WINTER CROP ROTATION WITH HERBICIDES TO CONTROL FERAL RYE (*SECALE CEREALE*) AND ITALIAN RYEGRASS (*LOLIUM PERENNE* SSP. *MULTIFLORUM*)

By

Joshua Aaron Bushong

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Thesis Approved:

Dr. Thomas F. Peeper

Thesis Adviser

Dr. Don S. Murray

Dr. Francis M. Epplin

Dr. A. Gordon Emslie

Dean of the Graduate College

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

This thesis is a manuscript to be submitted for publication in Weed Technology, a Weed Science Society of America publication.

WINTER CROP ROTATION WITH HERBICIDES TO

CONTROL FERAL RYE (*SECALE CEREALE*)

AND ITALIAN RYEGRASS (*LOLIUM*

PERENNE SSP. *MULTIFLORUM*)

Winter Crop Rotation and Herbicides to Control Feral Rye (*Secale cereale*) and Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*).[1]

Joshua A. Bushong [2]

Limited control options and herbicide resistance have increased feral rye and Italian ryegrass infestations in winter wheat in Oklahoma. A rotation with winter canola would increase control options. Field experiments were established in the fall of 2007 at four sites in Oklahoma to evaluate herbicide programs for controlling these two grasses in continuous winter wheat and in a winter wheat–winter canola rotation. Factors include the herbicide treatment applied to wheat in year one (untreated, imazamox + MCPA, or pinoxaden) and the crop-herbicide combination the second year. Crop-herbicide combinations in year two included a second year of wheat with the same herbicide treatments as the first year or winter canola with eight herbicide treatments. All herbicides were applied at labelled rates with appropriate additives. Weed densities were determined prior to planting a crop the third year. Pinoxaden reduced Italian ryegrass seed in harvested wheat 88 to 100% and reduced harvested feral rye seed only 18% at

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[2] Agriculturalist, Plant and Soil Sciences Department, Oklahoma State University, 368 Agriculture Hall, Stillwater, OK 74078. Corresponding author's E-mail: josh.bushong@okstate.edu

two sites with no reduction at two sites the first crop year. Imazamox + MCPA reduced Italian ryegrass seed in harvested wheat 38 to 65% at three sites with no reduction at one site and reduced feral rye seed 96% at two sites and 58% at two sites the first year. Imazamox + MCPA increased wheat yields 21 to 34%. Pinoxaden increased wheat yields 14% pooled over three sites but did not affect yield at one site. Rye was sparse in all treatments the second year. Italian ryegrass control in treatments with continuous wheat was higher with any pinoxaden treatment applied one or both years than with any imazamox + MCPA treatment. Italian ryegrass control with imazamox + MCPA was inconsistent across locations. All of the herbicide treatments in winter canola except trifluralin PPI without a sequential POST treatment controlled Italian ryegrass comparable to pinoxaden applied to wheat. Italian ryegrass densities after two crops with herbicide applied were greatly reduced but the weed was not completely eliminated.

Nomenclature: Clethodim; glyphosate; imazamox; MCPA; pinoxaden; quizalofop; trifluralin; feral rye, *Secale cereale* L. #[3] SECCE; Italian ryegrass, *Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot # LOLMU; canola, *Brassica napus* L. 'DKW 41-10'; wheat, *Triticum aestivum* L., 'Centerfield'.

Key words: winter wheat, winter canola, wheat-canola rotation, SECCE, LOLMU.

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[3]Letters following this symbol are WSSA-approved computer codes from Composite List of Weeds, Revised 2010. Available from WSSA.

Introduction

Winter wheat production in the southern Great Plains has become increasingly difficult due to infestations of winter annual grasses (Barnes, et al. 2001), particularly Italian ryegrass and feral rye. Italian ryegrass has become an important weed in winter wheat throughout several regions of the United States (Appleby et al. 1976; Trusler et al. 2007). In Oklahoma much of the winter wheat production is managed within a continuous wheat system with no crop rotation. Herbicides applied to continuous wheat are inconsistent in their effects on Italian ryegrass densities in the following wheat crop (Trusler et al. 2007); thus, annual herbicide applications are often required to manage this weed. Wheat fields severely infested with Italian ryegrass are often abandoned from small grain production (Ritter and Menbere 2002).

Italian ryegrass is very competitive with wheat and late maturing compared to wheat (Appleby et al. 1976; Liebl and Worsham 1987). Effective Italian ryegrass control is critical for wheat production because of its strong ability to compete with wheat (Hoskins et al. 2005). In Oklahoma, Italian ryegrass at 30 and 158 plants/m^2 reduced wheat yield by 16 and 20% indicating that yield loss increased at a slower rate at densities greater than 30 plants/m^2 than densities increasing from 0 to 30 plants/m^2 (Fast et al. 2009). Italian ryegrass also causes wheat lodging and complicates wheat harvesting by maturing latter than wheat (Ritter and Menbere 2002).

In the Pacific Northwest Italian ryegrass densities of 29 to 118 plants/m reduced wheat yield 7 to 50% (Appleby et al. 1976). In North Carolina, Italian ryegrass reduced wheat yields 4.2% for every 10 Italian ryegrass plants/m (Liebel and Worsham 1987). Herbicides registered or in development for selective Italian ryegrass control in wheat failed to provide consistent control which limited control options for wheat growers (Barnes et al. 2001).

Conventional methods for Italian ryegrass suppression include tillage before seeding wheat and application of various herbicides (Justice et al. 1994; Knife and Peeper 1991). Efforts to control Italian ryegrass in Oklahoma wheat have failed to prevent the continuing spread of this species. Such efforts may have been limited by the relatively high cost of herbicide application relative to the value of the wheat crop, by grazing restrictions on herbicide labels, by wheat growers deciding to use infested fields for grazing rather than for grain production, and by inconsistent control with herbicides (Trusler et al. 2001).

Feral rye has remained a difficult weed to control in winter wheat in Oklahoma. Its growth habit is very similar to winter wheat. Rye can be defined as a crop or a weed. As a crop, cereal rye can be used for grain, forage, hay, green manure, or as a cover crop (Sattell et al. 1998). Rye typically isn't seeded in many areas where wheat is grown due to its aggressiveness and ability to out compete other small grains (Leonard and Martin 1963; White et al. 2006). When rye becomes undomesticated or able to reproduce on its own without dependence on managed cultivation it becomes known as feral rye (Gressel 2005; White et al. 2006). Feral rye can decrease the value of a wheat crop through direct competition with wheat and by decreasing wheat quality. Since rye has vigorous early growth it limits early growth of wheat and ultimately thins the wheat stand.

Rye seed contamination in harvested wheat is considered foreign material which results in greater price reductions than dockage in wheat because rye is difficult to remove from the wheat (White et al. 2006). When feral rye seed content exceeds 5% the wheat grain grade is reduced to mixed grain, which can decrease grain price considerably (USDA, GIPSA 2006). Feral rye seed content in harvested wheat linearly increased price discounts 9 to 368 c/hl as feral rye density increased from 0 to 80 plants/m (Fast et al. 2009). Thus, interference from rye in wheat can be very detrimental to wheat profit.

There are multiple cultural methods one can use to suppress feral rye. These include decreased wheat row spacing, increased crop plant density (Roberts et al. 2001), delayed crop planting, and banding nitrogen fertilizer in the crop row (Mesbah and Miller 1999). Decreased row spacing to at least 20 cm and increased seeding rate of wheat can reduce interference from rye and increase wheat yield (Roberts et al. 2001). However, none of these cultural control methods reportedly provided adequate feral rye control. Variation in spike height, seed shatter, lodging, and seed weight increases the opportunity for rye populations to evade most cultural control practices (Peeper et al. 2008b).

Glyphosate at a 33% solution concentration can be applied with a ropewick applicator once rye becomes 25 to 30 cm taller than the wheat canopy (Lyon and Klein 2007). However, it can be difficult to avoid wheat injury and this system does not provide early-season control, which is typically essential to avoid yield losses.

Mesbah and Miller (1999) reported that because competition among weeds and crops is not independent of competition for other resources, the ability of winter wheat to accumulate and utilize available nutrients better than rye can also provide an advantage in competition for water and light than rye.

The only selective herbicide for feral rye control in wheat requires the use of a Clearfield® production system. This program combines the use of imazamox with a winter wheat cultivar containing a gene that confers tolerance, but not resistance, to this herbicide (Lyon and Klein 2007). Imazamox is an ALS-inhibiting herbicide that belongs to the imidazolinone chemical family and can persist in the soil with an average half life of 20 to 30 days (Anonymous 2007). Imazamox controls several winter annual grass species (Ball et al. 1999). In Colorado, imazamox treatments applied in early fall, late fall, and spring controlled feral rye 96, 57, and 45% (Pester et al. 2001). Wide variations in feral rye response to imazamox indicate that wheat producers should not expect complete control of feral rye with this herbicide (Peeper et al. 2008b).

Monoculture intensifies a weed flora dominated by one or more adapted species (Liebman and Dyck 1993). Repeated use of sulfonylurea and ACCase inhibitor herbicide groups has led to widespread resistance in Italian ryegrass (Anderson and Staska 1994; Peeper et al. 2008). In order to delay the onset of herbicide resistance, fields treated with imazamox should not be treated during the same season with another ALS-inhibitor herbicide (Lyon and Klein 2007).

Herbicide resistant Italian ryegrass is common in wheat fields in Texas, Arkansas, and Oklahoma (Peeper et al. 2008a). Some ALS-inhibiting herbicides can be used as alternatives to ACCase inhibiting herbicides, but are less consistent in Italian ryegrass control (Hoskins et al. 2005). Diclofop, an ACCase inhibitor, is one of several herbicides used to control Italian ryegrass in winter wheat in the Southern Great Plains (Trusler et al. 2007). Diclofop has been used continuously in many parts of southeastern United States since commercialization in the early 1980’s (Clemmer et al. 2004). But, Italian ryegrass has become resistant to diclofop and certain other ACCase inhibitors in many states throughout the U.S. (Heap 2010).

Cross-resistance refers to the resistance of an individual or a population to multiple herbicides because of a single resistance mechanism, whereas multiple resistance involves at least two resistance mechanisms (Kuk et al. 2008). Cross resistance is typically within herbicide families and multiple resistance between herbicide families. In France, a diclofop-resistant Italian ryegrass biotype from a field treated with diclofop for several years could still be controlled at regular use rates of other ACCase-inhibiting herbicides, including quizalofop (Prado et al. 2000). But, in Arkansas, cross resistance to diclofop and pinoxaden has been reported but not cross resistance to diclofop and clethodim or sethoxydim (Kuk et al. 2008).

Since pinoxaden is a relatively new ACCase-inhibiting herbicide, the actual binding site has yet to be identified which may be different than other ACCase-inhibiting herbicides like diclofop (AOPPs) or clethodim (CHDs) (Kuk et al. 2008). Thus, it should not be heavily relied upon because resistance may soon follow.

Italian ryegrass has been reported to have multiple resistance to ACCase inhibitor and ALS inhibitor herbicide classes in Arkansas and Idaho (Heap 2010). Lack of herbicide rotation has accelerated Italian ryegrass resistance due to the reliance on one class of herbicides. Once the option to use ACCase herbicides for Italian ryegrass control in wheat is removed, resistance pressure is added to the only other option, ASL-inhibiting herbicides. Developing additional control options will be essential for delaying resistance or multiple resistance.

A cultural control practice that could be utilized to help manage winter annual weeds and herbicide resistance would be a crop rotation that would permit the use of additional herbicide modes-of-action instead of monoculture continuous wheat.

Including a summer annual crop into a rotation can be a successful strategy to manage winter annual grass weeds (Lyon and Baltensperger 1995). A 3-year rotation of wheat every third year with either fallow or a summer crop in between allowed enough time between wheat crops to control feral rye and other winter annual grasses (Daugovish et al. 1999).

A winter crop rotation with canola and wheat has the potential to be more profitable than continuous wheat in Oklahoma. A rotation of winter canola followed by two years of dual-purpose wheat generates more expected net returns than three years of continuous dual purpose wheat. (DeVuyst et al. 2009).

Careful herbicide and crop selection can be major factors that influence success of a crop rotation. Imazamox + MCPA[1] has an 18 month plant-back restriction for non-Clearfield® canola cultivars in the eastern U.S. (including the majority of Oklahoma) and a 26 month restriction in the western U.S. (Anonymous, 2006). Although this experiment includes a rotation to winter canola 6 months following an imazamox+MCPA treatment, this rotation is not in accordance with the product label.

Winter canola varieties include conventional and herbicide resistant cultivars. Selective herbicides for winter annual grass control in conventional canola include trifluralin[3] incorporated before planting or clethodim[4], sethoxydim, and quizalofop[5] applied postemergence (Grey et al. 2006). Another option for broad-spectrum weed control in winter canola in the Southern Great Plains is glyphosate[6] in combination with a glyphosate-resistant canola variety. This herbicide can be used to control Italian ryegrass and many other weed species, which offers tremendous advantages compared to other herbicides used in canola production (Grey et al. 2006).

Trifluralin is a dinitroaniline herbicide and its mechanism of action is inhibition of the microtubule protein tubulin (Anonymous 2007). Since this herbicide belongs to a different herbicide family than herbicides commonly used in wheat, this makes it a good option for rotating herbicide modes of action. Trifluralin application rates vary with soil texture, soil organic matter, and by crop (Kirkland 1996). Trifluralin must be incorporated in order to prevent lose due to exposure of UV light and vaporization. It is relatively immobile in the soil and remained in the top 20 cm of the soil for up to 5 months in two soils in Tennessee (Dueseja and Holmes 1978).

The objective of this research was to determine whether a winter crop rotation including winter wheat and winter canola with herbicide treatments registered for rye and/or Italian ryegrass control was more effective in reducing those grassy weeds than repeated use of herbicides in continuous winter wheat.

Materials and Methods

In mid-November 2007 an experiment was initiated to evaluate a crop rotation with registered herbicides for managing Italian ryegrass and feral rye in fields traditionally seeded to winter wheat. Four experiments were established at Oklahoma State University's North Central (Site 1), Stillwater (Site 2), Cimarron Valley (Site 3), and South Central (Site 4) Research Stations. Soil information for each site is in Appendix A.

The experimental design was a randomized complete block with a factorial arrangement of treatments with an added check. Factors consisted of the herbicide treatment applied to winter wheat the first growing season and the herbicide-crop combination used the second growing season. The added check was seeded to wheat each year with no herbicide applied.

All sites had been previously managed as conventionally tilled continuous wheat. Sites 2 and 3 had natural infestations of ryegrass, but all four sites were seeded with a mixture of rye (variety not stated), Italian ryegrass cv 'Marshal', and winter wheat cv 'Centerfield' on November 10 ± 3 days, 2007 at 17, 11, and 67 kg/ha respectively. A preplant fertilizer was applied and incorporated prior to planting. The seed was planted into well tilled soil using a conventional grain drill with 18 cm row spacing. Planting dates and dates for all other field activities are in Appendix B.

In early February 2008 rye, Italian ryegrass, and volunteer wheat were counted in 10 randomly selected rows 1 m long at sites 1 and 2 to determine establishment densities. At Site 1 rye, Italian ryegrass, and wheat averaged 19, 34, and 114 plants/m and Site 2 averaged 17, 34, 119 plants/m, respectively.

Treatments applied in late March, 2008 to wheat with 3- to 4-tillers per plant (Table 1) were imazamox + MCPA [1] at 35 g ai/ha + 70 g ae/ha with nonionic surfactant at 0.25 %v/v and spray grade ammonium sulfate at 18 g/L of spray solution, pinoxaden [2] at 60 g ai/ha, and an untreated check (Table 2). In all tables containing imazamox + MCPA treatments, MCPA rates are actually in g ae/ha not g ai/ha. All herbicides were applied at rates recommended for use on wheat (Anonymous 2010). Herbicide treatments were applied to the wheat with a CO_2 –pressurized backpack sprayer delivering 140 L/ha at 235 kPa. Rye and Italian ryegrass growth stages at the time of herbicide application are in Table 1.

In mid-May 2008, rye heads were counted in one m of row from two rows of all plots. All plots were harvested in late June 2008 using a small plot combine with a 1.5-m wide header. The combine was adjusted to collect the majority of the rye and ryegrass with the wheat. The remaining grain was then harvested from each plot using a conventional combine with a 2.1 m wide header which was driven down the center of each plot to minimize contamination between plots. The second combine was also adjusted to maximize collection of rye and ryegrass seed with the wheat. It also collected the straw discharged from the plot combine and redistributed it evenly across the plots.

Seed volume weight and moisture content were determined on each harvested sample using standard procedures. Rye and Italian ryegrass seed content were estimated by hand removing that seed from a 25g subsample of harvested grain from each plot. Wheat yields were then corrected for rye and ryegrass seed content and adjusted to 12 percent seed moisture content.

Rye head density in May 2008, wheat yield in June 2008, and weed seed content of the harvested wheat data were analyzed as a randomized complete block with 10 subsamples of each treatment from each replication.

In late July 2008, glyphosate at 3.1 kg/ha with spray grade ammonium sulfate (NH_4SO_4) at 20.4 g/L of spray solution was applied to the wheat stubble using a tractor mounted sprayer with a PTO driven pump that delivered 187 L/ha spray solution. In late August, 2008, a heavy tandem disc was used to till the soil. Each plot was disced twice in opposite directions within the width of each plot to minimize soil movement between plots.

All plots were fertilized preplant with a 14-11-11-3 (N-P-K-S) fertilizer which supplied one third of the total N required for a 2800 kg/ha canola yield goal (Zhang and Raun 2004) and total recommended P, K, and S as per soil test recommendations. The wheat and canola were topdressed on January 9 ± 3 days, 2009 with urea fertilizer to supply the other two thirds of the recommended total N.

Year two treatments included winter canola as the crop with eight herbicide treatments or winter wheat with two herbicide treatments (Table 7). Crop oil concentrate at 1 %v/v was added to clethodim and quizalofop treatments.

On September 26 ± 5 days, 2008, PPI treatments were applied to appropriate canola plots and incorporated within 30 min with one pass of an s-tine field cultivator operated 3- to 5-cm deep. All plots were tilled with this cultivator as a final preplant tillage. The PPI treatments were not applied at site 2.

Winter canola cv. 'DKW 41-10' and wheat cv. 'Centerfield' were seeded within a day after application of PPI treatments with a small grain drill at 67 and 5.6 kg/ha.

The fall POST herbicide treatments were applied on November 18 ± 6 days, 2008 using methods previously described except that carrier volume was 187 L/ha. Treatments were applied to 5- to 9-tiller wheat, 5- to 7-leaf canola, and 2- to 3-tiller ryegrass.

Italian ryegrass, rye, and volunteer wheat densities were determined 68 ± 13 days after seeding in each of the four checks in the second year to evaluate the effects of year one treatments on weed density in the succeeding crop (Table 6).

The spring POST herbicide treatments were applied to canola in late February, 2009 using methods previously described. Ryegrass control was visually estimated in mid January and late May, 2009.

The canola and wheat were harvested with small plot combines in mid-June, 2009. The combines were set to collect Italian ryegrass seed with the wheat or canola seed. The harvested samples were weighed, scalped using a small commercial seed cleaner, and reweighed. The seed cleaner removed wheat straw, chaff, and canola pod fragments. Data from the harvested samples were collected using methods and equipment previously described, except that the canola yields were adjusted to 10% moisture. The crop plants remaining along plot edges were removed using a larger combine in the same manner as used the previous year.

Wheat seed volume weight, moisture content, and yield data collected in June 2009 from plots seeded to wheat both years were analyzed as a 3 (herbicide treatments the first year) by 2 (herbicide treatment the second year) factorial with an added check. Canola seed volume weight, moisture content, and yield data collected in June 2009 from plots seeded to wheat the first year and canola the second were analyzed as a 3 by 8 factorial, where the factors were herbicide treatments applied in years one and two.

The plots were tilled twice in opposite directions using a tandem disc in early July 2009. In early August 2009, glyphosate at 0.8 kg ai/ha was applied to control summer weeds using the same methods as the glyphosate application the previous year. The plots were tilled twice again with the same disc in mid-August. 2009. Italian ryegrass plants were counted in 0.5 m^2 of each plot in late September, 2009.

Visual estimates of Italian ryegrass control (Table 7), harvested Italian ryegrass seed (Table 10), and late September 2009 Italian ryegrass density (Table 11) data were analyzed as a 3 by 10 factorial with the continuous wheat check removed. Factors again were herbicide treatment applied the first year and herbicide-crop combinations the second year. Visual estimates of Italian ryegrass data were arcsin square root transformed prior to analysis. Harvested Italian ryegrass and Italian ryegrass density data were square root transformed prior to analysis. Original data are presented with means separation from the transformed data.

All data were subjected to ANOVA and means were separated using Fisher's Protected LSD range tests (P = 0.05). Data were pooled (P > 0.05) across sites and treatment factors whenever possible. SAS 9.2 [7] was used for data analysis.

Results and Discussion

Effects of first year treatments. Rye heads in mature wheat at site 1 were reduced (P=0.0043) by pinoxaden 18% and by imazamox + MCPA 98% (Table 2). Pinoxaden is not registered for rye control (Anonymous 2008). Thus, these results were not unexpected. Pooled across Sites 2, 3, and 4, imazamox + MCPA reduced (P = 0.0002) rye heads 59% and pinoxaden did not reduce rye head density.

Pinoxaden and imazamox + MCPA increased (P = 0.0006) wheat grain yield 14% and 21% pooled across Sites 1, 2, and 3 (P = 0.35) where rye and ryegrass densities were 18 and 34 plants/m^2. Imazamox + MCPA increased wheat yield 37% at Site 4 (P = 0.02) whereas pinoxaden did not increase yield at this Site (Table 3).

Pinoxaden did not reduce feral rye seed content in wheat harvested in June 2008 at any Site (Table 4). Imazamox + MCPA reduced (P < 0.0001) feral rye seed content by 96% pooled across Sites 1 and 4 and 58% pooled across Sites 2 and 3. Inconsistent rye control among the four Sites with imazamox + MCPA may have been influenced by application timing. The imazamox + MCPA label recommends that application should be made prior to first tiller formation for optimum control (Anonymous 2006). Growth stages of rye were 3 to 6.5 tillers at application (Table 1). Since the wheat crop was seeded in November POST application of the treatments was delayed until spring when the plants started to actively grow again.

Pinoxaden reduced Italian ryegrass seed content in harvested wheat 88 ($P = 0.0008$), 90 ($P = 0.0057$), 92 ($P = 0.0001$), and 100% ($P = 0.0332$) at Sites 1, 2, 3 and 4, respectively. Imazamox + MCPA reduced Italian ryegrass seed content in harvested wheat 38, 65, and 47% at Sites 1, 2, and 3, but an anticipated reduction in Italian ryegrass content at Site 4 could not be confirmed because of the large CV in the data (Table 5). Clemmer et al. (2004) found that imazamox controlled more Italian ryegrass when applied in the fall or sequentially in the fall and spring than applied only in the spring, in which he achieved highly variable spring Italian ryegrass control of 9, 16, or 58% among 3 Sites.

In plots that received no herbicide treatment in the preceding wheat crop, Italian ryegrass, rye, or volunteer wheat densities at 68 ± 13 days after seeding canola or wheat on September 27 ± 4 days 2008, were unaffected by which crop had been seeded (Table 6). Pinoxaden and imazamox + MCPA applied to wheat in March 2008 reduced ($P < 0.0001$) Italian ryegrass densities in canola seeded in September 2008 at all Sites. However, pinoxaden reduced Italian ryegrass 87 % and imazamox +MCPA reduced it only 38%.

Rye densities were too sparse at all Sites to distinguish among treatments the second year. Much of the rye was collected by the plot harvester the first year. Also, rye varies considerably in dormancy (Peeper 2008b) and the seed used may have been a biotype with little dormancy. Volunteer wheat densities in the unsprayed canola were higher in the pinoxaden and imazamox + MCPA treatments than in the continuous wheat with no herbicide check. This may have been due to the difficulty of distinguishing between the wheat crop and volunteer wheat.

Effects of two years of treatment. Visual estimates of Italian ryegrass control from May 30 ± 2 days 2009 pooled across Sites 1, 2, and 4 ($P = 0.4655$). An interaction was found between first and second year treatments in the Italian ryegrass control data at Sites 1, 2, and 4 ($P < 0.0001$) and at Site 3 ($P = 0.0002$) (Table 7). First year pinoxaden treatments controlled Italian ryegrass 8% more than imazamox + MCPA pooled across Sites 1, 2, and 4 ($P < 0.0001$) and 15% more than the untreated Site 3 ($P = 0.0046$) and pooled across Sites 1, 2, and 4. All continuous wheat treatments that contained pinoxaden 1 or 2 yrs had higher control than any imaxamox + MCPA treatments that did not contain pinoxaden either year. Pinoxaden treatments that were applied to continuous wheat controlled Italian ryegrass at least 90% at Site 3 and 96% across Sites 1, 2, and 4. Pinoxaden applied in year one followed by any canola herbicide treatment in year two, except trifluralin, controlled Italian ryegrass at least 97%.

Neither 1 or 2 yrs of herbicide treatments affected harvested wheat moisture content or yield in late June, 2009 (Table 8). Imazamox + MCPA applied to wheat the second year with no herbicide treatment the previous year decreased ($P = 0.0113$) seed volume weight at Site 2. There were no herbicide treatment effects on seed volume weight at Sites 2 or 3.

Canola harvest data in June 2009 pooled across the three treatments applied to wheat in 2008 (Table 9). All herbicide treatments applied to the canola increased seed volume weight compared to the untreated canola with no differences among herbicide treatments.

Canola herbicide treatment did not affect canola seed moisture content pooled across Sites 1 and 4 ($P = 0.0771$) or at Site 2 ($P = 0.1935$). All three of these Sites had low seed moisture content at harvest. At Site 3, all herbicide treatments applied to canola decreased canola moisture content compared to the untreated canola with no differences among herbicide treatments. The higher moisture content ($P = 0.0127$) of the untreated treatment at Site 3 was attributed to its Italian ryegrass seed content.

Canola seed yield data pooled across all Sites ($P = 0.0652$). All canola herbicide treatments increased ($P < 0.0001$) canola seed yield compared to the untreated canola. Trifluralin PPI alone increased canola yield less than four other canola herbicide treatments (Table 9).

Italian ryegrass seed that was removed from harvested wheat and canola in June 2009 was reduced by all herbicide treatments. Data pooled ($P = 0.8777$) across Sites 1, 2, and 4 and had a strong interaction ($P < 0.0001$) between main effects at all Sites. Imazamox + MCPA applied without pinoxaden in either year or sequential applications of imazamox + MCPA it did not reduce Italian ryegrass as well as most other herbicide treatments. Trifluralin applied PPI to canola did not reduce Italian ryegrass seed as well as the other herbicide treatments. Quizalofop, clethodim, sequential applications of glyphosate, and trifluralin followed by a POST treatment reduced Italian ryegrass seed as much as any continuous wheat treatment that had pinoxaden with the only exception being quizalofop without a herbicide applied the previous year.

An interaction ($P < 0.0001$) was found in Italian ryegrass densities in September 2009 (Table 11). Italian ryegrass was reduced at all Sites ($P = 0.9973$) in all herbicide treatment combinations except imazamox + MCPA without pinoxaden in either year and the trifluralin PPI with no previous herbicide treatment.

Glyphosate controlled Italian ryegrass at least 76% in all treatments and at least 84% in all treatments that had a herbicide the previous year. This is consistent with Grey et al. (2006), who reported that Italian ryegrass control exceeded 83 % with all glyphosate treatments that were applied to 1- to 4- leaf canola.

No herbicide or crop and herbicide treatment reduced Italian ryegrass densities more than 91% (Table 11). Thus, a third year of herbicide treatment would be recommended to further suppress Italian ryegrass.

Sources of Materials

[1] Clearmax™, BASF Corporation Agricultural Products, 26 Davis Drive, Research Triangle Park, NC 27709.

[2] Axial® XL, Syngenta Crop Protection, Inc.. P.O. Box 18300, Greensboro, NC 27419-8300

[3] Treflan® HFP, DOW AgroSciences LLC, Indianapolis, IN 46268.

[4] Select® 2 EC, Valent U.S.A Corporation, P.O. Box 8025, Walnut Creek CA 94596-8025.

[5] Assure® II, E.I. du Pont de Nemours and Company, Wilmington, DE 19898.

[6] Roundup PowerMAX®, Monsanto Company, 800 N. Lindbergh Blvd. St. Louis, MO 63167.

[7] SAS, version 9.2, SAS Institute Inc., SAS Campus Drive, Cary, NC 27513.

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Table 1. Growth stages when postemergence herbicide treatments were applied at all sites. [a]

Application	Plant species	Site 1	Site 2	Site 3	Site 4
Spring 2008	wheat	4 L	3 T	4 T	4 T
	rye	3 T	3 T	7 T	4 T
	Italian ryegrass	3 L	3 T	3 T	3 T
Fall 2008	wheat	5 T	5 T	9 T	6 T
	canola	5 L	6 L	7 L	5 L
	Italian ryegrass	2 T	2 T	3 T	3 T
Spring 2009	canola	10 L	15 D	NA	25 D

[a] Abbreviations: L, leaves per plant; T, tillers per plant; D, diameter in cm.

Table 2. Effect of pinoxaden and imazamox + MCPA applied in late March, 2008 on rye head density in winter wheat in mid May, 2008 at Site 1 and pooled across Sites 2, 3, and 4. [a]

Treatment	Rate	Site 1	Sites 2, 3, and 4
	g ai/ha	no./m^2	
untreated	---	80 a	116 a
pinoxaden	60	66 b	130 a
imazamox + MCPA	35 + 70	2 c	47 b
LSD (0.05)		11	15
CV (%)		40	61

[a] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05).

Table 3. Effect of pinoxaden and imazamox + MCPA applied in late March, 2008 on grain yield of wheat that was infested with rye and Italian ryegrass and harvested in June, 2008, pooled over Sites 1, 2, and 3 and at Site 4.[a]

Treatment	Rate	Sites 1,2, and 3	Site 4
	g ai/ha	kg/ha	
untreated	---	1270 b	2010 b
pinoxaden	60	1470 a	2260 b
imazamox + MCPA	35 + 70	1600 a	3210 a
LSD (0.05)		150	760
CV (%)		20	10

[a] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05).

Table 4. Effect of pinoxaden and imazamox + MCPA applied in late March, 2008 on feral rye seed content vs. winter wheat harvested in June, 2008, pooled across Sites as indicated.[ab]

Treatment	Rate	Sites 1 and 4	Sites 2 and 3
	g ai/ha	——— % W/W ———	
untreated	---	28 a	38 a
pinoxaden	60	23 b	35 a
imazamox + MCPA	35 + 70	1 c	16 b
LSD (0.05)		2	7
CV (%)		11	21

[a] Abbreviations: % W/W, percent feral rye seed weight per harvested grain weight.
[b] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05).

Table 5. Effect of pinoxaden and imazamox + MCPA applied in late March, 2008 on Italian ryegrass seed content vs. winter wheat harvested in June, 2008 at four Sites.[ab]

Treatment	Rate	Site 1	Site 2	Site 3	Site 4
	g ai/ha	% W/W			
untreated	---	0.26 a	0.81 a	1.57 a	0.05 a
pinoxaden	60	0.03 c	0.08 b	0.12 c	0.00 b
imazamox + MCPA	35 + 70	0.16 b	0.28 b	0.83 b	0.02 ab
LSD (0.05)		0.08	0.35	0.33	0.04
CV (%)		29	52	22	82

[a] Abbreviations: % W/W, percent Italian ryegrass seed weight per harvested grain weight.
[b] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05).

Table 6. Mean weed densities 68 ± 13 days after the second crop was seeded at four Sites in treatments that did not receive an herbicide the second crop year.[a]

			Italian ryegrass	Rye		Volunteer wheat
Crop rotation	First crop treatment	Rate	Mean	Site 1, 3, and 4	Site 2	Mean
		g ai/ha	plants/m			
wheat-wheat	untreated	---	99 a	0 a	3 a	20 c
wheat-canola	untreated	---	106 a	0 a	7 a	30 cb
	pinoxaden	60	13 c	1 a	7 a	78 a
	imazamox + MCPA	35 + 70	61 b	0 a	2 a	54 ab
ANOVA P value			< 0.0001	0.4363	0.4991	0.0002
CV (%)			30	17	44	37

[a] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05). Means were square root transformed prior to analysis with actual data shown.

Table 7. Visual estimates of Italian ryegrass control in late May, 2009 following 2 yrs of treatment based on zero control in plots seeded to winter wheat both yrs with no herbicide. [abc]

			Treatment applied to first crop					
Treatment applied to second crop			Sites 1, 2, and 4			Site 3		
Crop	Treatment	Rate	untreated	pinoxaden	imaz+MCPA	untreated	pinoxaden	imaz+MCPA
		g ai/ha	%					
Wheat	pinoxaden	60	97 ab	99 a	98 a	96 a-d	98 ab	97 abc
	imazamox + MCPA	35 + 70	72 c	96 ab	86 b	69 hi	90 a-e	56 i
Canola	untreated	---	8 e	70 c	26 d	5 k	69 ghi	18 j
	glyphosate	770	96 ab	99 a	96 ab	88 c-f	99 ab	85 efg
	glyph. fb glyph.	770 fb 770	98 a	99 a	99 a	99 a	97 abc	96 a-d
	quizalofop	77	89 b	99 a	91 ab	86 def	97 abc	89 c-f
	clethodim	105	93 ab	98 a	98 a	87 b-f	98 ab	90 b-e
	trifluralin	1120	66 c	91 ab	86 b	75 fgh	90 b-f	76 fgh
	trifl. fb quiz.	1120 fb 77	97 a	99 a	99 a	99 a	99 a	99 a
	trifl. fb cleth.	1120 fb 105	99 a	99 a	99 a	96 a-d	99 a	95 a-e

[a] Pinoxaden and imazamox + MCPA rates were the same each crop year.

[b] Abbreviations: imax+MCPA, imazamox + MCPA; glyph. fb glyph., glyphosate followed by glyphosate; trifl. fb quiz., trifluralin followed by quizalofop; trifl. fb cleth., trifluralin followed by clethodim.

[c] Means within each Site or pooled mean of Sites followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05). Means were arcsin square root transformed prior to analysis with actual data shown.

Table 8. Winter wheat seed volume weight, moisture content, and grain yield of continuous wheat plots in June, 2009 after 2 yrs of treatment. [a-e]

				Seed volume weight		Moisture content		Yield	
Crop 1 treatment	Rate	Crop 2 treatment	Rate	Site 2	Sites 3 and 4	Sites 2 and 3	Site 4	Sites 2 and 4	Site 3
	g ai/ha		g ai/ha	kg/hl		%		kg/ha	
untreated	---	untreated	---	45.2	63.0	17.3	8.0	590	1410
		pinoxaden	60	68.5 a	74.0 a	14.3 a	8.6 a	1020 a	1890 a
		imaz+MCPA	35 + 70	59.6 b	73.1 a	13.8 a	8.9 a	860 a	1890 a
pinoxaden	60	pinoxaden	60	71.4 a	73.3 a	14.5 a	8.9 a	880 a	1580 a
		imaz+MCPA	35 + 70	67.8 a	73.8 a	13.4 a	9.0 a	920 a	1740 a
imaz+MCPA	35 + 70	pinoxaden	60	66.5 a	74.2 a	14.1 a	8.5 a	820 a	1700 a
		imaz+MCPA	35 + 70	69.4 a	72.1 a	13.8 a	9.0 a	990 a	1740 a
ANOVA P values									
Crop 1				0.0144	0.6888	0.9455	0.9103	0.6942	0.1980
Crop 2				0.0355	0.4938	0.3766	0.1639	0.7904	0.5688
Crop 1 x Crop 2				0.0113	0.2480	0.4295	0.5235	0.3031	0.6545

[a] Wheat yield data were adjusted to 12% moisture content.
[b] Data for continuous untreated wheat were not included in the statistical analyses.
[c] Abbreviations: imaz+MCPA, imazamox + MCPA
[d] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05).
[e] Main effects and interaction: Crop 1, treatment applied to the first crop as main factor; Crop 2, treatment applied to the second crop as main factor; Crop 1 x Crop 2, interaction.

Table 9. Effect of herbicide treatment applied to winter canola on winter canola seed volume weight, moisture content, and yield in June, 2009, pooled across the three treatments applied to wheat the previous crop year, and pooled across Sites as indicated. [ab]

		Seed volume weight			Moisture content			
Canola treatment	Rate	Site 1	Site 2	Sites 3 and 4	Sites 1 and 4	Site 2	Site 3	Yield
	g ai/ha	kg/hl			%			kg/ha
untreated	---	56.3 b	58.9 b	53.3 b	6.0 a	4.8 a	12.4 a	1570 c
glyphosate	770	65.4 a	63.1 a	59.8 a	5.6 a	4.7 a	10.6 b	1980 a
glyphosate fb glyphosate	770 + 770	64.6 a	63.0 a	60.1 a	5.8 a	4.6 a	10.1 b	1910 ab
quizalofop	77	65.5 a	62.8 a	60.1 a	5.8 a	4.6 a	10.9 b	2000 a
clethodim	105	64.4 a	62.1 a	60.4 a	5.7 a	4.6 a	10.2 b	1980 a
trifluralin	1120	63.4 a	---	60.1 a	5.7 a	---	10.4 b	1850 b
trifluralin fb quizalofop	1120 + 77	65.3 a	---	60.4 a	5.7 a	---	10.4 b	2010 a
trifluralin fb clethodim	1120 + 105	65.9 a	---	61.1 a	5.8 a	---	10.5 b	1960 ab
LSD (0.05)	---	2.9	1.5	2.1	NSD	NSD	1.1	120

[a] Canola yield data were adjusted to 10% moisture content.

[b] Means within each column followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05).

Table 10. Italian ryegrass seed removed from harvested wheat or canola in June, 2009 following two yrs of treatments. [a-d]

Treatment applied to second crop			Treatment applied to first crop					
			Sites 1, 2, and 4			Site 3		
Crop	Treatment	Rate	untreated	pinoxaden	imaz+MCPA	untreated	pinoxaden	imaz+MCPA
		g ai/ha	kg/ha					
Wheat	untreated		183.3	---	---	259.2	---	---
	pinoxaden	60	3.1 efg	0.7 fg	1.7 fg	3.8 f-i	1.0 hi	0.8 hi
	imaz. + MCPA	35 fb 70	17.1 d	3.7 efg	10.7 de	81.6 bc	7.7 d-i	68.5 c
Canola	untreated	---	285.8 a	48.4 c	169.9 b	411.3 a	98.1 b	372.0 a
	glyphosate	770	1.9 efg	2.1 efg	2.8 efg	18.0 de	1.6 ghi	9.0 d-h
	glyph. fb glyph.	770 fb 770	0.7 fg	0.6 fg	0.5 fg	1.7 ghi	1.1 ghi	5.7 e-i
	quizalofop	77	4.4 efg	0.7 fg	3.4 efg	9.7 d-g	2.8 f-i	9.2 d-i
	clethodim	105	3.6 efg	0.5 fg	1.5 fg	5.9 d-i	3.1 f-i	5.5 f-i
	trifluralin	1120	72.4 c	12.5 de	7.7 def	46.0 c	12.2 def	24.6 f
	trifl. fb quiz.	1120 fb 77	1.9 fg	0.4 fg	0.3 g	1.0 hi	0.5 i	0.8 i
	trifl. fb cleth.	1120 fb 105	0.3 g	0.2 g	0.3 g	0.9 hi	1.1 hi	1.2 ghi

[a] Pinoxaden and imazamox + MCPA rates were the same each crop year.

[b] Abbreviations: imaz. + MCPA, imazamox + MCPA; glyph. fb glyph., glyphosate followed by glyphosate; trifl. fb quiz., trifluralin followed by quizalofop; trifl. fb cleth., trifluralin followed by clethodim.

[c] Data for continuous untreated wheat were not included in the statistical analyses.

[d] Means within each Site or pooled mean of Sites followed by the same letter do not differ according to Fisher's Protected LSD test (P = 0.05). Means were square root transformed prior to analysis with actual data shown.

Table 11. Ryegrass density reduction in late September, 2009 following 2 yrs of treatment and tillage during the summer of 2009, pooled across all four Sites, compared with the untreated continuous wheat treatment.

Treatment applied to second crop		Rate	Treatment applied first crop		
			unsprayed	pinoxaden	imaz+MCPA[b]
		g ai/ha	%		
Wheat	pinoxaden	60	77 ab [b]	82 a	76 ab
	imazamox + MCPA	35 fb 70	59 c	77 ab	62 c
Canola	untreated	---	9 e	70 bc	38 d
	glyphosate	770	76 ab	83 a	84 a
	glyph. fb glyph.[c]	770 fb 770	84 a	91 a	88 a
	quizalofop	77	84 a	88 a	88 a
	clethodim	105	83 a	90 a	81 a
	trifluralin	1120	63 c	87 a	82 a
	trifl. fb quiz.[c]	1120 fb 77	83 a	89 a	91 a
	trifl. fb cleth.[c]	1120 fb 105	83 a	84 a	87 a

[a] Pinoxaden and imazamox + MCPA rates were the same each crop year.
[b] Means followed by the same do not differ according to Fisher's Protected LSD test (P = 0.05). Means were square root transformed prior to analysis with actual data shown.
[c] Abbreviations: glyph. fb glyph., glyphosate followed by glyphosate; trifl. fb quiz., trifluralin followed by quizalofop; trifl. fb cleth., trifluralin followed by clethodim.

APPENDIX A

SOIL INFORMATION FOR EACH SITE.

Characteristic	Site 1	Site 2	Site 3	Site 4
Series	Grant	Pulaski	Teller	Dale
Texture	Silt loam	Sandy loam	Sandy loam	Silt loam
Classification	fine-silty, mixed, superactive, thermic Udic Argiustolls	coarse-loamy, mixed, superactive, thermic Udic Ustifuvents	fine-loamy, mixed, active, thermic Udic Argiustolls	fine-silty, mixed, superactive, thermic Pachic Haplustolls
Organic Matter %	1.7	1.4	1.1	1.2
pH	6.4	6.4	6.3	7.9

APPPENDIX B

SEQUENCE OF ACTIVITIES AT EACH SITE FOR THE FIELD EXPERIMENT.

Activity	Site 1	Site 2	Site 3	Site 4
Wheat/rye/Italian ryegrass mixture seeded	11/13/07	11/09/07	11/07/07	11/07/07
Wheat/rye/Italian ryegrass densities determined	02/09/08	02/09/07	NA	NA
POST treatments applied to wheat	03/19/08	03/25/08	03/20/08	03/26/08
Applied Harmony Extra to all plots	04/07/08	04/07/08	04/02/08	NA
Rye head densities determined	05/13/08	05/13/08	05/13/08	05/19/08
All plots harvested	06/26/08	06/27/08	06/25/08	06/24/08
Glyphosate applied to fallow plots	07/23/08	07/23/08	07/22/08	07/22/08
Disc tillage twice to all plots	08/28/08	08/27/08	09/02/08	08/29/08
Applied PPI treatments to canola	09/26/08	NA [a]	09/24/08	10/01/08
Applied preplant fertilizer to all plots	09/26/08	NA	09/24/08	10/01/08
Preplant tillage with field cultivator	09/26/08	09/23/08	09/24/08	10/01/08
Canola seeded	09/26/08	09/23/08	09/24/08	10/01/08
Wheat seeded	09/26/08	09/24/08	09/24/08	10/01/08
POST herbicides applied to wheat & canola	11/19/08	11/12/08	11/17/08	11/24/08
Densities counted in untreated plots	11/25/08	12/12/08	12/12/08	11/25/08
Topdress fertilizer applied to all plots	01/07/09	01/08/09	01/12/09	01/08/09
Italian ryegrass control visually evaluated	01/22/09	01/22/09	01/21/09	01/20/09
POST herbicides applied to canola	03/06/09	02/23/09	02/24/09	02/24/09
Italian ryegrass control visually evaluated	04/09/09	NA	04/06/09	04/09/09
Italian ryegrass control visually evaluated	06/01/09	05/29/09	05/29/09	05/30/09
All plots harvested	06/15/09	06/10/09	06/08/09	NA
Disc tillage to all plots	07/02/09	07/06/09	07/06/09	07/02/09
Glyphosate applied to all plots	08/05/09	08/03/09	08/03/09	08/05/09
Disc tillage to all plots	08/14/09	08/17/09	08/13/09	08/13/09
Italian ryegrass densities determined	09/19/09	09/28/09	09/21/09	09/25/09

[a] PPI herbicide treatments were not applied at site 2.

APPENDIX C

MONTHLY HIGH AND LOW TEMPERATURE, MEAN TEMPERATURE, AND TOTAL PRECIPITATION FOR ALL SITES. [a]

		Site 1				Site 2				Site 3				Site 4			
		Temperature				Temperature				Temperature				Temperature			
Year	Month	H[b]	L[b]	M[b]	PPT[b]	H	L	M	PPT	H	L	M	PPT	H	L	M	PPT
		°C			cm	°C			cm	°C			cm	°C			cm
2007	November	-8	27	9	0.3	-8	27	10	2.1	-8	27	11	1.6	-9	28	11	1.3
	December	-16	21	1	4.6	-9	20	2	5.6	-8	20	3	2.9	-12	22	3	2.0
2008	January	-13	23	2	0.6	-12	24	3	0.9	-12	23	3	1.6	-12	24	4	0.4
	February	-13	25	3	5.1	-14	26	4	7.5	-12	26	4	6.1	-13	27	5	5.8
	March	-10	25	9	9.5	-11	26	10	10.0	-9	26	10	9.7	-9	31	11	6.1
	April	-1	29	13	5.1	-2	30	14	15.1	-2	29	14	11.8	-1	33	15	10.8
	May	1	33	20	10.5	2	34	20	15.7	3	33	21	15.9	1	37	22	11.0
	June	13	38	25	29.0	13	34	25	13.0	14	34	26	13.0	13	35	26	14.2
	July	15	40	27	9.6	14	38	27	15.6	16	39	28	11.4	16	41	28	2.4
	August	16	41	26	2.3	14	39	25	5.7	16	40	26	3.9	16	40	26	10.8
	September	9	34	21	11.3	6	34	20	6.0	8	33	21	6.7	4	33	20	3.4
	October	0	30	15	11.7	-4	31	15	6.2	-3	30	16	5.4	-3	31	16	3.9
	November	-7	28	9	1.2	-8	28	9	4.0	-6	27	9	12.4	-5	28	10	3.3

	December	-13	23	2	1.7	-15	25	3	1.9	-13	25	3	2.7	-12	24	4	1.1
2009	January	-15	21	1	0.2	-15	24	1	0.5	-14	25	2	0.7	-13	27	2	1.8
	February	-9	24	7	0.8	-11	24	8	3.5	-9	24	8	2.6	-8	27	9	1.8
	March	-9	32	10	3.0	-9	30	11	10.6	-8	30	11	9.2	-7	30	12	3.8
	April	-6	31	14	9.0	-6	33	15	12.0	-5	33	15	11.7	-7	33	15	14.0
	May	6	35	18	3.8	6	34	19	7.7	8	33	19	8.7	7	33	19	16.2
	June	11	40	27	5.9	10	39	27	5.2	13	39	27	4.9	12	39	27	5.3
	July	16	44	27	6.5	14	42	27	13.2	16	44	27	13.1	14	41	28	8.5
	August	13	39	25	19.2	10	37	25	18.3	12	37	25	13.2	14	40	27	11.3
	September	7	36	21	1.3	5	34	20	11.3	7	34	21	8.7	6	35	21	8.3

[a] Source: Oklahoma Climatological Survey, Univ. of OK., http://www.mesonet.org.

[a] Abbreviations: H, monthly high temperature; L, monthly low temperature; M, monthly mean temperature; PPT, total monthly precipitation.

VITA

Joshua Aaron Bushong

Candidate for the Degree of

Master of Science

Thesis: WINTER CROP ROTATION WITH HERBICIDES TO CONTROL FERAL RYE (*SECALE CEREALE*) AND ITALIAN RYEGRASS (*LOLIUM PERENNE* SSP. *MULTIFLORUM*)

Major Field: Plant and Soil Sciences

Biographical:

Personal Data: Born in Weatherford, Oklahoma, September 11, 1984, the son of David and Linda Bushong. Married to Annette Kristine Bushong on August 12, 2007.

Education: Graduated from Weatherford High School, Weatherford, Oklahoma, in May 2003; received Bachelor of Science degree in Crop Science from Oklahoma State University, Stillwater, Oklahoma in May 2008; completed requirements for the Masters of Science degree in Crop Science at Oklahoma State University, Stillwater, Oklahoma in May, 2010.

Experience: Raised on a family farm near Weatherford, Oklahoma; Undergraduate research assistant at Oklahoma State University, June 2003 to May 2008; Graduate research assistant at Oklahoma State University, May 2008 to August 2008; Agriculturalist at Oklahoma State University, August 2008 to present.

Professional Memberships: Southern Weed Science Society; Western Society of Weed Science.

Name: Joshua Aaron Bushong Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: WINTER CROP ROTATION AND HERBICIDES TO CONTROL FERAL RYE (*SECALE CEREALE*) AND ITALIAN RYEGRASS (*LOLIUM PERENNE* SSP. *MULTIFLORUM*).

Pages in Study: 39 Candidate for the Degree of Master of Science

Major Field: Plant and Soil Sciences

Scope and Method of Study: Limited control options and herbicide resistance have increased feral rye and Italian ryegrass infestations in winter wheat production in Oklahoma. A rotation with winter canola would increase control options. Field experiments were established in the fall of 2007 at four sites in Oklahoma to evaluate herbicide programs for controlling these two grasses in continuous winter wheat and in a winter wheat–winter canola rotation. Factors include the herbicide treatment applied to wheat in year one (untreated, imazamox + MCPA, or pinoxaden) and the crop-herbicide combination the second year. Crop-herbicide combinations in year two included a second year of wheat with the same herbicide treatments as the first year or winter canola with eight herbicide treatments. All herbicides were applied at labelled rates with appropriate additives. Weed densities were determined prior to planting a crop the third year.

Findings and Conclusions: Pinoxaden reduced Italian ryegrass seed in harvested wheat 88 to 100% and reduced harvested feral rye seed only 18% at two sites with no reduction at two sites the first crop year. Imazamox + MCPA reduced Italian ryegrass seed in harvested wheat 38 to 65% at three sites with no reduction at one site and reduced feral rye seed 96% at two sites and 58% at two sites the first year. Imazamox + MCPA increased wheat yields 21 to 34%. Pinoxaden increased wheat yields 14% pooled over three sites but did not affect yield at one site. Rye was sparse in all treatments the second year. Italian ryegrass control in treatments with continuous wheat was higher with any pinoxaden treatment applied one or both years than with any imazamox + MCPA treatment. Italian ryegrass control with imazamox + MCPA was inconsistent across locations. All of the herbicide treatments in winter canola except trifluralin PPI without a sequential POST treatment controlled Italian ryegrass comparable to pinoxaden applied to wheat. Italian ryegrass densities after two crops with herbicide applied were greatly reduced but the weed was not completely eliminated.

ADVISER'S APPROVAL: Dr. Thomas F. Peeper