Chapter VI

Influence of AE F130060 03 Application Timing and Rate on Wheat (*Triticum aestivum*) Response and Italian Ryegrass (*Lolium multiflorum*) Control

Abstract: Field experiments were conducted in Virginia in 2000 and 2001 to investigate responses of winter wheat and Italian ryegrass to postemergence applications of the experimental herbicide mixture AE F130060 03. Experimental factors evaluated were herbicide application rate, Italian ryegrass growth stage, and the presence of absence of methylated seed oil (MSO). Greenhouse experiments were also conducted to further quantify the effects of AE F130060 03 application rate on growth responses of diclofop-methyl-sensitive and –resistant Italian ryegrass. In field experiments, AE F130060 03 controlled both diclofop-methyl-sensitive and –resistant Italian ryegrass. In most instances, AE F130060 03 applied at 15 or 18 g ai/ha in the presence of absence of MSO provided similar Italian ryegrass control and reductions in inflorescence emergence. Although AE F130060 03 controlled existing Italian ryegrass 4 wk after any application timing, application timing had the greatest impact on late-season Italian ryegrass control and inflorescence emergence. Applications made to two- to three-leaf Italian ryegrass resulted in greater Italian ryegrass emergence following application, thereby resulting in lesser apparent late-season control and greater Italian ryegrass inflorescence emergence compared to applications made to two- to three-tiller or four- to five-tiller Italian ryegrass. Although wheat injury from AE F130060 03 applications was substantially greater than injury from diclofop-methyl, wheat recovered and yields from AE F130060 03-treated wheat were similar to diclofop-methyl-treated wheat and at least 21% greater than yields from nontreated wheat. In greenhouse experiments, differential growth responses between diclofop-methyl-sensitive and –resistant Italian ryegrass occurred following AE F130060 03 application at normal (15 g

ai/ha) and below-normal application rates. When rates were increased beyond normal application rates, however, similar growth responses were seen in diclofop-methyl-sensitive and –resistant Italian ryegrass. On the basis of these results, AE F130060 03 is an effective herbicide for control of Italian ryegrass; however, later applications made to two- to three-tiller or four- to five-tiller Italian ryegrass may result in lowest amounts of Italian ryegrass emergence after application.

Nomenclature: AE F130060 03 {8.3:1.7 mixture of AE F130060 00, proposed common name mesosulfuron-methyl, 2-[(4,6-dimethoxypyrimidin-2-*yl* carbamoyl)sulfamoyl]-4-methanesulfonamido)-*p*-toluic acid, plus AE F115008 00, proposed common name iodosulfuron-methyl-sodium, 4-iodo-2-[3-(4-methoxy-6-methyl-1,3,5-triazin-2-*yl*)ureidosulfonyl]benzoic acid}; AE F107892, proposed common name mefenpyr diethyl, 1-(2,4-dichlorophenyl)-4,5-dihydro-5-methyl-1*H*-pyrazole-3,5-dicarboxylic acid; diclofop-methyl; Italian ryegrass, *Lolium multiflorum* Lam. LOLMU #[19]; winter wheat, *Triticum aestivum* L. 'Pioneer 2643', 'Pioneer 26R24', 'Pocohontas'.

Additional index words: diclofop-methyl resistance, resistance management.

Abbreviations: ACCase, acetyl coenzyme A carboxylase (EC 6.4.1.2); ALS, acetolactate synthase (EC 4.1.3.18); MSO, methylated seed oil; POST, postemergence; WBT, wk before treatment; WAP, wk after planting; WAT, wk after treatment.

INTRODUCTION

Winter wheat is an economically important crop throughout much of the U.S. However, winter wheat production has declined during the past 11 yr from 49.7 million ha harvested in 1990 at a value of $5.4 billion to 31.3 million ha

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

harvested in 2001 at a value of $3.8 billion (Anonymous 2002a). Low wheat prices and other production concerns have led to this declining production.

Weeds are a major production concern in winter wheat. Producers typically encounter several winter annual broadleaf and grass weeds that compete with wheat. Italian ryegrass is ranked as one of the ten most common and troublesome weeds in wheat in all nine Southern states (Webster 2000). Wheat grain yield reductions as high as 92% have occurred from competition with Italian ryegrass (Appleby et al. 1976; Hashem et al. 1998). Liebl and Worsham (1984) reported a 5% yield loss for every 10 Italian ryegrass plants/m^2. The competitive ability of Italian ryegrass with wheat is related to the ability of ryegrass to reduce wheat tillering (Appleby et al. 1976; Ketchersid and Bridges 1987) and deplete soil nitrogen and phosphorus resources intended for wheat (Liebl and Worsham 1987; Perez-Fernandez and Coble 1998). Also, Italian ryegrass has a faster leaf expansion rate than wheat (Ball et al. 1995). Severe infestations of Italian ryegrass are not uncommon in North Carolina and Virginia wheat fields and often result in field abandonment[20].

Italian ryegrass control programs utilizing cultural practices such as wheat seeding arrangement, seeding density, and use of more competitive wheat varieties have been ineffective in reducing Italian ryegrass competition with wheat (Appleby and Brewster 1992; Hashem et al. 1998). Chemical weed management strategies are therefore the only practical means of controlling Italian ryegrass in wheat.

Diclofop-methyl was registered for Italian ryegrass control in wheat in North Carolina and Virginia in the early 1980’s. Diclofop-methyl is an aryloxyphenoxypropanoate herbicide that inhibits acetyl coenzyme A carboxylase (ACCase, EC 6.4.1.2), a chloroplastic enzyme essential to fatty acid biosynthesis in susceptible monocot species (Kocher 1984; Bravin et al. 2001).

[20]A. C. York, North Carolina State University; E. S. Hagood, Virginia Tech, personal communication.

Diclofop-methyl has controlled Italian ryegrass since its registration but repeated use of this herbicide has selected Italian ryegrass biotypes resistant to diclofop-methyl. These diclofop-methyl-resistant Italian ryegrass biotypes currently infest more than 50% of the wheat hectarage in Virginia and cause annual net losses in excess of $3.2 million[21]. Also, diclofop-methyl-resistant biotypes of many grass species are often cross resistant to other herbicides with the same mode-of-action (Cocker et al. 2001; Bourgeois et al. 1997; Bravin et al. 2001; Kuchuran and Beckie 2000). For this reason, introduction of herbicides with alternative modes-of-action are essential for wheat production in areas where diclofop-methyl-resistant Italian ryegrass populations persist.

Sulfonylurea herbicides differ from ACCase-inhibiting herbicides by inhibiting acetolactate synthase (ALS, EC 4.1.3.18), the enzyme that catalyzes the first parallel reaction in the biosynthesis of the branched chain amino acids valine, leucine, and isoleucine (Ray 1984). AE F130060 03 is an 8.3:1.7 mixture of the two experimental sulfonylurea herbicides AE F130060 00 and AE F115008 00. AE F130060 00 (proposed common name mesosulfuron-methyl) has activity primarily against monocotyledonous weeds while AE F115008 00 (proposed common name iodosulfuron-methyl-sodium) acts primarily against dicotyledonous weeds (Anonymous 2002b; Anonymous 2002c). Postemergence (POST) applications of this sulfonylurea mixture at 15 to 18 g ai/ha have effectively controlled Italian ryegrass and several winter annual dicotyledonous weed species and can be applied to wheat when used with the crop safener and adjuvant AE F107892 (proposed common name mefenpyr diethyl) (Anderson et al. 2002; Bailey et al. 2002; Crooks et al. 2002; Hand et al. 2002). AE F107892 was developed in 1993 as a crop safener for fenoxaprop-P-ethyl, but also safens certain other chemical classes (Hopkins 1997). In addition, foliar absorption of this herbicide

[21]Hagood, E. S., Jr. 2000. Application for specific exemption in accordance with section 18 of FIFRA to use Axiom herbicide to control annual ryegrass in wheat.

combination in Italian ryegrass may be enhanced with the addition of methylated seed oil (MSO) (Anonymous 2002b).

Weed growth stage can have a major impact on the efficacy of annual grass herbicides used in cereals (Blackshaw and Harker 1996). Diclofop-methyl was more effective on green foxtail (*Setaria viridis* L.) when applied at an early growth stage (Morrison and Maurice 1984). Similarly, imazamethabenz was more effective on wild oat when applied at early growth stages (Harker and O'Sullivan 1991; Pillmoor and Caseley 1984). Harker and Blackshaw (1991) found that green foxtail and wild oat (*Avena fatua* L.) control was usually better when ICIA 0604 was applied at the two- to three-leaf stage. However, later applications of ICIA 0604 often led to less weed presence at harvest because later emergence of green foxtail and wild oat often occurred after early applications (Harker and Blackshaw 1991).

Although AE F130060 03 has controlled diclofop-methyl-sensitive and –resistant Italian ryegrass at various growth stages (Bailey et al. 2002; Crooks et al. 2002), this herbicide mixture has little soil residual activity and thus does not adequately prevent additional Italian ryegrass seedling emergence following application (Anonymous 2002b). On the Eastern Shore region of Virginia, Italian ryegrass has a long germination period and can emerge any time between wheat planting and late December[22]. Therefore, application timing may be important in maximizing the utility of AE F130060 03 to prevent late-season competition from Italian ryegrass in winter wheat.

In this research, the effect of AE F130060 03 application timing relative to Italian ryegrass growth stage was investigated in comparison to diclofop-methyl. Additional objectives were to investigate the effects of AE F130060 03 application rate and MSO on diclofop-methyl-sensitive and –resistant Italian ryegrass control. Greenhouse experiments were also conducted to further quantify levels of diclofop-methyl resistance in Virginia Italian ryegrass

[22]H. P. Wilson, Virginia Tech, personal communication.

populations and investigate responses of these populations to AE F130060 03 rates.

MATERIALS AND METHODS

Greenhouse Experiments

Dose-response experiments were conducted in the greenhouse at the Eastern Shore Agricultural Research and Extension Center near Painter, VA in 2002 to evaluate growth responses of diclofop-methyl-sensitive and –resistant Italian ryegrass to incremental rates of AE F130060 03 and diclofop-methyl. Italian ryegrass seed were collected from wheat fields in Northampton Co., VA in 1998. Diclofop-methyl-sensitive Italian ryegrass was collected from a field where diclofop-methyl had not been used previously. This population was confirmed to be sensitive to diclofop-methyl at 1120 g/ha in preliminary greenhouse experiments (data not presented). Diclofop-methyl-resistant Italian ryegrass was collected from a field where diclofop-methyl had been used extensively since 1989 with insensitivity to diclofop-methyl reported by the grower in 1996. Preliminary greenhouse experiments confirmed that this population had at least two-fold resistance levels to diclofop-methyl (data not presented). Eighteen seed from each of these populations were sown in 10- by 10-cm square pots filled with growth medium[23]. Pots were watered daily and fertilized weekly[24] throughout the duration of the experiments.

Greenhouse experiments were arranged in a two by two by six factorial treatment design. Factors included Italian ryegrass population at two levels (diclofop-methyl-sensitive or diclofop-methyl-resistant), herbicide at two levels (AE F130060 03 or diclofop-methyl), and herbicide application rate at six

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[23]Metro-Mix 500, Scotts-Sierra Horticultural Products Co., Marysville, OH 43040.

[24]Peters Professional General Purpose 20-20-20. Scotts-Sierra Horticultural Products Company, 14111 Scottslawn Rd., Marysville, OH 43041.

levels (0, 1/8 X, 1/2 X, 1 X, 2 X, and 8 X). Levels of herbicide application rate correspond to 0, 1.9, 7.5, 15, 30, and 120 g ai/ha of AE F130060 03 and 0, 140, 560, 1120, 2240, and 8960 g ai/ha of diclofop-methyl. In all AE F130060 03 applications, the safener and adjuvant AE F107892 was included at rates that were twice the herbicide rate (3.8, 15, 30, 60, and 240 g ai/ha). Herbicide applications were made when Italian ryegrass reached the four-leaf stage of growth (13 to 14 cm tall). Four wk after herbicide applications, Italian ryegrass was visually evaluated for percent mortality, height was measured, and plant biomass above the soil level was harvested. Harvested biomass was dried for 2 wk and then weighed. Dry biomass of herbicide-treated Italian ryegrass was converted to percent of the dry biomass of nontreated controls of respective Italian ryegrass populations. Greenhouse experiments were completely randomized with six replications of treatments and the experiment was conducted twice.

Field Experiments

Field experiments were conducted at the Eastern Shore Agricultural Research and Extension Center near Painter, VA in 2000 and 2001 as well as in private grower fields near Cape Charles, VA in 2000 and near Pungoteague, VA in 2001. Identification of resistance patterns to diclofop-methyl, timing of important field operations, and rainfall at experimental locations are listed in Table 6.1. Experiments conducted at Painter contained a commercially-available diclofop-methyl-sensitive Italian ryegrass cultivar[25]. To insure uniform infestations of diclofop-methyl-sensitive Italian ryegrass at Painter, this commercial cultivar was broadcast uniformly onto the experimental area at 36 kg/ha on October 18, 2000 and 40 kg/ha on October 16, 2001 prior to wheat seeding. Italian ryegrass seed were lightly incorporated into the top 2.5 cm of soil with an S-tine cultivator with double rolling baskets. Two wk after

[25]Oregon Grown Premium Quality Grass Seed. Italian ryegrass, variety not stated. Wetsel, Inc., 1345 Diamond Springs Road, Virginia Beach, VA 76618.

seeding, Italian ryegrass densities at Painter were 108 and 129 plants/m^2 in 2000 and 2001, respectively.

Duplicate experiments with diclofop-methyl-resistant Italian ryegrass were conducted at a site near Cape Charles, VA in 2000 and at two sites near Pungoteague, VA in 2001. Natural infestations of diclofop-methyl-resistant Italian ryegrass were prevalent at Cape Charles and Pungoteague sites and resistance levels of at least two-fold were confirmed at each site (Table 1). At Cape Charles, the experimental site had a history of diclofop-methyl use since at least 1990, and decreased control from diclofop-methyl was observed in 1996. Preliminary greenhouse screens indicated diclofop-methyl resistance levels of at least two-fold (1680 g ai/ha diclofop-methyl) in this population (data not presented). At Pungoteague, both sites had a history of diclofop-methyl use since 1995, and decreased control from diclofop-methyl was observed in 2000. In preliminary rate response studies conducted at each of these sites, Italian ryegrass populations had at least four-fold resistance levels to diclofop-methyl (3360 g ai/ha diclofop-methyl) (data not presented). Italian ryegrass densities present at the initiation of experiments were 5 plants/m^2 at Cape Charles in 2000 and 194 and 237 plants/m^2 at sites 1 and 2, respectively, at Pungoteague in 2001.

Two d after seeding diclofop-methyl-sensitive Italian ryegrass at Painter, ‘Pocohontas’ soft red winter wheat was planted at 168 kg/ha on October 20, 2000 and October 18, 2001 using a grain drill equipped with double disk openers and press wheels on 17-cm row spacing. Soil type at Painter was a Bojac sandy loam (mixed, thermic Typic Hapludult) with pH 6.2 and <1% organic matter. ‘Pioneer 2643’ soft red winter wheat was planted at approximately 180 kg/ha using a grain drill with 18-cm row spacing at Cape Charles in late October 2000 and ‘Pioneer 26R24’ soft red winter wheat was planted at 150 kg/ha using a grain drill at both Pungoteague sites in early November 2001. Plot size at all locations was 2 by 6.1 m. The experimental design at all locations was a randomized complete block with three replications. Herbicides were applied at Painter with a tractor-mounted plot sprayer that was calibrated to deliver 236 L/ha at 207 kPa through flat fan spray tips[26]. At Cape Charles and Pungoteague, herbicides were applied with propane-pressurized backpack sprayers calibrated to deliver 195 L/ha at 207 kPa through flat-fan spray tips.

Experiments were arranged in a two by two by three factorial treatment design with AE F130060 03 rate at two levels (15 or 18 g ai/ha), MSO at two levels (no MSO or MSO at 0.5% (v/v)), and application timing at three levels (two- to three-leaf, two- to three-tiller, or four- to five-tiller Italian ryegrass). Within each application timing, diclofop-methyl at 1120 g ai/ha was included for comparison. In all AE F130060 03 applications, the safener and adjuvant AE F107892 was included at rates equal to the herbicide rate (15 or 18 g/ha). A nontreated check was included for comparison.

Wheat injury was visually estimated at all locations 2 wk after each application timing. Italian ryegrass control was visually estimated at all locations 4 wk after each application timing and again 1 to 2 wk prior to wheat harvest. Because weed control at the end of the season can have the greatest influence on yield potential and will influence harvest efficiency (Wilcut et al. 1994), only the late-season evaluations of weed control will be presented. Wheat injury and Italian ryegrass control were rated using a 0 to 100% scale where 0 = no visible wheat injury or Italian ryegrass control and 100 = complete wheat death or complete Italian ryegrass control (Frans et al. 1986). Also, at the time of late-season Italian ryegrass control ratings, counts of Italian ryegrass inflorescences/m^2 were made at all locations except Cape Charles. Wheat grain was harvested at Painter on June 20, 2001 and June 11, 2002, weighed, and grain yield was adjusted to 13.5% moisture. In 2002, one grain sample of approximately 100 g was collected from each plot as wheat was

[26]TeeJet 8003 flat fan spray tips, Spraying Systems Co., North Ave., Wheaton, IL 60188.

harvested at Painter. Grain samples were dried and percent moisture per plot was calculated. Samples were then cleaned using U.S. Standard No. 8 and No. 10 sieves[27] and amounts of Italian ryegrass seed in harvested grain were determined as a percentage of grain sample weight. Grain was not harvested at the Cape Charles and Pungoteague locations.

Greenhouse and field data were subjected to factorial analyses of variance in SAS[28] with sums of squares partitioned to reflect the factorial treatment designs. Data from nontreated controls were not included in the factorial analysis, but inflorescence emergence and yield data from nontreated controls were included in single-degree-of-freedom pairwise comparisons of all herbicide treatments against the nontreated control. Separation of appropriate means is based on Fisher’s protected LSD at P=0.05. Homogeneity of data for greenhouse experiments allowed pooling of data over experiments. Field data were combined over years or locations when appropriate. Analysis of data residual plots indicated heterogeneity of variance among wheat injury and Italian ryegrass control data. Therefore, data for wheat injury and Italian ryegrass control were arcsine transformed prior to analysis. Mean separation for wheat injury and Italian ryegrass control data are based on transformed data, although nontransformed means are presented for clarity.

RESULTS AND DISCUSSION

Greenhouse Experiments

Percent biomass reduction of Italian ryegrass by AE F130060 03 differed between diclofop-methyl-sensitive and –resistant Italian ryegrass populations at the 1/8 X, 1/2 X, and 1 X rates (1.9, 7.5, and 15 g/ha, respectively) (Figure

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[27]U.S. Standard Testing Sieves. Fisher Scientific Company. Fair Lawn, NJ 07410.

[28]Statistical Analysis Systems (SAS) software, Version 7.0, SAS Institute, Inc., Box 8000, SAS Circle, Cary, NC 27513.

6.1A). At these rates, AE F130060 03 reduced biomass of diclofop-methyl-sensitive Italian ryegrass 57, 65, and 76%, respectively. Biomass reduction of diclofop-methyl-resistant Italian ryegrass was 28, 43, and 48% at 1/8 X, 1/2 X, and 1 X rates. When AE F130060 03 application rates were increased to 2 X and 8 X rates, biomass reductions in the two Italian ryegrass populations were similar, with reductions of 73 to 84% with 2 X application rates and 80 to 88% with 8 X application rates.

As expected, growth responses of the two Italian ryegrass populations to diclofop-methyl differed at all application rates (Figure 6.1B). Even in the diclofop-methyl-sensitive population, substantial reductions in biomass production (49%) occurred only when diclofop-methyl rates were increased to at least 2 X and increased further to 83% biomass reduction at the 8 X rate. In diclofop-methyl-resistant Italian ryegrass, biomass reduction was only 2 to 4% from 1/8 X, 1/2 X, and 1 X application rates, and was no more than 10 to 13% from 2 X and 8 X application rates.

Field Experiments

Diclofop-methyl-sensitive Italian ryegrass

Wheat response. There was sufficient homogeneity in data for wheat injury at Painter between 2000 and 2001 to allow pooling of data over the two years. Analysis of variance indicated a significant MSO by application timing interaction for wheat injury at Painter, so data are presented accordingly. Wheat injury occurred from AE F130060 03 at any application timing. However, this injury was generally transitory and was not evident by late season. Appearance of injury to wheat was a general stunting with some discoloration (purpling), particularly when colder temperatures occurred at the time of and shortly after application. At all application timings except those made to two- to three-leaf Italian ryegrass, MSO did not influence wheat injury. MSO increased injury from 14 to 18% when AE F130060 03 was applied at 18 g/ha to two- to three-leaf Italian ryegrass (Table 6.2).

AE F130060 03 application timing had the greatest influence on wheat injury. Within each application rate and MSO combination, greatest wheat injury usually occurred with later applications made to four- to five-tiller Italian ryegrass. Conversely, least amounts of wheat injury occurred from applications made to two- to three-tiller Italian ryegrass. At any application timing, wheat injury from any AE F130060 03 treatment was greater than injury from diclofop-methyl, which caused no more than 3% wheat injury at any application timing.

Italian ryegrass control. Significant year by herbicide treatment interaction occurred between diclofop-methyl-sensitive Italian ryegrass control data in 2000 and 2001; therefore data are presented by year. In 2000, AE F130060 03 application rate or MSO did not influence Italian ryegrass control at any application timing; therefore, AE F130060 03 data are averaged over rate and MSO. Application timing had the greatest effect on Italian ryegrass control, as four- to five-tiller applications resulted in better late-season Italian ryegrass control. Late-season Italian ryegrass control from AE F130060 03 was 86 and 82% when applications were made to two- to three-leaf or two- to three-tiller Italian ryegrass, respectively. When applications were made to four- to five-tiller Italian ryegrass, control was increased to 97% (Table 6.3). Two- to three- tiller or four- to five-tiller applications of AE F130060 03 were more effective than diclofop-methyl in controlling diclofop-methyl-sensitive Italian ryegrass. Other researchers have also noted decreased grass control when diclofop-methyl is applied at later growth stages (Schreiber et al. 1979).

In 2001, neither AE F130060 03 application rate nor MSO affected Italian ryegrass control from two- to three-leaf or four- to five-tiller applications. However, AE F130060 03 controlled two- to three-tiller Italian ryegrass better when applied at 18 g/ha or with MSO. AE F130060 03 at 15 g/ha controlled two-to three-tiller Italian ryegrass 82% and this control was similar to diclofop-methyl (78%) (Table 6.3). Control increased to 88 to 90% when AE F130060 03 was applied at 15 g/ha with MSO or at 18 g/ha with or without MSO. Two- to three-leaf applications of AE F130060 03 controlled diclofop-methyl-sensitive Italian ryegrass 82 to 86%. Consistent with data from 2000, most effective late-season Italian ryegrass control occurred from AE F130060 03 applications made to four- to five-tiller Italian ryegrass. These applications controlled Italian ryegrass 98 to 99% regardless of rate and the presence or absence of MSO. Control from diclofop-methyl was also better with later applications. Diclofop-methyl controlled Italian ryegrass 78% at the two- to three-leaf timing, 86% at the two- to three-tiller timing, and similar to AE F130060 03 (97%) at the four- to five-tiller timing.

Inflorescence emergence. Due to a significant year by herbicide treatment interaction, data for Italian ryegrass inflorescence emergence are presented separately by year. In 2000, Italian ryegrass inflorescence emergence was not influenced by AE F130060 03 application timing, rate, or the addition of MSO, as Italian ryegrass that received any AE F130060 03 treatment produced no more than 2 inflorescences/m^2 (Table 6.4). Inflorescence emergence was lower in Italian ryegrass treated with AE F130060 03 than in diclofop-methyl-treated Italian ryegrass (8 inflorescences/m^2). Nontreated Italian ryegrass produced 102 inflorescence/m^2 in 2000.

In 2001, Italian ryegrass inflorescence emergence was influenced primarily by application timing, and also by MSO in treatments applied to two- to three-tiller Italian ryegrass. With applications made to two- to three-tiller Italian ryegrass, inflorescence emergence was 53 and 48 inflorescences/m^2 following applications of AE F130060 03 at 15 or 18 g/ha, respectively (Table 6.4). When MSO was included in these applications, inflorescence emergence decreased to 28 to 39 inflorescences/m^2 and was similar to inflorescence emergence in diclofop-methyl-treated Italian ryegrass. With herbicide applications made to two- to three-leaf Italian ryegrass, inflorescence emergence ranged from 44 to 75 inflorescences/m^2. Within all AE F130060 03 treatments, fewest inflorescences emerged from Italian ryegrass treated at the four- to five-tiller stage of growth (3 to 8 inflorescences/m^2). Later applications of diclofop-methyl also resulted in fewer inflorescences. Inflorescence emergence in Italian ryegrass treated with diclofop-methyl decreased from 59 inflorescences/m^2 with two- to three-leaf applications to 4 inflorescences/m^2 with four- to five-tiller applications. Nontreated Italian ryegrass produced 183 inflorescences/m^2 in 2001.

Although Italian ryegrass control from AE F130060 03 was generally similar between 2000 and 2001, greater overall inflorescence emergence occurred in 2001. These differences may be attributed to slightly lower planting rates of diclofop-methyl-sensitive Italian ryegrass and also better moisture conditions before and after applications in 2000 (Table 6.1).

Wheat yield. Year by herbicide treatment interaction occurred for wheat yield data, so yield data are presented by year. In 2000, wheat yields were influenced by AE F130060 03 application timing and MSO. Data are averaged over AE F130060 03 application rate since this factor did not influence wheat yield. Effects of MSO occurred only with AE F130060 03 applications made to two- to three-leaf Italian ryegrass. Wheat treated with AE F13006 03 at 15 g/ha or 18 g/ha at the early application timing produced 5125 kg/ha. When MSO was included in these treatments, wheat produced 5400 kg/ha (Table 6.5). Similar yield occurred from wheat treated with early applications of diclofop-methyl. Within two- to three-tiller applications, however, wheat treated with any herbicide produced 5140 to 5450 kg/ha. Likewise, wheat that received any four- to five-tiller herbicide application produced 4920 to 5110 kg/ha.

Application timing also influenced yield of wheat treated with diclofop-methyl, as yield of diclofop-methyl-treated wheat decreased from 5480 kg/ha following applications to two- to three-leaf Italian ryegrass to 4920 kg/ha following applications made to four- to five-tiller Italian ryegrass. Decreased yield from wheat treated with later diclofop-methyl applications may be indicative of the effects of decreased Italian ryegrass control from later applications in 2000. All herbicide applications made at any timing, however, resulted in wheat yield that was higher than nontreated wheat (4080 kg/ha).

In 2001, yields of wheat treated with any AE F130060 03 treatment were not affected by application timing, rate, or MSO. Similarly, yield of diclofop-methyl-treated wheat was not influenced by application timing. Yields of wheat that received any herbicide treatment were similar, ranging from 4640 to 5150 kg/ha. These yields were significantly greater than yields of nontreated wheat (2150 kg/ha) (data not presented).

Although herbicide treatment influenced Italian ryegrass control and subsequent inflorescence emergence in 2001, Italian ryegrass was sufficiently dry at the time of wheat harvest that moisture of harvested wheat grain was not affected. Percent moisture in collected grain samples was 9.3 to 9.9% in any treatment (data not presented). However, the percentage of sample dry weight attributed to Italian ryegrass seed was lower in herbicide-treated wheat compared to nontreated wheat. Grain samples collected from wheat treated with any AE F130060 03 treatment or diclofop-methyl contained 0.12 to 0.34% Italian ryegrass seed (by wt.). Grain samples of nontreated wheat contained 1% Italian ryegrass seed (by wt.) (data not presented).

Diclofop-methyl-resistant Italian ryegrass

Wheat response. Significant location by herbicide treatment interaction occurred for wheat injury; therefore, data are presented by location. Wheat injury at Cape Charles was affected only by application timing; therefore, AE F130060 03 data are averaged over application rate and MSO. At both Pungoteague sites, significant AE F130060 03 application rate by timing and/or MSO by timing interactions occurred; therefore, data are presented for all herbicide treatments and application timings.

Similar to wheat injury at Painter, AE F130060 03 applications made to diclofop-methyl resistant Italian ryegrass resulted in wheat injury that was greater than injury from diclofop-methyl. Wheat injury from diclofop-methyl never exceeded 2% at any diclofop-methyl-resistant location (Table 6.6). At Cape Charles in 2000, greatest injury from any AE F130060 03 treatment occurred from applications made to two- to three-tiller Italian ryegrass (14 to 18%). Within two- to three-leaf and two- to three-tiller application timings, wheat injury increased with the addition of MSO to AE F130060 03 at 15 g/ha. With applications made to two- to three-leaf Italian ryegrass, injury was 7% from AE F130060 03 applied without MSO and increased to 9% with the addition of MSO. With mid-season applications made to two- to three-tiller Italian ryegrass, wheat injury from AE F130060 03 was 14% at 2 WAT and increased to 18% with the addition of MSO. Four- to five-tiller applications of AE F130060 03 resulted in 4 to 5% wheat injury that was independent of application rate and MSO.

Less wheat injury generally occurred following mid-season AE F130060 03 applications to two- to three-tiller Italian ryegrass at the first site near Pungoteague in 2001. Two wk following mid-season applications, injury ranged from 10 to 14% regardless of AE F130060 03 application rate or the addition of MSO (Table 6.6). Two wk following early-season or late-season applications wheat injury ranged from 12 to 29%. At both early- and late-season application timings, injury from AE F130060 03 at 15 g/ha was increased by the addition of MSO. Additionally, wheat injury from early-season applications increased with rate and MSO addition.

Wheat injury patterns at the second site near Pungoteague in 2001 were similar to patterns seen at Cape Charles in that greatest injury generally occurred from AE F130060 03 applications to two- to three-tiller Italian ryegrass. Wheat injury ranged from 7 to 15% from two- to three-leaf applications of AE F130060 03, 31 to 41% from two- to three-tiller applications, and 18 to 35% from four- to five-tiller applications (Table 6.6). Early-season wheat injury from AE F130060 03 was influenced by application rate, where 15 g/ha resulted in 7 to 8% injury and 18 g/ha increased injury to 14 to 15%. Within mid-season applications, AE F130060 03 at 15 g/ha caused 31% wheat injury that increased to 39 to 41% when MSO was added or when rate was increased to 18 g/ha with or without MSO. Within the late-season application timing, wheat injury from AE F130060 03 at 15 g/ha was 18% and increased to 35% with the addition of MSO.

Italian ryegrass control. Significant location by herbicide treatment interaction occurred for diclofop-methyl-resistant Italian ryegrass control between Cape Charles and Pungoteague locations. However, no location by herbicide treatment interaction occurred between data for the two Pungoteague sites. Therefore, data are presented separately for Cape Charles and averaged over the two Pungoteague sites. At Cape Charles in 2000, Italian ryegrass control was not affected by AE F130060 03 application timing, rate, or the addition of MSO. Therefore, AE F130060 03 data from Cape Charles are averaged over application timing, rate, and MSO. All AE F130060 03 treatments controlled diclofop-methyl-resistant Italian ryegrass 97% while diclofop-methyl controlled this population only 6% (Table 6.7).

At Pungoteague sites, diclofop-methyl-resistant Italian ryegrass control by AE F130060 03 was influenced only by application timing, so AE F130060 03 data are averaged over application rate and MSO. AE F130060 03 controlled Italian ryegrass at Pungoteague sites best with applications made to two- to three-tiller Italian ryegrass. Late-season Italian ryegrass control from AE F130060 03 at either Puntoteague site were 71% from two- to three-leaf applications, 96% from two- to three-tiller applications, and 84% from four- to five-tiller applications (Table 6.7). Control of Pungoteague populations of diclofop-methyl-resistant Italian ryegrass from diclofop-methyl ranged from 30 to 43%.

Decreased Italian ryegrass control from four- to five-tiller applications of AE F130060 03 are most likely due to heavy densities of Italian ryegrass that occurred at each of the Pungoteague sites. Italian ryegrass densities present at the initiation of these experiments were 194 plants/m^2 at site 1 and 237 plants/m^2 at site 2, compared to densities of 108 to 129 plants/m^2 in the population sown at Painter in 2000 and 2001, respectively (Table 6.1). Initial Italian ryegrass densities at Pungoteague likely increased further by the time of four- to five-tiller applications. Heavy Italian ryegrass densities coupled with enlarging wheat canopies could have compromised coverage of Italian ryegrass in later AE F130060 03 applications. Nonetheless, late-season Italian ryegrass control from four- to five-tiller applications was still 84%.

In comparing data from diclofop-methyl-resistant Italian ryegrass locations, lack of an AE F130060 03 application timing effect and generally better control at Cape Charles may also be related to lower Italian ryegrass densities and better moisture conditions before and after early applications at Cape Charles. Initial Italian ryegrass densities at Cape Charles were only 5 plants/m^2 compared to 194 and 237 plants/m^2 at Pungoteague sites (Table 6.1). Also, 1.37 cm of rainfall occurred in the 2 wk prior to two- to three-leaf applications at Cape Charles followed by an additional 5.31 cm of rainfall after application (Table 1). At both Pungoteague sites, no rainfall occurred in the 2 wk prior to or 2 wk after two- to three-leaf applications. Lack of rainfall and greater Italian ryegrass densities at Pungoteague may have resulted in early-season plant stress that made Italian ryegrass more difficult to control with two- to three-leaf applications. Decreased Italian ryegrass control from POST herbicides has been reported when this weed was under drought stress and at high densities (Burrill and Appleby 1978).

Inflorescence emergence. Relatively low Italian ryegrass densities (5 plants/m^2) at Cape Charles did not warrant measurement of Italian ryegrass inflorescence emergence. However, diclofop-methyl-resistant inflorescence emergence was recorded at both Pungoteague sites, where natural diclofop-methyl-resistant Italian ryegrass densities were nearly twice as great as the diclofop-methyl-sensitive population sown at Painter (Table 6.1).

Data are averaged over the two Pungoteague sites due to lack of a location by herbicide treatment interaction for Italian ryegrass inflorescence emergence. Inflorescence emergence at Pungoteague reflected the effects seen in Italian ryegrass control, as inflorescence emergence was influenced only by AE F130060 03 application timing. Reductions in inflorescence emergence were greatest from AE F130060 03 applications to two- to three-tiller Italian ryegrass. AE F130060 03 reduced inflorescence emergence 67% with two- to three-leaf applications, 98% with two- to three-tiller applications, and 85% with four- to five-tiller applications (Table 6.8). As expected, AE F130060 03 controlled and reduced diclofop-methyl-resistant Italian ryegrass inflorescence emergence greater than diclofop-methyl, which reduced inflorescence emergence 27 to 44% (171 to 221 inflorescences/m^2). All herbicide applications reduced inflorescence emergence compared to the nontreated control, which produced 304 inflorescences/m^2.

Similar to trends observed in Italian ryegrass control, intensive Italian ryegrass densities present at Pungoteague at the time of four- to five-tiller AE F130060 03 applications most likely contributed to increased Italian ryegrass inflorescence emergence compared to earlier applications made to two- to three-tiller Italian ryegrass.

Although AE F130060 03 controls Italian ryegrass from the two- to three-leaf stage until the end of tillering, this herbicide mixture does not prevent additional Italian ryegrass germination and emergence following application (Anonymous 2002b). These results illustrate that, under moderate Italian ryegrass densities of up to 129 plants/m^2, later applications to four- to five-tiller Italian ryegrass may result in lesser emergence following application and consequently lesser inflorescence emergence to potentially interfere with harvest at the end of the season. At higher Italian ryegrass densities, mid-season applications made to two- to three-tiller Italian ryegrass may be most effective in controlling Italian ryegrass and reducing inflorescence emergence at the end of the season. At moderate or high densities, early applications made to two- to three-leaf Italian ryegrass resulted in the greatest emergence following application and would most likely result in the greatest late-season competition with wheat.

While results from greenhouse experiments showed differential responses of four-leaf diclofop-methyl-sensitive and –resistant Italian ryegrass to AE F130060 03 at normal and below-normal rates, increasing application rates resulted in similar reductions in biomass of diclofop-methyl-sensitive and –resistant Italian ryegrass. Obvious differences in responses of diclofop-methyl-sensitive and –resistant Italian ryegrass to AE F130060 03 did not occur in field experiments. Four wk after each application timing at Painter and Cape Charles and after two- to three-leaf and two- to three-tiller applications at Pungoteague sites, diclofop-methyl-sensitive and –resistant Italian ryegrass treated with any AE F130060 03 treatment was controlled at least 95% (data not presented). In all cases, with the exception of the four- to five-tiller application at Cape Charles, it was apparent that reduced late-season Italian ryegrass control from earlier applications was due to emergence of Italian ryegrass following application. Even under heavy Italian ryegrass densities at the time of four- to five-tiller applications at Pungoteague sites where control from AE F130060 03 was lower than from four- to five-tiller applications at Painter, control was still 84%.

In these experiments, AE F130060 03 controlled and reduced inflorescence emergence of both diclofop-methyl-sensitive and –resistant Italian ryegrass.

As expected, AE F130060 03 was more effective against diclofop-methyl-resistant Italian ryegrass than diclofop-methyl and, in several instances, was more effective than diclofop-methyl on diclofop-methyl-sensitive Italian ryegrass. Although AE F130060 03 caused greater wheat injury than diclofop-methyl at any application timing, wheat recovered and yields were not affected. Wheat treated with any AE F130060 03 treatment produced yields that were at least 21% greater than nontreated wheat in 2000 and at least 116% greater than nontreated wheat in 2001. According to these results, AE F130060 03 is an effective herbicide for control of Italian ryegrass. However, applicators wishing to make a single application of this herbicide should be judicious in choosing the application timing and avoid early applications prior to Italian ryegrass tillering to minimize Italian ryegrass emergence after application.

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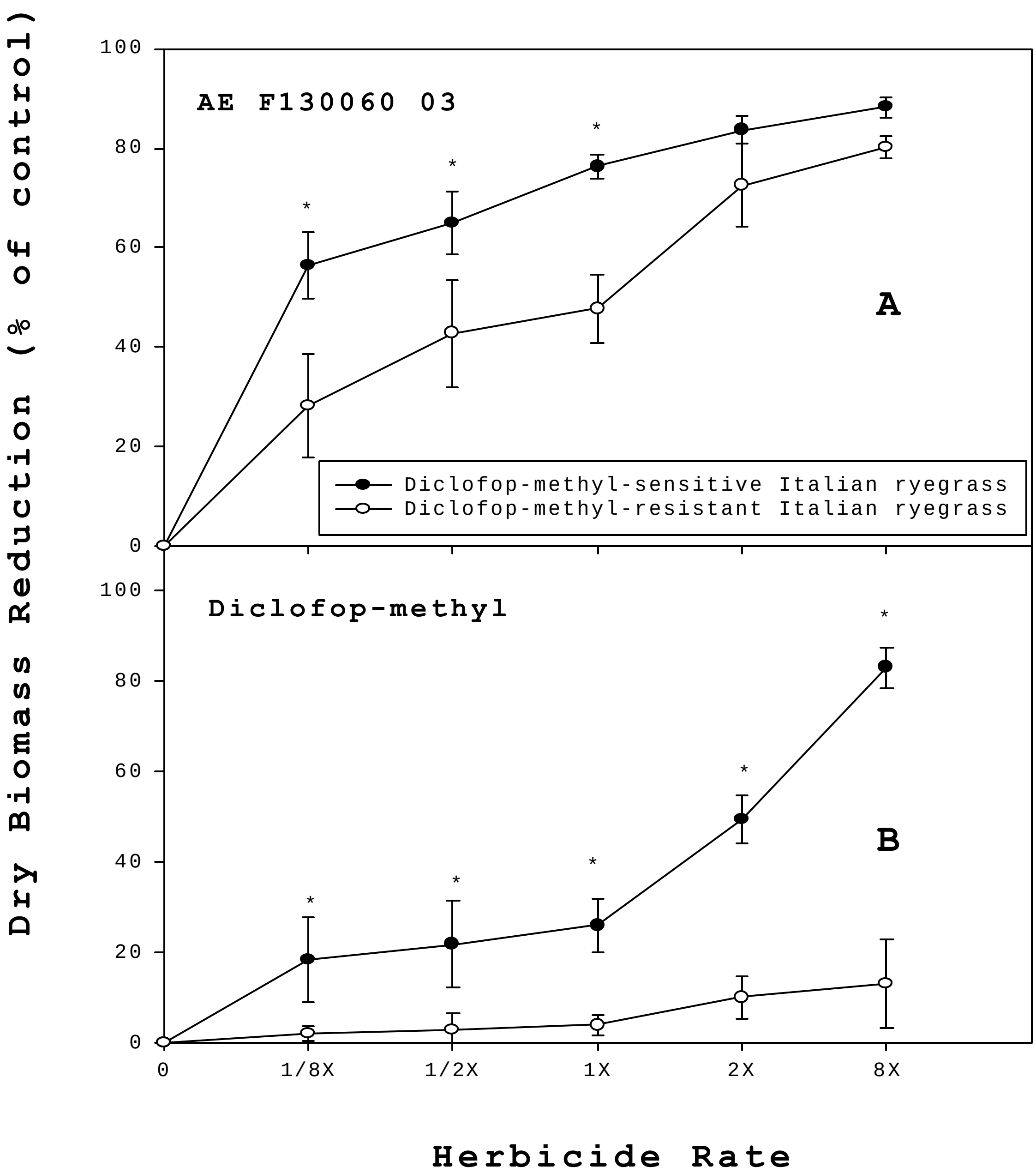
CAPTIONS FOR FIGURES

Figure 6.1. Growth responses of diclofop-methyl-sensitive and –resistant Italian ryegrass to incremental rates of AE F130060 03 (6.1A) and diclofop-methyl (6.1B) as a percent of nontreated dry biomass. 1/8 X, 1/2 X, X, 2 X, and 8 X rate increments correspond to 1.9, 7.5, 15, 30, and 120 g ai/ha AE F130060 03 and 140, 560, 1120, 2240, and 8960 g ai/ha diclofop-methyl, respectively. Error bars represent the standard error of the mean of two experiments with six replications per experiment. Asterisks denote significant difference between Italian ryegrass population within a rate of herbicide at the P = 0.05 significance level.



Dry Biomass Reduction (% of control)
100
80
60
40
20
0
AE F130060 03
A
Diclofop-methyl-sensitive Italian ryegrass
Diclofop-methyl-resistant Italian ryegrass
Diclofop-methyl
B
0
1/8X
1/2X
1X
2X
8X
Herbicide Rate

Table 6.1. Levels of diclofop-methyl resistance and densities of Italian ryegrass populations, and rainfall before and after herbicide applications in Accomack and Northampton Co., VA in 2000 and 2001.

		Italian ryegrass				Rainfall	
Year	Location	Diclofop-methyl resistance	Density	Application timing	Application date	2 WBT	2 WAT
			— plants/m^2 —			cm	
2000	Painter	0	108	two-three-leaf	11-13-00	0.15	3.99
				two-three-tiller	11-20-00	1.19	3.02
				four- to five-tiller	2-20-01	3.15	2.67
2000	Cape Charles	≥two-fold	5	two- to three-leaf	2-3-01	1.37	5.31
				two- to three-tiller	3-8-01	2.11	6.93
				four- to five-tiller	4-8-01	3.71	3.61
2001	Painter	0	129	two- to three-leaf	11-7-01	0.05	0
				two- to three-tiller	12-4-01	0.23	0
				four- to five-tiller	1-2-02	0	5.18
2001	Pungoteague	≥four-fold	194	two- to three-leaf	12-16-01	0	0
				two- to three-tiller	1-31-02	4.47	2.51
				four- to five-tiller	3-10-02	2.39	4.62
2001	Pungoteague	≥four-fold	237	two- to three-leaf	12-16-01	0	0
				two- to three-tiller	3-5-02	2.39	4.06
				four- to five-tiller	3-10-02	2.39	4.62

[a]Abbreviations: WBT = wk before treatment; WAT = wk after treatment.

Table 6.2. Influence of herbicide rate and application timing on wheat injury 2 wk following herbicide applications for control of diclofop-methyl-sensitive Italian ryegrass near Painter, VA in 2000 and 2001.

		Wheat injury[abcd]		
	Herbicide	Italian ryegrass growth stage at application		
Herbicides	application rate	two- to three-leaf	two- to three-tiller	four- to five-tiller
	g/ha		%	
AE F130060 03[e]	15	17 abA	8 aB	19 aA
AE F130060 03 + MSO[f]	15	14 bB	8 aB	23 aA
AE F130060 03	18	14 bB	8 aB	23 aA
AE F130060 03 + MSO	18	18 aB	9 aC	24 aA
Diclofop-methyl	1120	0 cA	2 bA	3 bA

[a]Data averaged over years.

[b]Wheat injury data collected 2 wk after each application timing.

[c]Means within a column followed by the same lowercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[d]Means within a row followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[e]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

[f]AE F130060 03 applied with methylated seed oil (MSO) at 0.5% (v/v).

Table 6.3. Influence of herbicide rate and application timing on diclofop-methyl-sensitive Italian ryegrass control near Painter, VA.

Herbicides	Herbicide application rate	Italian ryegrass control[abcd] — Italian ryegrass growth stage at application: two- to three-leaf	two- to three-tiller	four- to five-tiller
	g/ha	%		
2000[e]*:*				
AE F130060 03	-	86 aB	82 aB	97 aA
Diclofop-methyl	1120	80 aA	77 bA	70 bA
2001:				
AE F130060 03[f]	15	82 abB	82 cB	98 abA
AE F130060 03 + MSO[g]	15	83 abB	88 abB	99 aA
AE F130060 03	18	83 abC	89 abB	99 aA
AE F130060 03 + MSO	18	86 aC	90 aB	99 aA
Diclofop-methyl	1120	78 bC	86 bcB	97 bA

[a]Data presented by year.

[b]Italian ryegrass control data collected late season 1 wk prior to wheat harvest.

[c]Means within a column and year followed by the same lowercase letter are not significantly different according to Fisher’s protected LSD at P = 0.05.

[d]Means within a row and year followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[e]Data for AE F130060 03 treatments averaged over rate and MSO in 2000.

[f]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

[g]AE F130060 03 applied with methylated seed oil (MSO) at 0.5% (v/v).

Table 6.4. Influence of herbicide rate and application timing on diclofop-methyl-sensitive Italian ryegrass inflorescence emergence near Painter, VA.

		Italian ryegrass inflorescence emergence[abcd]			
			2002[f]		
	Herbicide		Italian ryegrass growth stage at application		
Herbicides	application rate	2001[e]	two- to three-leaf	two- to three-tiller	four- to five-tiller
	g/ha	inflorescences/m^2			
AE F130060 03[g]	15	2 b	75 aA	53 aA	4 aB
AE F130060 03 + MSO[h]	15	0 b	47 aA	28 bcAB	4 aB
AE F130060 03	18	0 b	47 aA	48 abA	3 aB
AE F130060 03 + MSO	18	1 b	44 aA	39 abcAB	8 aB
Diclofop-methyl	1120	8 a	59 aA	17 cB	4 aB
Nontreated control		102*[i]	183*		

[a]Data presented by year.

[b]Inflorescence emergence recorded late season 1 wk prior to wheat harvest.

[c]Means within a column and year followed by the same lowercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[d]Means within a row and year followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[e]Inflorescence emergence data for 2001 averaged over application timing.

[f]Inflorescence emergence data for 2002 presented by application timing.

[g]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

[h]AE F130060 03 applied with methylated seed oil (MSO) at 0.5% (v/v).

[i](*) = Inflorescence emergence in nontreated control significantly higher than in herbicide-treated plots according to Fisher's protected LSD at $P = 0.05$.

Table 6.5. Wheat yield following herbicide applications for control of diclofop-methyl-sensitive Italian ryegrass near Painter, VA in 2000.

		Wheat yield[ab]		
	Herbicide	Italian ryegrass growth stage at application		
Herbicides	application rate	two- to three-leaf	two- to three-tiller	four- to five-tiller
	g/ha	kg/ha		
AE F130060 03[cd]	-	5125 bA	5140 aA	5020 aA
AE F130060 03 + MSO[e]	-	5400 aA	5270 aA	5110 aA
Diclofop-methyl	1120	5480 aA	5450 aA	4920 aB
Nontreated control		4080*[f]		

[a]Means within a column followed by the same lowercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[b]Means within a row followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[c]Data for AE F130060 03 treatments averaged over application rate.

[d]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

[e]AE F130060 03 applied with methylated seed oil (MSO) at 0.5% (v/v).

[f](*) = Wheat grain yield in nontreated control significantly lower than in herbicide-treated plots according to Fisher's protected LSD at P = 0.05.

Table 6.6. Wheat injury following herbicide applications for diclofop-methyl-resistant Italian ryegrass control near Cape Charles and Pungoteague, VA.

		Wheat injury[abcd]		
	Herbicide	Italian ryegrass growth stage at application		
Herbicides	application rate	two- to three-leaf	two- to three-tiller	four- to five-tiller
	g/ha	%		
Cape Charles[e]*:*				
AE F130060 03[f]	15	7 bB	14 bA	4 aB
AE F130060 03 + MSO[g]	15	9 aB	18 aA	5 aB
Diclofop-methyl	1120	0 dA	0 cA	0 cA
Pungoteague site 1:				
AE F130060 03	15	12 dAB	10 aB	19 bA
AE F130060 03 + MSO	15	16 cB	10 aB	29 aA
AE F130060 03	18	20 bA	14 aA	22 abA
AE F130060 03 + MSO	18	25 aA	12 aB	23 abA
Diclofop-methyl	1120	0 eA	2 bA	2 cA
Pungoteague site 2:				
AE F130060 03	15	7 bC	31 bA	18 bB
AE F130060 03 + MSO	15	8 bB	40 aA	35 aA

AE F130060 03	18	14 aC	41 aA	22 bB
AE F130060 03 + MSO	18	15 aB	39 aA	24 bB
Diclofop-methyl	1120	2 cA	0 cA	1 cA

[a]Data presented by location.

[b]Wheat injury data collected 2 wk after each application timing.

[c]Means within a column and location followed by the same lowercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[d]Means within a row and location followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[e]Data for AE F130060 03 treatments at Cape Charles averaged over application rate.

[f]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

[g]AE F130060 03 applied with methylated seed oil (MSO) at 0.5% (v/v).

Table 6.7. Influence of herbicide application timing on diclofop-methyl-resistant Italian ryegrass control near Cape Charles and Pungoteague, VA.

Herbicides	Herbicide application rate	Italian ryegrass control[abcd]			
			Pungoteague sites[fg]		
			Italian ryegrass growth stage at application		
		Cape Charles[e]	two- to three-leaf	two- to three-tiller	four- to five-tiller
	g/ha	%			
AE F130060 03[hi]	-	97 a	71 aC	96 aA	84 aB
Diclofop-methyl	1120	6 b	43 bA	30 bB	35 bAB

[a]Data presented by location.

[b]Italian ryegrass control recorded late season 1 wk prior to wheat harvest.

[c]Means within a column followed by the same lowercase letter within a location are not significantly different according to Fisher's protected LSD at P = 0.05.

[d]Means within a row followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[e]Italian ryegrass control data for Cape Charles averaged over application timing.

[f]Italian ryegrass control data for Pungoteague sites presented by application timing.

[g]Italian ryegrass control data averaged over Pungoteague sites.

[h]Data for AE F130060 03 treatments averaged over application rate and MSO.

[i]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

Table 6.8. Diclofop-methyl-resistant Italian ryegrass inflorescence emergence following herbicide applications near Pungoteague, VA in 2002.

		Italian ryegrass inflorescence emergence[abc]		
	Herbicide	Italian ryegrass growth stage at application		
Herbicides	application rate	two- to three-leaf	two- to three-tiller	four- to five-tiller
	—— g/ha ——	—— inflorescences/m^2 ——		
AE F130060 03[de]	15	99 bA	6 bC	45 bB
Diclofop-methyl	1120	171 aA	221 aA	184 aA
Nontreated control		—— 304*[f] ——		

[a]Data averaged over Pungoteague sites.

[b]Means within a column followed by the same lowercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[c]Means within a row followed by the same uppercase letter are not significantly different according to Fisher's protected LSD at P = 0.05.

[d]Data for AE F130060 03 treatments averaged over application rate and MSO.

[e]Crop safener and adjuvant AE F107892 included with all AE F130060 03 applications at 15 or 18 g/ha.

[f](*) = Inflorescence emergence in nontreated control significantly higher than in herbicide-treated plots according to Fisher's protected LSD at P = 0.05.