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# Metribuzin and Chlorsulfuron Effect on Grain of Treated Winter Wheat (*Triticum aestivum*)[1]

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*Abstract.* **A field experiment was conducted to determine the influence of metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one] and/or chlorsulfuron {2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl)benzenesulfonamide} on germination, coleoptile growth, and mineral accumulation of seed from treated parent plants. The herbicides were applied postemergence in the spring to 'Vona' and 'Centurk' winter wheat (*Triticum aestivum* L.). The rate of metribuzin was 360 g ai/ha, with chlorsulfuron applied at 18, 35, or 70 g/ha. Metribuzin reduced grain yields of both varieties approximately 40%, whereas chlorsulfuron at the higher rates reduced grain yields of only Vona. Seed germination was not affected by either herbicide, but metribuzin, when applied alone, reduced coleoptile growth of Vona seed. The addition of chlorsulfuron to metribuzin eliminated this growth reduction. The mineral concentration of the seed of both varieties indicated that metribuzin and chlorsulfuron did not affect mineral translocation to the seed by the parent plant.**
*Additional index words*. **Mineral accumulation, germination, coleoptile growth, antagonism, BROTE.**

## INTRODUCTION

Metribuzin applied postemergence controls downy brome (*Bromus tectorum* L. #[3] BROTE) in winter wheat, but varietal tolerances to metribuzin are variable. In Oklahoma, spring applications of metribuzin at 400 g/ha reduced grain yields of Vona by 50% but did not affect the grain yield of Centurk (10). In northeastern Colorado, a spring application of metribuzin at 360 g/ha reduced grain yields of Vona and Centurk 41 and 38%, respectively (1). Runyan et al. (10) reported that metribuzin injury to winter wheat was influenced by the amount of rainfall received in the 2-week period after metribuzin application, with higher levels of rainfall resulting in greater grain yield losses. With the erratic rainfall patterns prevalent in the Central Great Plains, it would be difficult to predict the intensity of metribuzin injury before application. Also, in areas of intense downy brome infestations, producers in the Central Great Plains will accept a crop yield loss caused by metribuzin in order to reduce the downy brome population. It is unknown, however, whether metribuzin or chlorsulfuron will affect the seed viability or vigor if the parent winter wheat plants are injured by these herbicides.

Herbicide effect on seed of treated plants has been examined. Henzell et al. (7) reported that soil-applied atrazine [6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine] at sublethal rates affected the seed of mouseearcress [*Arabidopsis thaliana* (L.) Heynh. # ARBTH] by reducing germination and bleaching germination seedlings. Conversely, chlorsulfuron did not affect the mouseearcress seed. Kintner and Aldrich (8) applied sublethal rates of chlorsulfuron to velvetleaf (*Abutilon theophrasti* Medic. # ABUTH) at flower bud formation and found that seed number, weight, and germination were all reduced. However, chlorsulfuron applied postemergence at 140 g/ha to rye (*Secale cereale* L.) did not affect seed viability or germination (13). Thus,

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differential species response to chlorsulfuron by seed occurs.

Another possible response of plants injured by herbicides is altered mineral uptake. Olson (9) reported that soil-applied trifluralin [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine] reduced N, P, and K uptake by wheat seedlings but increased the uptake of Ca and Mg. Bucholtz and Lavy (4) found that soil-applied alachlor [2-chloro-*N*-(2,6-diethylphenyl)-*N*-(methoxymethyl)acetamide] and trifluralin reduced $HPO^{2-}$ and $SO^{2-}$ accumulation in oat (*Avena sativa* L.) plants. Foliar-applied herbicides also have affected mineral uptake by plants. Chlorsulfuron plus barban (4-chloro-2-butynyl-3-chlorophenylcarbamate) reduced the plant content of N and P in durum wheat (*Triticum durum* Desf.) at anthesis but increased N and P content in the grain (12).

Chlorsulfuron controls broadleaf weeds in winter wheat and is applied in the spring before the boot stage (2). Since metribuzin can also be applied in the spring, tank combinations of these herbicides will occur. Winter wheat tolerance to chlorsulfuron is based on plant metabolism of the molecule (11). When two herbicides are applied in combination, plant metabolism of one or both herbicides may be altered, thus changing the tolerance range of the plant species (6). Since environmental or cultural factors may result in metribuzin injury to winter wheat, the objective of this study was to determine the effect of metribuzin and/or chlorsulfuron applied postemergence in the spring on the grain yields and seed of two winter wheat varieties, Vona and Centurk. Germination, coleoptile growth, and mineral accumulation of the seed of treated plants were measured to determine if the herbicide effect on growing plants was transferred to the seed.

## MATERIALS AND METHODS

Vona and Centurk winter wheat seed were planted with a hoe drill in rows spaced 30 cm apart, at 50 kg/ha on October 9, 1982, and September 26, 1983, at Akron, CO. The soil was a Platner loam (Aridic Paleustoll), composed of 37% sand, 47% silt, and 16% clay; it contained 1.3% organic matter and had a pH of 6.7. Nitrogen was applied at 56 kg/ha in September of each year before planting. The soil contained 22 mg/kg of N and 14 mg/kg of P in the surface 15 cm. A randomized complete block design with four replications was used for each variety. Individual plots were 3.8 m wide and 7.5 m long, and all, including the nontreated control, were handweeded as needed to prevent weed competition.

Metribuzin at 360 g/ha and chlorsulfuron at 18, 35, and 70 g/ha were applied alone and in combination to tillered wheat on April 21, 1983, and April 28, 1984. The herbicides were applied in 280 L/ha of spray solution at 1.9 kPa with a tractor-mounted sprayer equipped with hollow-cone nozzles. Rainfall in the 2-week period after application was 53 mm in 1983 and 43 mm in 1984.

Grain was harvested from an area 1.6 by 5 m in 1983 and from four 1-m rows in 1984. Yield components were determined by counting all heads in two rows 1 m long, with the number of kernels/head and kernel weight measured from 20 heads that were selected at random. Seed viability of progeny were determined by germinating 100 seed in 9-cm petri dishes in darkness for 10 days at 16 C. To determine seedling vigor, 10 seed were selected randomly from each treatment and germinated in the dark on wet paper towels at 16 C. The seed were watered daily. Coleoptile length was measured to the nearest mm 4, 5, 6, and 7 days after the initial water application. All studies for each variable were repeated for each variety in both years.

Mineral determinations were made from grain that was ground into a fine powder with a Wiley mill (20-mesh screen). The powdered samples were analyzed for N by semimicro Kjeldahl, for P by phosphomolybdate colorimetry, and for K, Mg, Ca, Mn, Fe, Zn, and Cu by atomic absorption spectrophotometer. All mineral data are expressed on a weight basis.

All data were subjected to analyses of variance, and differences between means were determined at the 5% level of significance. Since the results did not differ significantly between years, plant response and mineral concentrations were averaged over years and presented separately for each variety.

## RESULTS AND DISCUSSION

**Plant response.** Metribuzin applied alone or mixed with chlorsulfuron reduced Vona grain yields 41 and 29%, respectively (Table 1). Chlorsulfuron applied alone at 35 and 70 g/ha also resulted in 15 and 14% yield loss, respectively. The treatments of metribuzin plus chlorsulfuron at 35 and 70 g/ha resulted in significantly more grain than the metribuzin-alone treatment; however, the yield for these mixtures was still less than the weed-free control. Calculations based on Colby's formula (5) indicate that antagonism between metribuzin and chlorsulfuron occurred. The expected yield reduction was 50.9%, while the observed yield reduction was 25.2% for the metribuzin plus chlorsulfuron at 70 g/ha treatment. Thus, chlorsulfuron at higher rates diminished the toxic effect of metribuzin to Vona.

Neither kernel weight nor germination of the Vona grain was affected by any herbicide treatment (Table 1). However, the metribuzin-alone treatment resulted in less vigorous seedlings as evidenced by a 15% reduction in coleoptile length 7 days after inhibition. Atrazine, a chemically related herbicide, was also found to reduce seedling growth of *A. thaliana* seed (7). When metribuzin was combined with chlorsulfuron at 35 and 70 g/ha, reduced coleoptile growth did not occur, although yield losses did result. This reduction by chlorsulfuron of metribuzin toxicity found with coleoptile growth of the seed also occurred with the parent plants (grain yield effect), again indicating that chlorsulfuron was antagonistic to metribuzin activity on Vona.

All treatments with metribuzin significantly reduced grain yields of Centurk (Table 2). However, no yield loss by Centurk occurred at any rate of chlorsulfuron as was found with Vona. Wheat varietal response to chlorsulfuron has also been observed in Australia (3). The antagonistic effect of chlorsulfuron on metribuzin toxicity observed with the grain yields of Vona did not occur with Centurk. Metribuzin, applied alone or with chlorsulfuron, reduced kernel weight (Table 2); however, metribuzin injury to the parent Centurk plant affected neither germination nor coleoptile growth of Centurk seed.

**Mineral accumulation.** The seed content of K, Mg, Mn, Fe, and Zn were not affected by herbicide treatment in either variety, thus the data are not presented. With Vona, metribuzin alone, chlorsulfuron alone at 18 g/ha, and these two combined increased Cu concentration above that of the nontreated control (Table 3). N content in grain was increased by three treatments (which reduced grain yields), of metribuzin alone and metribuzin plus chlorsulfuron at 18 and 35 g/ha. Tanaka and Anderson (12) also reported increased N concentration in durum grain when chlorsulfuron plus barban or diclofop {(±)-2-[4-(2,4-dichlorophenoxy) phenoxy] propanoic acid} decreased grain yields of the parent plants.

Herbicide influence on mineral accumulation in Centurk seed differed from Vona (Table 3). Cu and N concentrations of Centurk grain were not affected by herbicide treatment, but metribuzin alone increased the concentration of Ca compared to the weed-free control. The combination of metribuzin with chlorsulfuron at 35 g/ha increased P and Ca compared to the weed-free control, but this effect was not observed with the other two metribuzin-chlorsulfuron combinations. With both varieties, none of the herbicide treatments reduced the concentration of any mineral below that of the weed-free control. Thus, a spring application of metribuzin and/or chlorsulfuron that injures the parent plants does not reduce the translocation of minerals to the seed of Vona or Centurk.

Grain yield of Vona and Centurk winter wheat was reduced by metribuzin when it was applied at the tillering stage. Only Vona appeared susceptible to chlorsulfuron injury at 35 and 70 g/ha. Neither herbicide affected germination of seed of either variety, but coleoptile growth of Vona was reduced by metribuzin. Producers in the Central Great Plains who will accept a crop yield loss caused by

*Table 1.* Plant response of Vona winter wheat to postemergence applications of metribuzin and chlorsulfuron in 1983 and 1984.

| Postemergence treatments | | | | | Coleoptile growth | |
|---|---|---|---|---|---|---|
| Herbicides | Rate | Grain yield | 100-kernel weight | Germination | 4 days | 7 days |
| | (g/kg) | (kg/ha) | (g) | (%) | (mm) | |
| Metribuzin | 360 | 1700* | 2.71 | 100 | 3.3* | 17.2* |
| Chlorsulfuron | 18 | 2600 | 2.72 | 98 | 4.3 | 20.4 |
| Chlorsulfuron | 35 | 2440* | 2.93 | 100 | 4.4 | 21.0 |
| Chlorsulfuron | 70 | 2450* | 2.79 | 100 | 4.6 | 21.1 |
| Metribuzin + chlorsulfuron | 360 + 18 | 1850* | 2.78 | 99 | 3.8 | 19.3 |
| Metribuzin + chlorsulfuron | 360 + 35 | 2090* | 2.81 | 99 | 4.4 | 23.0 |
| Metribuzin + chlorsulfuron | 360 + 70 | 2140* | 2.79 | 99 | 4.1 | 20.1 |
| Control, (weed-free) | . . . | 2860 | 2.77 | 100 | 4.1 | 20.4 |
| LSD (0.05) | | 360 | NS | NS | 0.6 | 3.0 |

*Indicates treatment value significantly differs from the control (weed-free).

*Table 2.* Plant response of Centurk winter wheat to postemergence applications of metribuzin and chlorsulfuron in 1983 and 1984.

| Postemergence treatments | | | | | Coleoptile growth | |
|---|---|---|---|---|---|---|
| Herbicide | Rate | Grain yield | 100-kernel weight | Germination | 4 days | 7 days |
| | (g/kg) | (kg/ha) | (g) | (%) | (mm) | |
| Metribuzin | 360 | 1480* | 2.66* | 100 | 4.2 | 19.5 |
| Chlorsulfuron | 18 | 2290 | 2.76 | 100 | 3.9 | 20.8 |
| Chlorsulfuron | 35 | 2330 | 2.86 | 99 | 4.0 | 21.0 |
| Chlorsulfuron | 70 | 2160 | 2.77 | 99 | 3.8 | 19.7 |
| Metribuzin + chlorsulfuron | 360 + 18 | 1630* | 2.68* | 100 | 4.0 | 18.2 |
| Metribuzin + chlorsulfuron | 360 + 35 | 1600* | 2.70* | 100 | 4.5 | 20.5 |
| Metribuzin + chlorsulfuron | 360 + 70 | 1530* | 2.68* | 100 | 4.0 | 19.2 |
| Control, (weed-free) | . . . | 2360 | 2.84 | 100 | 4.4 | 20.5 |
| LSD (0.05) | | 560 | 0.12 | NS | NS | NS |

*Indicates treatment value significantly differs from the control (weed-free).

*Table 3.* Effect of postemergence applications of metribuzin and chlorsulfuron on mineral accumulation in grain of Vona and Centurk winter wheat, 1983 and 1984.

| Postemergence treatments | | Minerals | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Vona | | | | Centurk | | | |
| Herbicide | Rate | N | P | Ca | Cu | N | P | Ca | Cu |
| | (g/kg) | —— (g/kg) —— | | — (mg/kg) — | | —— (g/kg) —— | | — (mg/kg) — | |
| Metribuzin | 360 | 21.5* | 3.67 | 311 | 4.3* | 22.0 | 4.15 | 361* | 4.3 |
| Chlorsulfuron | 18 | 20.5 | 3.48 | 311 | 5.1* | 21.7 | 4.07 | 303 | 4.5 |
| Chlorsulfuron | 35 | 20.3 | 3.56 | 307 | 4.2 | 21.7 | 4.04 | 309 | 4.3 |
| Chlorsulfuron | 70 | 20.4 | 3.63 | 320 | 3.8 | 21.4 | 3.98 | 294 | 4.6 |
| Metribuzin + chlorsulfuron | 360 + 18 | 21.1* | 3.74 | 332 | 4.5* | 22.0 | 4.03 | 327 | 4.2 |
| Metribuzin + chlorsulfuron | 360 + 35 | 21.6* | 3.74 | 316 | 4.2 | 22.4 | 4.30* | 355* | 4.8 |
| Metribuzin + chlorsulfuron | 360 + 70 | 20.3 | 3.73 | 305 | 4.1 | 22.6 | 4.14 | 342 | 4.9 |
| Control, (weed-free) | . . . | 19.9 | 3.58 | 306 | 3.7 | 21.4 | 4.09 | 322 | 4.0 |
| LSD (0.05) | | 1.0 | NS | NS | 0.5 | NS | 0.20 | 31 | NS |

*Indicates treatment value significantly differs from the control (weed-free).

metribuzin in order to reduce the downy brome population should be cautious in planting the seed of treated Vona, since reduced seedling vigor may result. However, this seedling vigor response to metribuzin did not occur with Centurk.

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