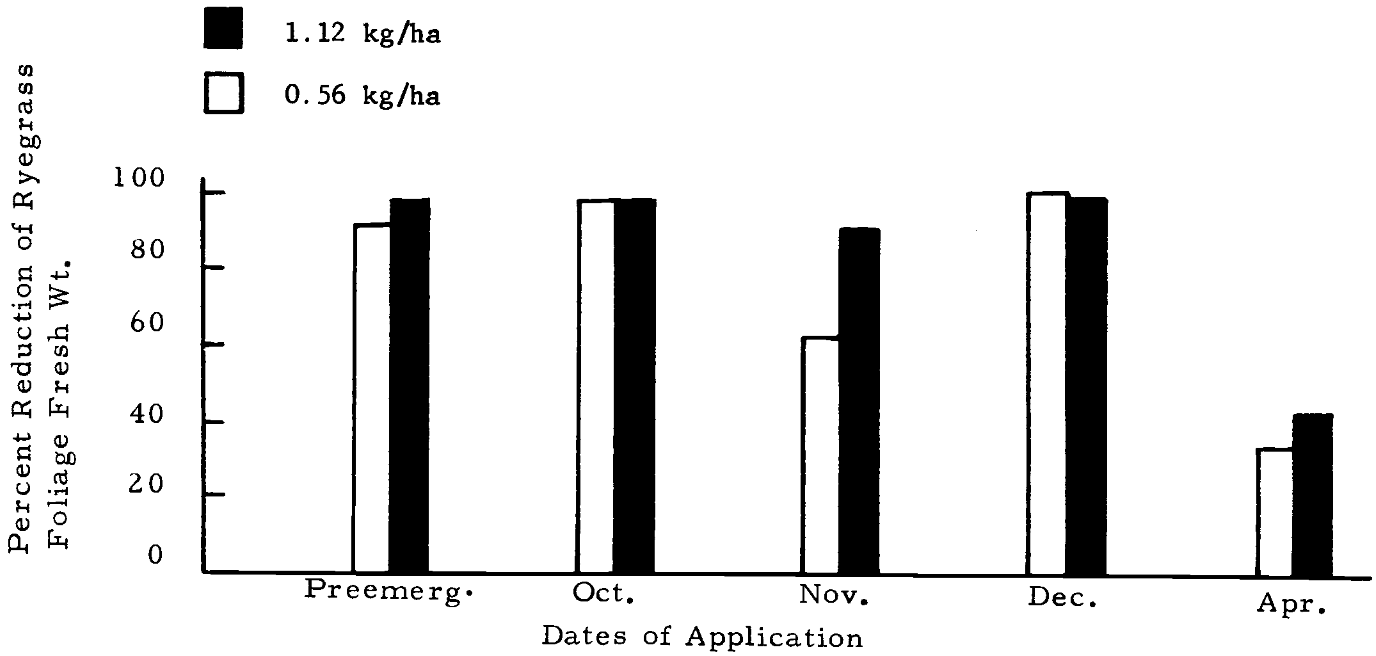


Figure 5. Response of Hyslop wheat to different application dates and rates of metribuzin.



Fiqure 6. Response of ryegrass to different application dates and rates of metribuzin.

Table 3. Response of Hyslop wheat to different application dates and rates of metribuzin.

Treatments	Average Wheat Grain Yield Grams/plot	Bu/A
0.56 kg/ha metribuzin		
Preemergence	5664	96.1
October 25, 1973	5535	83.8
November 20, 1973	6410	108.8
December 10, 1973	6075	103.1
April 5, 1974	6565	111.4
check	6455	109.5
1.12 kg/ha metribuzin		
Preemergence	5165	87.7
October 25, 1973	4890	83.0
November 20, 1973	5600	95.0
December 10, 1973	5485	93.1
April 5, 1974	5236	88.9
check	5490	93.2

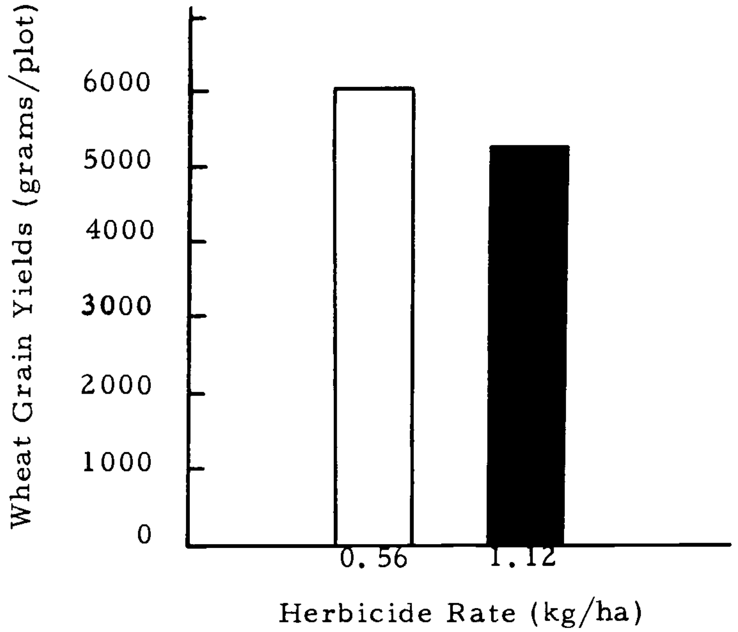


Figure 7. Response of Hyslop wheat to two rates of metribuzin.

Table 4. Visual evaluations of wheat injury from metribuzin applied at two rates and five dates.

Treatments	Average injury rating[1/] March 22, 1974	June 30, 1974
<u>0.56 kg/ha metribuzin</u>		
Preemergence	37	22
October 25, 1973	38	15
November 20, 1973	4	6
December 10, 1973	3	7
April 5, 1974	-	0
check	0	0
<u>1.12 kg/ha metribuzin</u>		
Preemergence	86	33
October 25, 1973	86	37
November 20, 1973	25	20
December 10, 1973	26	20
April 5, 1974	-	29
check	0	0

[1/] Rating scale: 0 = no injury, 100 = complete kill

Averages of visual evaluations of percent ryegrass control are presented in Table 5 and in Appendix Table 5. Fresh weights of ryegrass and percent ryegrass reduction are presented in Table 6 and in Appendix Table 6.

The reason for the low yields of untreated check plots in the 1.12 kg/ha blocks is not known. The experimental area was extremely wet during most of the winter and lateral movement of metribuzin from treated plots into the check plots is possible. However, there was no visible indication that this had occurred, either from wheat or ryegrass observations.

According to these results, adequate selectivity for metribuzin on winter wheat can be obtained by delaying application until the tillering stage. Excellent ryegrass control can still be achieved at this time.

Table 5. Visual evaluations of ryegrass control made on June 26, 1974.

Treatments	Average % control[1/]
<u>0.56 kg/ha metribuzin</u>	
Preemergence	94
October 25, 1973	97
November 20, 1973	62
December 10, 1973	99
April 5, 1974	19
check	0
<u>1.12 kg/ha metribuzin</u>	
Preemergence	97
October 25, 1973	98
November 20, 1973	95
December 10, 1973	99
April 5, 1974	40
check	0

[1/] Rating scale based on 0 = no control and 100% = complete kill.

Table 6. Effect of timing of metribuzin on Italian ryegrass.

Treatments	Weight of fresh ryegrass foliage	% Ryegrass reduction
	(gms/m^2)	
<u>0.56 kg/ha metribuzin</u>		
Preemergence	0.300	92
October 25, 1973	0.075	98
November 20, 1973	1.484	62
December 10, 1973	0	100
April 5, 1974	2.623	33
check	3.918	0
<u>1.12 kg/ha metribuzin</u>		
Preemergence	0.076	98
October 25, 1973	0.080	98
November 20, 1973	0.348	92
December 10, 1973	0.035	99
April 5, 1974	2.582	39
check	4.255	0

COMPARISON OF SUSCEPTIBILITY TO METRIBUZIN OF WHEAT AND BARLEY CULTIVARS

General Materials and Methods

The objective of the greenhouse experiments was to compare the responses of wheat and barley cultivars to metribuzin. Experiments were conducted either in the greenhouse or in growth chambers.

Soil used in experiments was collected at the East Agronomy Farm, near Corvallis. It was a Chehalis silty clay loam with 1.7% organic matter content (Table 7).

Five wheat and two barley cultivars were used for the experiments. Wheat cultivars were Hyslop, McDermid, Wanser, Paha, and Yamhill. Kamiak and Hudson were the barley cultivars.

Nine seeds of each cultivar were planted in 10 by 10 cm plastic pots. Seeding depth was 1.5 cm. All pots were placed in shallow watering pans for the duration of the experiments. After planting, soil was periodically subirrigated by putting water in the watering pans so that it would move through the holes in the pots and up through the soil by capillary action. Liquid fertilizer was applied to the soil at intervals to maintain good plant growth.

When plants were at the two-leaf stage, pots were arranged in blocks according to plant growth.

Table 7. Mechanical analysis of Chehalis silty clay loam, East Agronomy Farm.

Depth inches	Sand %	Silt %	Clay %
0 - 18	16.8	53.8	29.4
18 - 36	22.6	43.6	33.8

Metribuzin was applied with a variable speed, track-mounted sprayer in a volume of 450 l of water/ha using an 8003E Teejet nozzle at a pressure of 2.8 kg/square cm (40 psi).

After spraying, pots were sprinkler irrigated to help the downward movement of the herbicide. Subsequently, sub and sprinkler irrigation methods were used alternately to keep the herbicide in the root zone.

Plants were harvested 2 weeks after treatment by cutting at soil level with small scissors. Plant material was put in glass weighing bottles and dried in an oven at 85 C for 24 hours. Dry weights were determined with a Mettler balance after cooling the bottles at room temperature. Weights were recorded to the nearest mg. For data presentation, dry weights were converted to percentage of untreated control.

When herbicide effects were studied, the results were analyzed as a randomized block design with a factorial arrangement of treatments with cultivars, rates, and replications as factors.

Experiment I.

Materials and Methods

Plants were grown under greenhouse conditions. Temperature was between 20 C - 27 C. Wheat and barley cultivars were seeded on September 11, 1974. Plants were sprayed on September 24, 1974. Metribuzin rates were 0.11 kg/ha, 0.33 kg/ha, 0.56 kg/ha, and 1.68 kg/ha. The treatments were replicated three times. On October 10, 1974, treated plants were harvested and dry weights were determined.

Results

Results expressed as percentage of the respective checks are presented in Table 8 and Appendix Tables 7 and 8. There were significant differences between rates and between cultivars. Rates x culticars interaction was not significant, indicating that the difference between cultivars did not depend on the rates of metribuzin.

Barley cultivars were significantly less susceptible (Figure 8) to metribuzin injury than wheat cultivars. Kamiak was the least susceptible cultivar of all the cultivars tested. Wheat cultivars were similar in their response to metribuzin.

Increasing rates of metribuzin caused a decrease in dry weights in wheat cultivars. This would be expected because metribuzin is

Table 8. Response of wheat and barley cultivars to metribuzin.

Cultivars	Dry foliage wt. % of check
Kamiak (barley)	113.2883 a[1/]
Hudson (barley)	82.7258 b
Wanser (wheat)	57.0625 bc
Yamhill (wheat)	56.2700 c
Paha (wheat)	51.1833 c
Hyslop (wheat)	48.8400 c
McDermid (wheat)	44.5650 c

[1/] Values with the same letter are not significantly different at the 5% level based on Duncan's multiple range test.

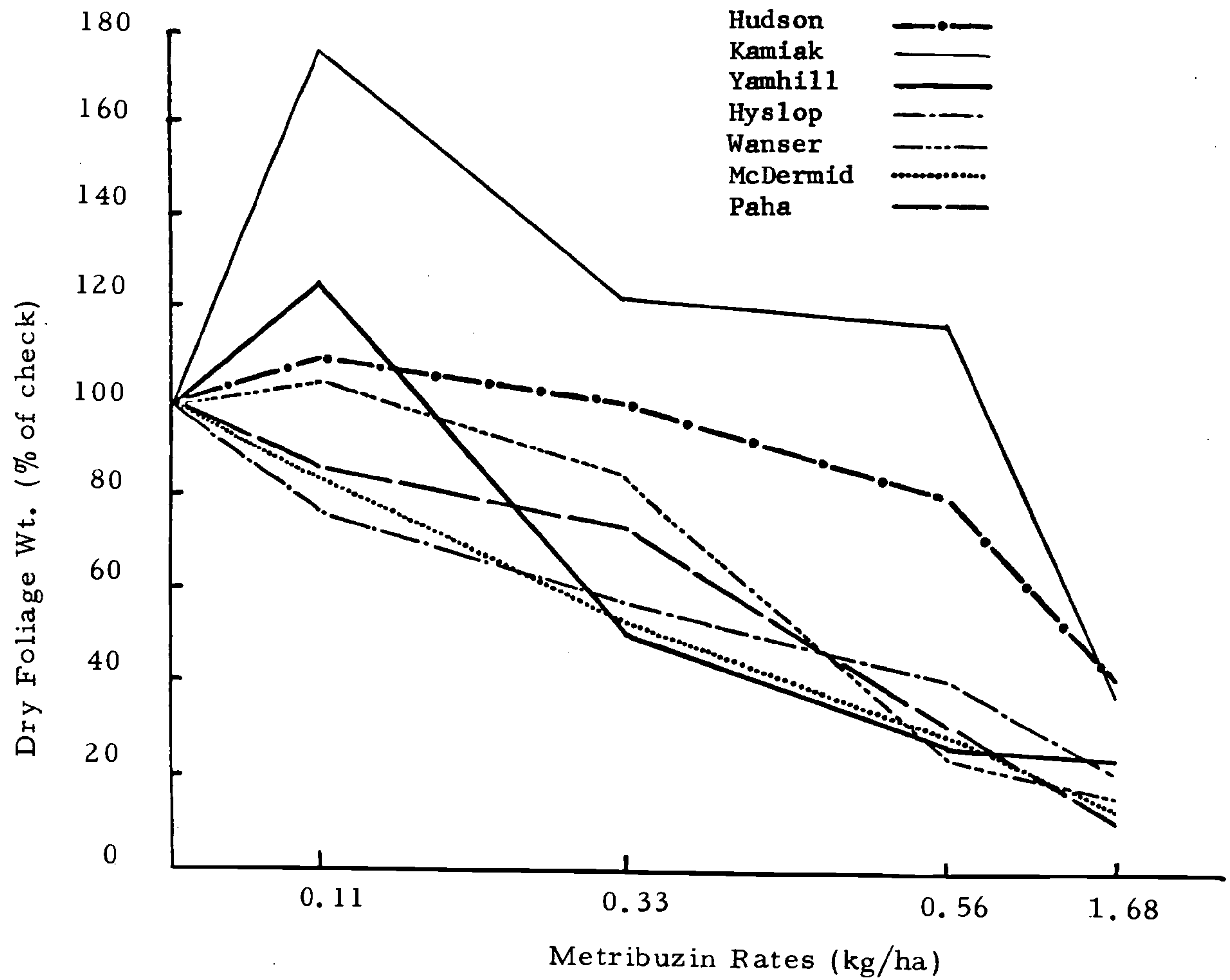


Figure 8. Response of wheat and barley cultivars to rates of metribuzin applied at two-leaf stage.

reported to cause photosynthesis inhibition.

Figure 9 shows the average response of wheat and barley cultivars to rates of metribuzin. In barley, lower rates stimulated growth.

The most obvious visual symptoms of injury were stunting, tip burning and localized sunken areas on the leaves which turned chlorotic-necrotic with time. These symptoms were first evident about 1 week after spraying.

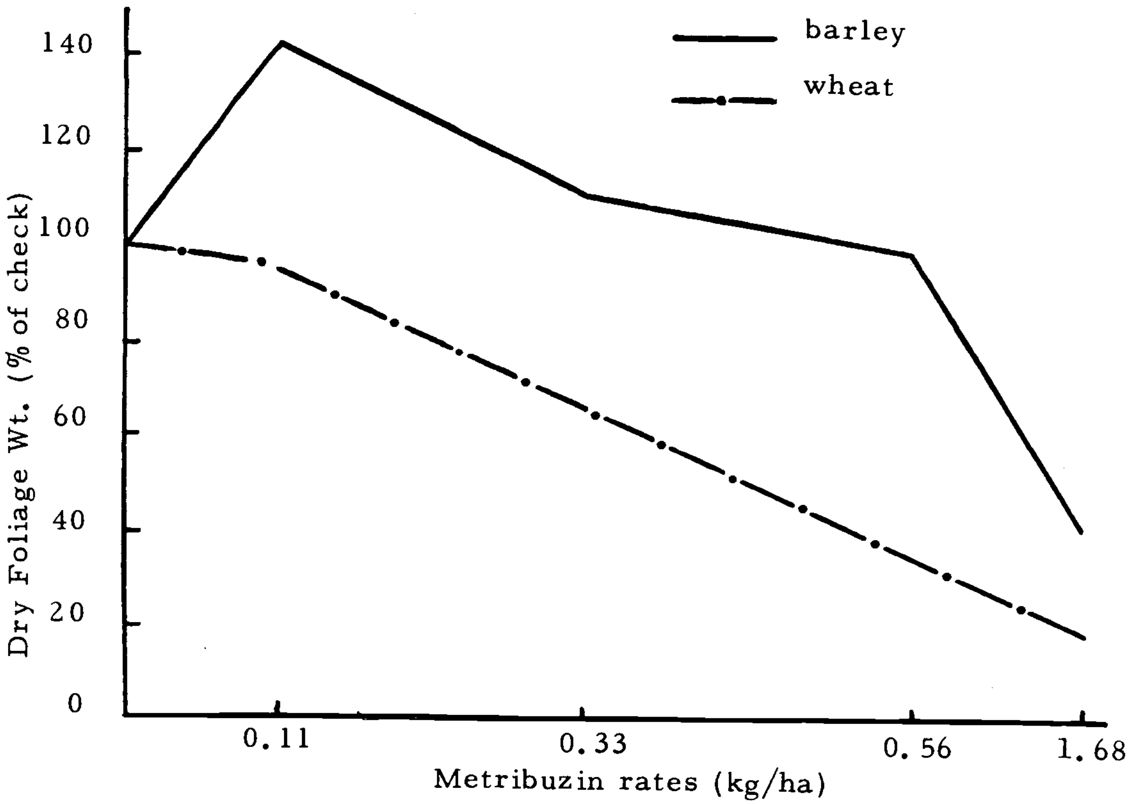


Figure 9. Response of wheat and barley cultivars to metribuzin applied at two-leaf stage.

Experiment II.

This experiment was established in order to verify the results of the first one. Two experiments were established in which plants failed to grow normally under greenhouse conditions. They were etiolated because of the low light intensity and high temperature. So, the experiment was repeated under growth chamber conditions.

Materials and Methods

Cultivars were seeded on February 20, 1975 and grown under greenhouse conditions until they were 2 cm tall. Then, they were transferred into two growth chambers for the remainder of the experiment. Plants were kept in growth chambers under 14 hr photoperiod. Temperature in both chambers was maintained at 15 C. Light intensity provided by fluorescent tubes and incandescent bulbs was approximately 16,500 lux.

Metribuzin was applied at the two-leaf stage on March 7, 1975. Treatments were replicated five times. Plants were harvested 20 days after spraying and dry weights were determined on March 28, 1975.

During the experiment, pots were regularly switched from one growth chamber to the other to compensate for any variation in growth chamber conditions.

Results

Results expressed as percentage of the respective checks are presented in Table 9 and Appendix Tables 9 and 10. There were significant differences between rates and between cultivars. Rates x cultivars interaction was not significant. This indicated that the difference between cultivars was not rate dependent.

Figure 10 shows the response of wheat and barley cultivars to rates of metribuzin at the two-leaf stage. Barley cultivars were not different from wheat cultivars in their response to metribuzin. Although the difference was not statistically significant, still Kamiak tended to be less susceptible to metribuzin injury than Hudson. Paha and Wanser were the least susceptible wheat cultivars. Yamhill, Hyslop, and McDermid were similar in their response. Figure 11 shows the average response of wheat and barley cultivars to rates of metribuzin. All rates of metribuzin caused growth reduction in barley and wheat cultivars.

Table 9. Response of wheat and barley cultivars to metribuzin.

Cultivars	Dry foliage wt. % of check
Paha (wheat)	61.7265 a[1/]
Wanser (wheat)	59.2575 ab
Kamiak (barley)	49.7760 bc
Yamhill (wheat)	44.3280 c
McDermid (wheat)	43.0690 c
Hyslop (wheat)	41.0160 c
Hudson (barley)	40.6090 c

[1/] Values with the same letter are not significantly different at the 5% level based on Duncan's multiple range test.

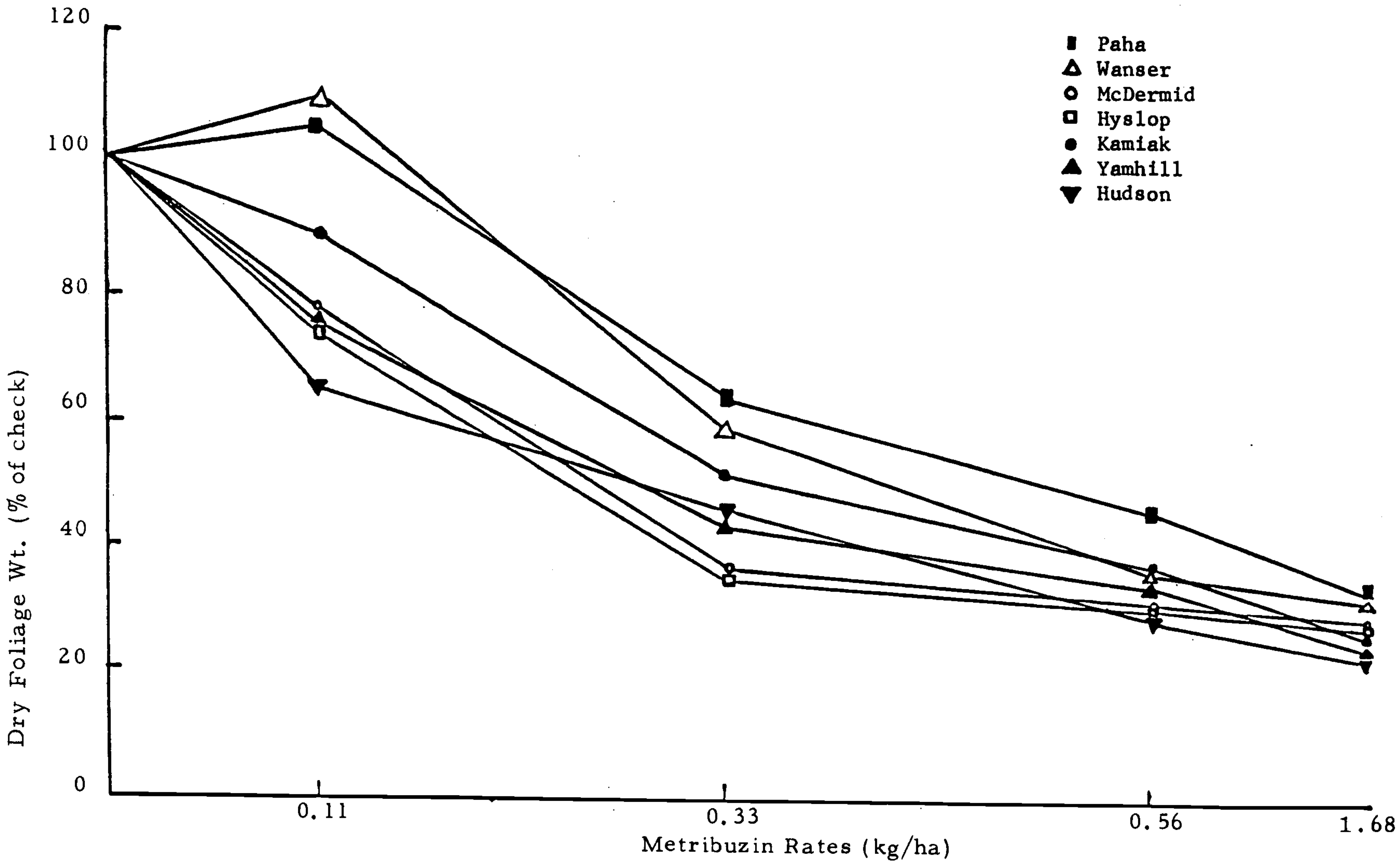


Figure 10. Response of wheat and barley cultivars to rates of metribuzin applied at two-leaf stage.

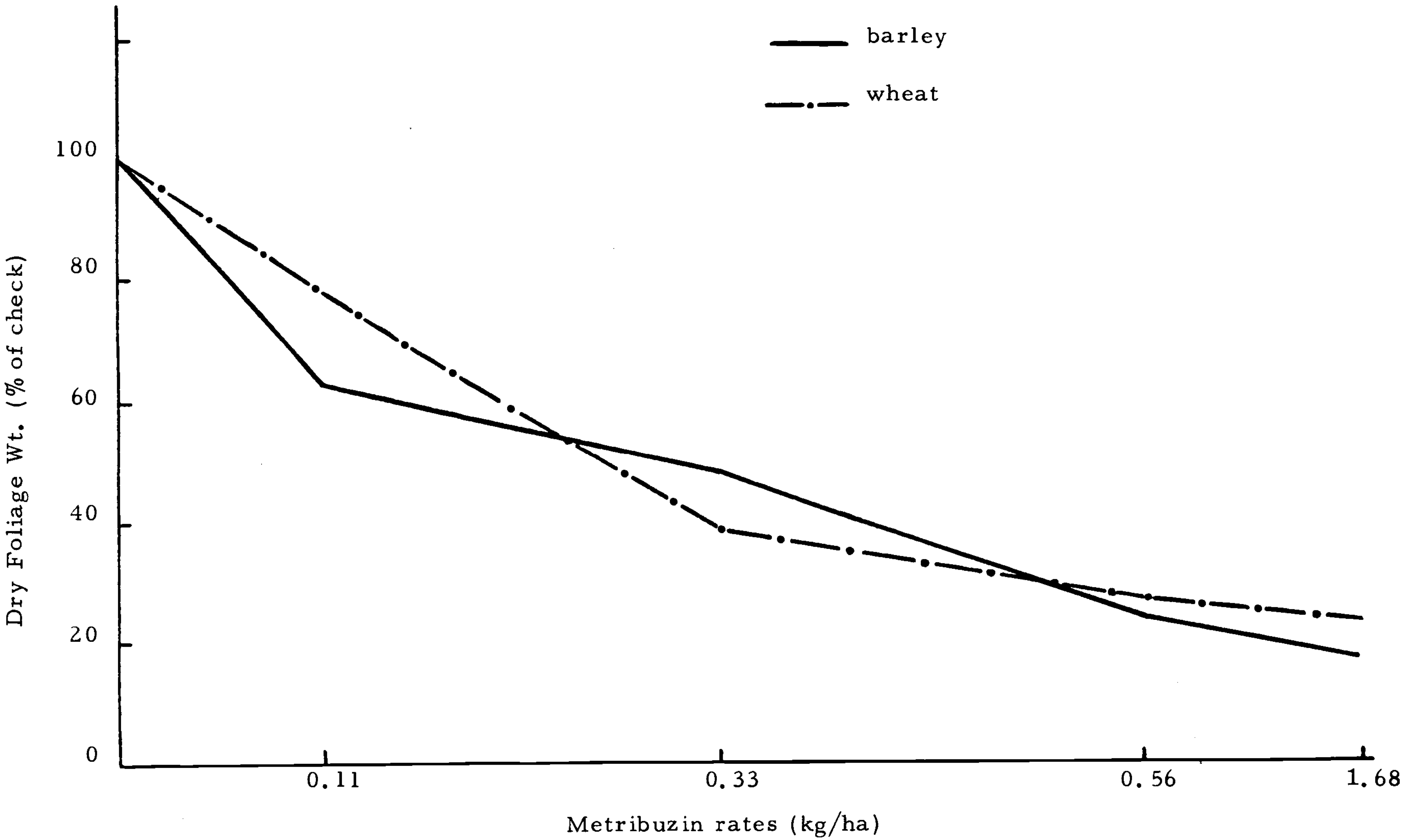


Figure 11. Response of wheat and barley cultivars to metribuzin applied at two-leaf stage.

Discussion

Greenhouse and growth chamber conditions influenced the response of cultivars differently.

The first experiment was conducted early in the fall under greenhouse conditions. Although no exact measurements were made, light intensity was obviously higher in the greenhouse than in the growth chambers. There were also differences between the temperatures of the greenhouse and growth chambers. While the temperature in the greenhouse varied from 20 C to 27 C, it was maintained at 15 C in the growth chambers.

Wheat cultivars grown under growth chamber conditions responded to metribuzin injury somewhat differently than when they were grown under greenhouse conditions. However, it is possible to group the cultivars according to their response. Although the order is different in each experiment, still Paha, Wanser, and Yamhill appeared to be somewhat less susceptible to metribuzin injury than Hyslop and McDermid in both experiments. However, differences were not always statistically significant and no definite conclusions can be drawn without further study.

Lower light intensity and lower temperature in the growth chambers influenced response of barley cultivars more than wheat cultivars. Barley cultivars grown under growth chamber conditions showed more injury. This might be explained by the production of thinner cuticles with less wax content which is more permeable to aqueous sprays under low light intensities (36).

Temperature also affects deposition of cuticle. Plants grown under a cool environment deposit less lipoidal material which goes to make up the cuticle. At low temperatures, less wax is deposited in relation to cutin (36). The reason for a greater difference in barley response between the two experiments than in wheat response is not known.

Although in the second experiment, barley cultivars were found to be more susceptible to metribuzin injury than in the first experiment, still Kamiak tended to be less susceptible than Hudson.

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Appendix Table 1. Winter Wheat Yield (Grams/plot), Schmidt Farm - 1974.

Treatments	Replications					
0.56 kg/ha metribuzin	I	II	III	IV	V	Avg
1st application	6075	5125	5175	6375	5570	5664
2nd application	5325	5475	5200	5625	6050	5535
3rd application	7175	5560	6800	6675	5840	6410
4th application	6675	5500	6925	6450	4825	6075
5th application	7200	6100	6750	6000	6775	6565
check	6525	5425	6650	7325	6350	6455
1.12 kg/ha metribuzin						
1st application	5275	5650	5350	4900	4650	5165
2nd application	4825	5250	4600	4950	4825	4890
3rd application	4375	5950	5500	6000	6175	5600
4th application	5175	5700	5350	6650	4550	5485
5th application	4780	5850	4825	6250	4475	5236
check	5550	5625	5900	6100	4275	5490

Appendix Table 2. Analysis of variance on grain yields (grams/plot).

Source	df	SS	MS	F
Replications	4	3,525,154.20	881,288.55	0.7695
Rate	1	9,752,601.65	9,752,601.65	8.5150*
Error a	4	4,581,385.85	1,145,346.46	------
Time	5	5,318,438.40	1,063,687.68	3.8134**
Rate x Time	5	1,164,128.35	232,825.67	0.8347
Error b	40	11,157,499.80	278,937.50	
Total	59	35,499,308.33		

C. V. = 9%

$L.S.D._{.05}$ = 767.082 for comparison of rates

$L.S.D._{.05}$ = 588.44 for comparison of rates in each application time

$L.S.D._{.05}$ = 477.3 for comparison of application times

Appendix Table 3. Visual evaluations of percent wheat injury, March 22, 1974.

Treatments	Percent wheat injury					
	R1	R2	R3	R4	R5	Avg
<u>0.56 kg/ha metribuzin</u>						
1st application	45	50	40	40	10	37
2nd application	20	60	40	50	20	38
3rd application	10	5	0	0	5	4
4th application	0	5	0	5	5	3
5th application	--	--	--	--	--	--
check	0	0	0	0	0	0
<u>1.12 kg/ha metribuzin</u>						
1st application	90	70	90	85	95	86
2nd application	85	90	85	90	80	86
3rd application	20	35	40	20	10	25
4th application	10	40	50	10	20	26
5th application	--	--	--	--	--	--
check	0	0	0	0	0	0

Appendix Table 4. Visual evaluations of percent wheat injury, June 30, 1974.

Treatments	Percent wheat injury					
	R1	R2	R3	R4	R5	Avg
<u>0.56 kg/ha metribuzin</u>						
1st application	20	35	25	20	10	22
2nd application	10	20	25	15	5	15
3rd application	0	10	5	5	10	6
4th application	0	10	0	5	20	7
5th application	0	0	0	0	0	0
check	0	0	0	0	0	0
<u>1.12 kg/ha metribuzin</u>						
1st application	30	25	30	35	45	33
2nd application	35	30	45	35	40	37
3rd application	50	20	20	5	5	20
4th application	25	10	20	5	40	20
5th application	35	20	35	5	50	29
check	0	0	0	0	0	0

Appendix Table 5. Visual evaluations as percent control of ryegrass, June 26, 1974.

Treatments	Percent ryegrass control					
	R1	R2	R3	R4	R5	Avg
<u>0.56 kg/ha metribuzin</u>						
1st application	90	98	90	95	95	94
2nd application	100	99	99	90	99	97
3rd application	50	85	50	55	70	62
4th application	95	100	100	100	99	99
5th application	25	20	20	25	5	19
check	0	0	0	0	0	0
<u>1.12 kg/ha metribuzin</u>						
1st application	100	99	99	90	98	97
2nd application	95	100	98	98	99	98
3rd application	95	98	90	95	95	95
4th application	100	98	100	98	99	99
5th application	85	0	15	25	75	40
check	0	0	0	0	0	0

Appendix Table 6. Weight of fresh ryegrass/quadrat, Schmidt Farm - June 28, 1974.

Treatments	Replications					
0.56 kg/ha metribuzin	I	II	III	IV	V	Avg
1st application	0.525	0.222	0.250	0.175	0.090	0.2524
2nd application	0	0	0	0.315	0	0.0630
3rd application	0.840	0.390	2.160	2.115	0.728	1.2466
4th application	0	0	0	0	0	0
5th application	2.080	2.667	2.164	1.870	2.235	2.2032
check	3.325	3.810	2.905	3.005	3.410	3.2910
1.12 kg/ha metribuzin						
1st application	0	0.700	0.250	0	0	0.0640
2nd application	0.140	0	0.020	0.175	0	0.0670
3rd application	0.525	0.220	0.380	0	0.335	0.2920
4th application	0	0.147	0	0	0	0.0294
5th application	0.720	3.755	2.960	3.070	0.340	2.1690
check	3.550	4.280	3.430	3.620	2.990	3.5740

Appendix Table 7. Responses of wheat and barley cultivars to rates of metribuzin.

Treatments	Percent of check R1	R2	R3	Avg
Hyslop (wheat)				
metribuzin at 0.11 kg/ha	97.99	79.41	53.11	76.84
metribuzin at 0.33 kg/ha	44.94	76.25	49.29	56.83
metribuzin at 0.56 kg/ha	63.37	23.38	36.07	40.94
metribuzin at 1.68 kg/ha	38.64	12.33	11.30	20.76
McDermid (wheat)				
metribuzin at 0.11 kg/ha	99.42	78.82	76.13	84.79
metribuzin at 0.33 kg/ha	39.21	72.61	43.20	51.67
metribuzin at 0.56 kg/ha	21.01	29.78	30.95	27.25
metribuzin at 1.68 kg/ha	14.92	15.31	13.42	14.55
Wanser (wheat)				
metribuzin at 0.11 kg/ha	97.10	78.22	136.01	103.78
metribuzin at 0.33 kg/ha	77.86	106.03	69.88	84.59
metribuzin at 0.56 kg/ha	22.20	25.95	24.86	24.34
metribuzin at 1.68 kg/ha	13.57	14.33	18.74	15.55
Paha (wheat)				
metribuzin at 0.11 kg/ha	70.87	89.66	95.21	85.25
metribuzin at 0.33 kg/ha	68.18	71.35	82.20	73.91
metribuzin at 0.56 kg/ha	29.87	31.49	32.48	31.28
metribuzin at 1.68 kg/ha	13.16	17.12	12.61	14.30
Yamhill (wheat)				
metribuzin at 0.11 kg/ha	186.04	126.32	62.72	125.03
metribuzin at 0.33 kg/ha	53.02	56.96	43.97	51.32
metribuzin at 0.56 kg/ha	29.66	33.94	16.20	26.60
metribuzin at 1.68 kg/ha	26.57	16.83	23.01	22.14

Appendix Table 7 (continued).

Treatments	Percent of check			
	R1	R2	R3	Avg
Hudson (barley)				
metribuzin at 0.11 kg/ha	123.80	114.67	91.04	109.84
metribuzin at 0.33 kg/ha	115.00	109.83	77.02	100.62
metribuzin at 0.56 kg/ha	67.32	100.49	71.03	79.61
metribuzin at 1.68 kg/ha	27.76	67.82	26.93	40.84
Kamiak (barley)				
metribuzin at 0.11 kg/ha	328.16	107.29	89.30	174.92
metribuzin at 0.33 kg/ha	161.74	125.32	79.59	122.22
metribuzin at 0.56 kg/ha	170.63	107.67	75.01	117.77
metribuzin at 1.68 kg/ha	49.73	26.09	38.93	38.25

Appendix Table 8. Analysis of variance for data in Appendix Table 1.

Source	df	SS	MS	F
Replications	2	8052.7358	4026.3679	4.0484*
Rates	3	83787.7809	27929.2603	28.0824**
Cultivars	6	43855.8982	7309.3164	7.3494**
Rates x Cultivars	18	14857.2305	825.4017	0.8299
Error	54	53705.5213	994.5467	

C.V. = 48%

Appendix Table 9. Responses of wheat and barley cultivars to rates of metribuzin.

Treatments	Percent of check					
	R1	R2	R3	R4	R5	Avg
Hyslop (wheat)						
metribuzin at 0.11 kg/ha	65.93	86.21	84.80	70.57	60.24	73.57
metribuzin at 0.33 kg/ha	40.32	30.09	42.22	36.84	25.99	35.09
metribuzin at 0.56 kg/ha	38.85	24.94	25.01	35.24	25.34	29.88
metribuzin at 1.68 kg/ha	27.77	22.16	22.37	33.29	22.04	25.53
McDermid (wheat)						
metribuzin at 0.11 kg/ha	48.45	89.84	81.01	94.85	72.74	77.38
metribuzin at 0.33 kg/ha	31.40	46.13	28.68	39.98	34.65	36.17
metribuzin at 0.56 kg/ha	28.89	31.91	28.64	40.16	22.03	30.33
metribuzin at 1.68 kg/ha	27.05	31.21	28.52	35.27	19.97	28.40
Wanser (wheat)						
metribuzin at 0.11 kg/ha	83.20	108.27	98.51	162.80	102.32	111.02
metribuzin at 0.33 kg/ha	41.29	37.48	52.25	110.29	49.17	58.10
metribuzin at 0.56 kg/ha	29.12	28.88	43.13	54.30	26.99	36.48
metribuzin at 1.68 kg/ha	21.48	26.35	30.53	51.95	26.84	31.43
Paha (wheat)						
metribuzin at 0.11 kg/ha	145.41	78.81	122.59	85.56	97.63	106.00
metribuzin at 0.33 kg/ha	100.03	28.73	88.74	55.07	44.02	63.32
metribuzin at 0.56 kg/ha	62.97	25.12	50.52	54.65	34.34	45.52
metribuzin at 1.68 kg/ha	38.19	21.71	35.75	39.37	25.32	32.07

Appendix Table 9 (continued).

Treatments	Percent of check					
	R1	R2	R3	R4	R5	Avg
Yamhill (wheat)						
metribuzin at 0.11 kg/ha	51.68	109.39	53.45	99.88	54.05	73.69
metribuzin at 0.33 kg/ha	35.48	55.66	32.91	44.49	45.04	42.72
metribuzin at 0.56 kg/ha	32.13	37.29	29.65	44.20	34.72	35.60
metribuzin at 1.68 kg/ha	22.19	18.35	19.97	35.51	30.52	25.31
Hudson (barley)						
metribuzin at 0.11 kg/ha	64.21	70.16	93.74	70.22	24.49	64.56
metribuzin at 0.33 kg/ha	61.24	50.28	52.35	52.24	12.96	45.81
metribuzin at 0.56 kg/ha	26.44	46.79	31.95	31.05	7.43	28.73
metribuzin at 1.68 kg/ha	33.34	24.56	24.96	26.30	7.47	23.33
Kamiak (barley)						
metribuzin at 0.11 kg/ha	88.08	79.37	107.66	63.44	101.28	87.97
metribuzin at 0.33 kg/ha	48.93	29.10	43.32	49.67	83.65	50.93
metribuzin at 0.56 kg/ha	41.83	29.32	33.50	34.14	41.64	39.09
metribuzin at 1.68 kg/ha	29.20	17.94	20.17	25.38	27.90	24.12

Appendix Table 10. Analysis of variance for data in Appendix Table 3.

Source	df	SS	MS	F
Replications	4	3369.7016	842.4254	3.2717*
Rates	3	69001.1911	23000.3970	89.3283**
Cultivars	6	9149.2081	1524.8680	5.9221**
Rates x Cultivars	18	4942.3025	274.5724	1.0664
Error	108	27808.6135	257.4872	
Total	139	114271.016800		

C. V. = 33.06%