Weed Technology. 1998. Volume 12:690–698

Response of Downy Brome (*Bromus tectorum*) and Rotational Crops to MON 37500[1]

SANDRA L. SHINN, DONALD C. THILL, WILLIAM J. PRICE, and DANIEL A. BALL[2]

Abstract: Field experiments were conducted to determine the effect of different rates and application times of MON 37500 on downy brome control in winter wheat and on rotational crop injury. In southeastern Washington, MON 37500 applied postemergence at 36 to 72 g ai/ha in the fall and spring controlled downy brome 90 to 97% and 45 to 71%, respectively. MON 37500 was applied postemergence to winter wheat at 18, 36, and 72 g/ha during fall 1995 and spring 1996 near Moscow, ID; Pendleton, OR; and Endicott, WA, to determine its effect on rotational crops planted during spring 1997. At Pendleton, OR, fall applications of MON 37500 at 18, 36, and 72 g/ha applied to actively growing wheat reduced seed yield of spring barley and pea 13 to 59% and 26 to 29%, respectively, when these crops followed winter wheat in the rotation. At this site, spring applications of 36 and 72 g/ha reduced seed yield of spring barley 17 to 34%; when applied in the fall or spring, MON 37500 reduced canola yield 31 to 73%. MON 37500 at 18 g/ha in the spring reduced pea biomass 32% at Endicott. Aboveground biomass and seed yield of barley, pea, lentil, and mustard at Moscow were not affected by MON 37500 carryover. However, using a grain sorghum bioassay, predicted final concentrations of MON 37500 in soil at all three locations 360 d after treatment (DAT) was similar, ranging from 0.5 to 2 ng ai/g. In growth chamber herbicide dose–response studies, grain sorghum shoot height was reduced more at lower doses (0.025 to 5 ng/g) of MON 37500 in Pendleton soil than in soils from the other field locations. Perhaps the greater rotational crop injury observed at the Pendleton location was partly related to greater soil activity of the herbicide.

Nomenclature: MON 37500, 1-(2-ethylsulfonylimidazol[1,2-*a*]pyridin-3-ylsulfonyl)-3-(4,6-dimethoxypyrimidin-2-yl)urea; downy brome, *Bromus tectorum* L. #[3] BROTE; barley, *Hordeum vulgare* L. 'Baronesse'; canola, *Brassica napus* L. 'Legend'; grain sorghum, *Sorghum bicolor* (L.) Moench 'DK58'; lentil, *Lens culinaris* Medic. 'Redchief'; mustard, *Sinapis alba* L. 'Idagold'; pea, *Pisum sativum* L. 'Columbia,' 'Dual'; winter wheat, *Triticum aestivum* L. 'Hill,' 'Madsen,' 'Rod,' 'Stephens.'

Additional index words: BROTE, pH, precipitation, soil residues, sorghum bioassay, triasulfuron, yield.

Abbreviations: DAT, days after treatment; OM, organic matter; POST, postemergence; PNW, Pacific Northwest; PPI, preplant incorporated.

INTRODUCTION

Winter wheat is an economically important crop in the Pacific Northwest (PNW) region of the United States. In this area, Idaho produced 1.9, Washington 4.5, and Oregon 1.7 million tonne of winter wheat in 1996, accounting for about 20% of the total winter wheat production in the United States (National Agricultural Statistics Services 1997). Annual brome species are widespread throughout the PNW and central U.S. Great Plains and are difficult to control in fall planted small grains (Driver et al. 1993; Richardson et al. 1986). Downy brome infests approximately 1.2 million ha of farmland in the PNW used to produce winter wheat (Richardson et al. 1986; Rydrych and Muzik 1968). Annual bromes reduced winter wheat grain yield 28 to 92% in eastern Washington (Rydrych and Muzik 1968) depending on weed density and environmental conditions. Currently control tactics for annual brome in winter wheat include crop rotation (Wicks 1984), fallow, delayed planting, and a few selective herbicides (Appleby and Morrow 1990).

Growers often rely on herbicides for weed control,

[1] Received for publication May 19, 1998, and in revised form September 14, 1998.

[2] Graduate Research Associate and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339; Research Associate, Statistical Programs, University of Idaho, Moscow, ID 83844-2339; Research Associate, Statistical Programs, University of Idaho, Moscow, ID 83844-2339; Associate Professor, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, OR 97801.

[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

some of which may persist in soil into the next growing season and injure rotational crops. Herbicide dissipation and effects on rotational crops can vary greatly between locations and years. Factors such as herbicide chemistry, rainfall, and soil pH, texture, and organic matter (OM) can affect herbicide dissipation. Some sulfonylurea herbicides, such as triasulfuron {2-(2-chloroethoxy-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] benzenesulfonamide} and chlorsulfuron {2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] benzenesulfonamide} can persist in the soil affecting growth of sensitive rotational crops for one or more growing seasons (Moyer et al. 1990; Peterson and Arnold 1985; Smith and Hsiao 1985). Chlorsulfuron applied to an acid soil (pH 5.8) had residual activity up to 26 mo after application (Brewster and Appleby 1983), whereas activity in an alkaline soil (up to pH 8.5) continued for longer than 4 yr after application (Moyer et al. 1990).

MON 37500[4] is a recently developed new sulfonylurea herbicide to control annual bromes and other grass weeds in winter wheat. In greenhouse studies, MON 37500 reduced the growth of Japanese brome (*Bromus japonicus* Thumb. *ex* Murr.), downy brome, and cheat (*Bromus secalinus* L.) without affecting winter wheat growth (Geier and Stahlman 1996).

Little is known about persistence of MON 37500 in the soil, which could affect where and how often the herbicide is used to control weeds in wheat. The purpose of this study was to determine the effect of rate and application timing of MON 37500 on downy brome control in winter wheat and on rotational crop injury.

MATERIALS AND METHODS

Downy Brome Control. Field studies were conducted in the winter wheat–fallow region of eastern Washington near Endicott in 1995–1996 and LaCrosse in 1996–1997 to determine the effect of MON 37500 application rate and timing on downy brome control and winter wheat injury. Madsen winter wheat was seeded at 90 kg/ha in rows spaced 18 cm apart September 15, 1995, and at 73 kg/ha in rows spaced 25 cm apart September 23, 1996. Precipitation was 426 mm from September 1995 to August 1996 and 567 mm from September 1996 to August 1997 (Washington Climatological Data 1995, 1996, 1997). The soil type at the Endicott site is an Athena silt loam (fine-silty, mixed, mesic Pachic Haploxerolls) with 3 to 7% slope, 5.7 pH, and 2.8% OM. The soil type at the LaCrosse site is a Walla Walla silt loam (coarse-silty, mixed, mesic Typic Haploxerolls) with 0% slope, 6.2 pH, and 0.8% OM.

The experimental design was a randomized complete block with four replicates. Plot size was 6.1 by 19.5 m in 1995 and 2.4 by 9.1 m in 1996. MON 37500 was applied postemergence (POST) at 18, 36, and 72 g/ha plus a 0.5% (v/v) nonionic surfactant[5] on November 1, 1995, and November 2, 1996, when winter wheat had two to four leaves and downy brome had one to two leaves, and March 19, 1996, and March 21, 1997, when winter wheat had three to nine tillers and downy brome had two to eight tillers. Treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 94 L/ha at 214 kPa.

Winter wheat injury was evaluated visually November 8, 1995, March 26 and November 9, 1996, and March 28, 1997, on a scale from 0 (no injury) to 100% (dead). Downy brome control was visually evaluated February 22 and May 2, 1996, and March 19 and May 20, 1997 on a scale from 0 (no control) to 100% (completely controlled). Downy brome aboveground biomass samples were collected May 30, 1996, and April 16, 1997, from one 0.25- m^2 quadrat randomly positioned in each plot. Downy brome plants were counted, cut at the soil surface, dried at 60 C for 72 h, and weighed. Winter wheat seeds were harvested from a 1.2- by 18.6-m area July 16, 1996, and a 1.2- by 8.2-m area July 29, 1997, using a small plot combine. Visually estimated crop injury, downy brome control, plant counts, biomass (square root transformed), and winter wheat yield data were subjected to ANOVA procedures, and means were separated using Fisher's protected LSD test. All computations were carried out using SAS version 6.12 (SAS 1991).

Rotational Crop Studies. Field studies were conducted near Moscow, ID, Pendleton, OR, and Endicott, WA. The soil types are listed in Table 1. Madsen winter wheat was seeded at Moscow at 95 kg/ha in rows spaced 18 cm apart October 9, 1995. Stephens winter wheat was seeded at Pendleton at 90 kg/ha in rows spaced 25 cm apart October 5, 1995, and a mixture of Madsen, Hill, and Rod winter wheat was seeded at Endicott at 84 kg/ha in rows spaced 18 cm apart October 28,1995.

The experimental design was a randomized, complete split block with four replicates. Main plots were 6.1 by 19.5 m at Moscow and Endicott and 4.6 by 9.1 m at Pendleton. MON 37500 plus a nonionic surfactant[5] at

[4] Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

[5] R-11 (alkylarylpolyethoxylate and compounded silicones), Wilfarm, L.L.C., 1952 West Market Street, Nappanee, IN 46550.

Table 1. Soil used in MON 37500 field and bioassay studies.

Location	Series	Texture	Classification	pH	OM[a]	Sand	Silt	Clay
						%		
Moscow, ID	Westlake-Latahco	Silt loam	Arglaquic Xeric Argiaibolls	5.4	2.6	47	42	11
Endicott, WA	Athena	Silt loam	Pachic Haploxerolls	5.4	2.8	29	66	5
Pendleton, OR	Walla Walla	Silt loam	Typic Haploxerolls	6.1	2.1	19	64	17

[a] Organic matter content.

0.5% (v/v) was applied to main plots at 0, 18, 36, and 72 g/ha December 5, 1995, and April 19, 1996 at Moscow; November 21, 1995, and March 18, 1996, at Endicott; and November 2, 1995, and March 19, 1996, at Pendleton. In addition, triasulfuron plus a nonionic surfactant[5] was applied at 18 g ai/ha and 0.25% (v/v), respectively, in both fall and spring. Winter wheat had two to three leaves at all locations when herbicides were applied in the fall and five to eight leaves at Pendleton and four to five leaves at Moscow and Endicott in the spring. Treatments were applied POST with a CO_2-pressurized backpack sprayer calibrated to deliver 94 L/ha at 275 kPa at Moscow and Endicott and 109 L/ha at 206 kPa at Pendleton.

Weed control was evaluated visually at Endicott April 9, 1996, using the procedure discussed previously. Weeds within a randomly selected 0.25-m^2 area in each plot were counted April 29, 1996, at Moscow. There were no weeds present at Pendleton. Wheat plants within a randomly selected 0.25-m^2 area in each plot were counted at Endicott November 17, 1995, and at Moscow December 5, 1995. At Pendleton, wheat heads within a 1-m^2 area were counted June 26, 1996. Wheat grain was harvested from a 1.2 by 19.5 m area in each plot at Moscow August 14, 1996, and at Endicott August 6, 1996, and from a 1.5 by 9.1 m area at Pendleton July 23, 1996, with a small-plot combine.[6] Grain was cleaned using an M2B Clipper[7] and weighed. Test weight (grain weight per unit volume) was determined using cleaned grain samples.

All plots were chisel plowed about 20-cm deep during fall 1996; the following spring all plots were shallowly cultivated in two directions with a field cultivator. Trifluralin [2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine] at 560 g ai/ha was applied preplant incorporated (PPI) and incorporated twice, 5 cm deep, with a field cultivator April 4 at Endicott and May 7, 1997, at Moscow to control weeds in mustard. A mixture of pendimethalin [(*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine)] at 660 g ai/ha plus imazethapyr {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid} at 50 g ai/ha was applied preplant (PP) and incorporated twice, 5 cm deep, to control weeds in pea and lentil at Moscow and Endicott. PPI herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 95 L/ha at 220 kPa. Baronesse barley at 95 kg/ha, Columbia pea at 106 kg/ha, Idagold mustard at 11 kg/ha, and Redchief lentil at 90 kg/ ha were seeded at Endicott April 5 and at Moscow May 8, 1997, with a double-disk planter. Dual pea at 196 kg/ha, Baronesse barley at 90 kg/ha, and Legend canola at 11 kg/ha were seeded at Pendleton March 31, 1997, with a double-disk planter. All crops were seeded about 3.8-cm deep at Moscow and Endicott and 2.5-cm deep at Pendleton in rows spaced 18-cm apart. Subplots were 6.1 by 4.9 m at Moscow and Endicott and 4.6 by 3.0 m at Pendleton.

Crop injury was evaluated visually in 1997 using a scale from 0 (no injury) to 100 (dead) at Endicott May 6, June 3, and June 30; at Moscow May 27, June 6, and July 1; and at Pendleton June 2 and 20. Aboveground crop biomass samples were collected in 1997 on June 12 at Pendleton, June 30 at Endicott, and July 8, at Moscow when the canola, lentil, mustard, and pea (per-plant basis) were at the 50% bloom stage and barley was 50% headed in the untreated control plots. The samples were collected from one 0.25-m^2 area randomly positioned within 1 m of the end of each subplot. Crop plants were counted, cut at the soil surface, placed in paper bags, dried at 60 C for 72 h, and weighed.

Barley, pea, and mustard were harvested August 18, 1997, at Moscow from a 1.3- by 5.5-m area using a small-plot combine. Lentil was harvested September 19, 1997, following desiccation with diquat dibromide [6,7-dihydrodipyrido(1,2-α:2′,1′-*c*) pyrazinediium dibromide] applied at 560 g ai/ha September 8. At Pendleton, pea was harvested July 9, canola July 16, and barley July 24, 1997, from a 1.5 by 4.6 m area. Crops were not harvested at the Endicott site because herbicide treatments failed to control a heavy infestation of mayweed chamomile (*Anthemis cotula* L. # ANTCO). Harvested seeds were cleaned using an M2B Clipper and weighed. Barley test weight (grain weight per unit volume) was

[6] Hans-Ulrich Hege, Saatzuchtmaschinen, Domane Hohebuch D-7112 Waldenburg, West Germany-Bundesrepublik Deutschland.

[7] Seedburo Co., 1022 West Jackson Boulevard, Chicago, IL 60607-2990.