CONVENTIONAL AND NO-TILL WHEAT (*TRITICUM AESTIVUM*) – SOYBEAN (*GLYCINE MAX.*) CROPPING SYSTEMS FOR ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) SUPPRESSION

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(*GLYCINE MAX.*) CROPPING

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MULTIFLORUM)

SUPPRESSION

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Conventional and No-Till Wheat (*Triticum aestivum*) – Soybean (*Glycine max.*) Cropping Systems for Italian Ryegrass (*Lolium multiflorum*) Suppression[1]

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Abstract: Three experiments were conducted in central Oklahoma to determine the effect of cropping system, tillage management, and herbicide treatments on Italian ryegrass density. Economic returns of the various options for Italian ryegrass control were determined. In continuous wheat, Italian ryegrass densities in mid September prior to application of selective herbicides were 12,300 to 15,000 plants/m^2 in no-tillage main plots versus 0 to 500 plants/m^2 in conventional tillage main plots. When applied POST to wheat, diclofop controlled more Italian ryegrass than tralkoxydim and sulfosulfuron. Wheat yields were greater in conventional tillage plots than in no-tillage plots at two of three sites. Double-cropped soybean yields were limited due to lack of soil water. In soybean stubble, Italian ryegrass was approximately 100 times more dense in no-tillage than in conventional tillage in January. None of the herbicides applied

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for selective weed control in soybeans consistently increased early season soybean yields. In the final wheat crop, none of the Italian ryegrass management treatments (cropping system – tillage – herbicide combinations) consistently reduced Italian ryegrass density. Of the Italian ryegrass management treatments applied to continuous wheat, three herbicide treatments in no-tillage at site 1 and all treatments in no-tillage at site 2 reduced Italian ryegrass density in the succeeding wheat crop. Of the treatments applied to the double-cropped and early season soybeans in the wheat-soybean system, all treatments applied to no-tillage plots reduced Italian ryegrass density at two of three sites. None of the treatments applied to conventional tillage plots in either cropping system reduced Italian ryegrass density. Italian ryegrass plant density in November and spike density were highly related to wheat yield at two and three sites. Only the conventional tillage wheat-double-cropped-early season-wheat rotation provided positive net returns from all sites. Among the various herbicide options in the wheat-soybean system, no treatment had higher net returns than imazethapyr or alachlor applied PRE.

Nomenclature: Alachlor; diclofop; imazethapyr; sulfosulfuron; tralkoxydim; wheat, *Triticum aestivum* L.; soybean, *Glycine max* L.; Italian ryegrass, *Lolium multiflorum* Lam. #[3] LOLMU.

Additional index words: Alachlor, cloransulam, diclofop, glyphosate,

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[3] 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.

imazethapyr, metolachlor, metolachlor + metribuzin, sulfosulfuron, tralkoxydim, cropping systems, grazeout, no-tillage.

INTRODUCTION

Italian ryegrass is a very competitive, late maturing, cool-season annual (Justice et al. 1994) that has become an important weed in winter wheat throughout most of the United States. In North Carolina, ten Italian ryegrass plants/m^2 reduced wheat yields 4%, and in Oregon, 93 plants/m^2 reduced yields 61% (Liebl and Worsham 1987; Appleby et al. 1976).

In northcentral Oklahoma, Italian ryegrass is spreading and infesting wheat fields due to its increasing popularity as a forage and erosion control grass (Peeper et al. 2000). In Arkansas, it infests almost every county in the state (Khodayari et al. 1983). Combine harvesting spreads seed (Martin 2001). Variation in germination, seedling emergence, seed production, and dormancy increase the difficulty in controlling Italian ryegrass (Anslow 1962; Martin 2001). In Oklahoma, winter wheat producers who have traditionally produced only monocrop continuous wheat are seeking options for controlling Italian ryegrass as well as improving economic returns from infested fields.

Wheat is a very flexible crop in the southern Great Plains where it is used for forage, forage and grain, or grain alone (Krenzer 1994). The combination of forage and grain production constitutes the largest portion of winter wheat production in Oklahoma (Epplin 1998). However, when weeds are severe, wheat forage may be harvested for hay or silage or may be grazed for the full growing season (Krenzer 1994).

The term "grazeout" refers to grazing of wheat for the full season with no grain production. Effective control of weeds can be accomplished using grazeout along with a tillage operation or herbicide application to kill the weeds immediately after the grazing is complete (Krenzer 1994). This is crucial in preventing the weeds from producing seed to infest the next wheat crop (Krenzer 1994). In southern and western Australia, grazing reduced rigid ryegrass (*Lolium rigidum*) density by 80% in subsequent crops (Sharkley et al. 1964; Reeves and Smith 1975).

Conventional methods for Italian ryegrass suppression include tillage before seeding wheat and application of various herbicides (Knife and Peeper 1991; Justice et al. 1994). Diclofop is registered for Italian ryegrass control for growth stages one leaf to two tillers, at a rate of up to 1120 g/ha; however, it has a full-season grazing restriction (Anonymous 2000b). Italian ryegrass was controlled 81 to 100% and wheat yields were increased 20 to 60% with diclofop applied POST at 500 to 1500 g/ha (Griffin 1986; Khodayari et al. 1983). In Oklahoma, diclofop applied POST at 560 to 840 g/ha controlled Italian ryegrass 90 to 100% and increased wheat yields 48 to 60% (Barnes et al. 2001; Justice et al.1994). In Georgia, grain yields of Italian ryegrass infested wheat treated with 560 to 1120 g/ha of diclofop were eight times greater than the check (Robinson and Banks 1983). In California, diclofop at 1120 g/ha completely controlled Italian ryegrass and increased wheat yields by 35% (Mitich et al. 1986).

Tralkoxydim, an ACCase inhibitor, is registered for control of Italian ryegrass when applied POST at 270 g/ha prior to development of the fifth leaf (Anonymous 2000a). Tralkoxydim POST at 200 g/ha controlled Italian ryegrass 84% and increased wheat grain yields from 2150 to 3550 kg/ha (Barnes et al. 2001). Tralkoxydim at a rate of 202 g/ha applied in the spring controlled Italian and perennial ryegrass (*Lolium perenne* L.) 86 to 95% in timothy (*Phleum pratense* L.) (Yenish and Eaton 1999).

Sulfosulfuron, an ALS inhibitor, is registered for control of Italian ryegrass when applied POST in the fall and for suppression of Italian ryegrass when applied POST in the spring at 35 g/ha (Anonymous 1999). Sulfosulfuron applied POST in the fall at 35 g/ha controlled Italian ryegrass 79% and increased wheat grain yield 44% (Barnes et al. 2001). In Idaho, sulfosulfuron applied POST in the spring at 35 g/ha controlled Italian ryegrass 45 to 65% (Rauch and Thill 1999).

Herbicide use for Italian ryegrass control in wheat in the southern Great Plains is limited by four factors. First, herbicide treatments for Italian ryegrass cost significantly more than growers are accustomed to paying for weed control. Second, some herbicides have grazing restrictions. Third, wheat growers often elect to use the crop for forage only rather than invest in weed control. Fourth, performance of many of the herbicides has not given consistently adequate control of Italian ryegrass to satisfy producers.

Monoculture intensifies a weed flora dominated by one or more adapted weeds (Liebman and Dyck 1993) and repeated use of herbicides for Italian ryegrass has led to resistance to sulfonylurea and ACCase inhibitor herbicides

(Anderson and Staska 1994). Therefore, exploration of crop rotations for Italian ryegrass control seems prudent.

In contrast to monocrop systems, rotational cropping systems provide an inconstant and frequently inhospitable environment, hindering the proliferation of any particular weed species (Liebman and Dyck 1993). Crop rotations have long been recognized as strategies for weed control (Francis et al. 1989). Downy brome densities were higher in continuous wheat than in a wheat-canola rotation (Blackshaw 1994). Compared to monocrop wheat, a wheat-grain sorghum rotation reduced wild oat density and decreased the seed bank (Martin and Felton 1993). The success of utilizing crop rotations for weed control and increasing returns depends heavily on weather conditions, crop choices, and management (Yamoah et al. 1998).

In winter wheat production areas of the southern Great Plains, there are no alternative winter crops. Thus, to avoid a year with no crop, a crop rotation that includes a summer crop and winter wheat must include a cropping sequence where one crop is seeded very soon after the other is harvested. Such double-cropping is risky in an area where rainfall is erratic and frequently sparse (Burton et al., 1996).

Soybeans are well adapted for crop rotation systems. In the U.S., soybeans are produced either as a double-crop or as a full season crop (Sims and Guethle 1992). In Kentucky, up to 38% of the total soybean production is the result of double-cropping (Grabau and Pfeiffer 1990). As long as adequate soybean yields can be obtained, greater net returns can be achieved from double-cropping soybeans and wheat than from a monocrop system (Shapiro et al. 1992).

In Oklahoma, the biggest limitation to achieving acceptable soybean yields is water. Relatively large amounts of water are needed for wheat and soybeans to reach optimal yields (Scott et al. 1987). Double-cropping soybeans after high-yielding wheat can hinder soybean success due to deplenishment of soil water required for stand establishment and growth (Daniels and Scott 1991; Sanford and Hairston 1984).

In Oklahoma, winter wheat is harvested in early to mid June and double-cropped soybeans are planted from mid to late June. Soybeans require approximately 56 cm of water for adequate growth and production from June through October [4]; however, average rainfall in central Oklahoma during this period is only 36 cm (Anonymous 1989). It is considered crucial to seed double-crop soybeans quickly after wheat harvest to take advantage of cooler temperatures and higher rainfall than that expected in July [4], but seeding in early July sometimes occurs when wheat harvest is delayed.

Conventional tillage is the most widely used method for Oklahoma wheat production. Tillage can effectively control weeds. However, labor, fuel costs, and soil erosion are concerns (Mannering et al. 1987). Because of the limited time available between wheat harvest and planting double-cropped soybeans in Oklahoma, the use of tillage to prepare the seedbed for the second crop is often

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not feasible. Thus, in Oklahoma, as in Missouri (Sims and Guethle 1992) no-tillage has become an increasingly important alternative.

No-tillage systems control erosion and enhance soil water retention (Wagger and Denton 1992). No-tillage has increased yields in a corn-soybean rotation due to increases in soil water availability and because of increased infiltration (Jones et al. 1969; Moschler et al. 1972; Wagger and Denton 1989). Alternatively, no-tillage has been reported to result in yields lower or equal to yields in conventional tillage (Wagger and Denton 1992). In Oklahoma, during a ten year study, mean wheat yields in no-tillage were less than those in conventional tillage using either a chisel, plow, or disk (Epplin et al. 1994). In the Mississippi Blacklands Prairie region, soybeans in heavy clay soils yielded 20% less with no-tillage than with conventional tillage (Hairston et al. 1984). Thus, local and regional suitabilities for tillage and crop rotations must be determined (Wagger and Denton 1992).

Another concern with no-tillage is achieving good weed control since weed seed densities are often higher than in conventional tillage (Dorado et al. 1999; Sims and Guethle 1992). Reduced tillage operations require increased usage of herbicides for weed control which can cause an economical strain (Buhler 1995; Kegode et al. 1999). Reduced tillage practices provide a favorable environment for Italian ryegrass (Martin et al. 2001).

The objectives of this research were: to determine the effect of selective herbicide treatments applied to wheat and rotating out of wheat for one growing season (replacing the missed wheat crop with double-cropped soybeans followed by early season soybeans) on Italian ryegrass density in the subsequent wheat crop. All treatments were evaluated using no-tillage and conventional tillage management. Additionally, economic returns of the various options for Italian ryegrass control were determined.

MATERIALS AND METHODS

Field experiments were established after wheat harvest in June 1999 at three sites in Oklahoma that had been infested with Italian ryegrass for five or more years. All sites had been harvested with grain combines. At sites 1, 2, and 3, wheat stubble and weed residue in the discharge swath area totaled 4900 (s.d. 2900), 10700 (s.d. 2500), and 6700 (s.d. 800) kg/ha. Outside the discharge swath area, stubble and weed residue totaled 2600 (s.d. 1970), 3200 (s.d. 580), and 2800 (s.d. 470) kg/ha.

Two crop rotations (continuous wheat and a wheat-soybean rotation) were included at each site. Each crop rotation was grown under conventional and no-tillage management and selected treatments were applied to the various crop rotation – soil management combinations. Subplot size was 3 by 7.5 m and each treatment was replicated four times (three at site 3). One half of a replication was no-tillage and the other half was conventional tillage. Each tillage system was divided into the continuous wheat rotation and the wheat-soybean rotation. Agronomic data collected from each crop rotation (prior to seeding the final wheat crop) were analyzed within each crop rotation using a randomized complete block experimental design with a split plot arrangement where tillage was the main plot and herbicide treatment was the subplot.

Data for the final wheat crop and economic data were analyzed using a split-plot arrangement with soil management as the main plot and each crop rotation – herbicide combination considered a subplot treatment, i.e., one possible combination that could have been imposed to reduce Italian ryegrass in the final wheat crop. Although this approach requires acceptance of forced randomization of the treatments due to the split-plot arrangement of the crop rotations, it was deemed the best approach to comparing all Italian ryegrass control options simultaneously.

The soil at Chickasha (site 1) was a Dale silt loam (fine-silty, mixed, thermic Pachic Haplustoll) with a pH of 6.0, 1.2% organic matter, and capability classification I (Bogard et al. 1978). The soil at Perry (site 2) was a Port silt loam (fine-silty, mixed, thermic Cumulic Haplustoll) with a pH of 5.6, 1.3% organic matter, and capability classification IIw (Henley et al. 1987). The "w" classification indicates that water in or on the soil may interfere with cultivation or plant growth (Henley et al. 1987). The soil at Perkins (site 3) was a Teller loam (fine-loamy, mixed, thermic Udic Argiustoll) with a pH of 5.8, 0.8% organic matter, and capability classification I (Henley et al. 1987).

Continuous Wheat System. The procedures used in this system are sequenced in Table 1. Conventional tillage plots were moldboard plowed about 23 cm deep. The plots were then disked (site 3 was not disked) once and field cultivated twice using a light s-tine field cultivator to prepare the seedbed. Weeds were counted in two quadrats in each plot.

No-tillage plots received 840 g ai/ha of glyphosate in September or October 1999 when the Italian ryegrass growth stage was one to three leaf. Hard red winter wheat, '2137', was planted at 67 kg/ha using a no-till grain drill equipped with coulters, double disk openers, and press wheels with 19-cm row spacing. Herbicide and cultural treatments used for Italian ryegrass control in this system were diclofop at 1120 g ai/ha, tralkoxydim at 270 g ai/ha + 0.5% v/v NIS, sulfosulfuron at 35 g ai/ha + 0.5% v/v NIS, grazeout, and a check. The herbicides were broadcast POST using a CO_2 pressurized backpack sprayer equipped with flat fan nozzles spaced 51 cm apart delivering 218 liters/ha traveling 5.5 km/hr. The Italian ryegrass growth stage at the time of treatment was 90% one leaf and 10% two leaf in the conventional tillage plots and 10% two leaf, 10% three leaf, 10% 1 tiller, 10% 3 tiller, 30% 4 tiller, and 30% 5 tiller in the no-tillage plots. Application of glyphosate in the no-tillage did not kill all of the Italian ryegrass present causing a wide range of growth stages.

Forage production was estimated by clipping wheat and Italian ryegrass from a 0.20m^2 area of each plot of the grazeout treatment. These plots were then rotary mowed to a height of two inches to simulate grazing. Glyphosate at 840 g/ha was broadcast POST on the no-tillage grazeout treatment approximately one month after mowing and the conventional tillage grazeout treatment was chiseled after harvest. Italian ryegrass control was visually rated before wheat harvest. Wheat was harvested using a small plot combine. The harvested samples were then weighed, scalped, reweighed, and cleaned using a small seed cleaner. Volume weight and moisture content were then determined and wheat yields were adjusted to 13.5% moisture.

Wheat-Soybean System. The procedures used in this system are sequenced in Table 1. Initial tillage was the same as in the continuous wheat system. Midland 8433 Roundup Ready®, group IV soybeans were inoculated and planted with a no-till row crop planter equipped in 76 cm rows at 415,000 seeds/ha in early July. PRE herbicides were applied using a CO_2 pressurized backpack sprayer equipped with flat fan nozzles spaced 51 cm apart delivering 218 liters/ha traveling 5.5 km/hr. Herbicide treatments included alachlor PRE at 2240 g ai/ha, imazethapyr PRE at 70 g ai/ha, metolachlor PRE at 1430 g ai/ha, metolachlor + metribuzin PRE at 2520 g ai/ha, cloransulam PRE at 35 g ai/ha, and glyphosate POST at 840 g/ha. Glyphosate at 840 g/ha was tank mixed with all PRE herbicides in no-tillage plots. The no-tillage untreated also received 840 g ai/ha of glyphosate PRE. All four rows of the double-cropped soybean plots were harvested with a small plot combine. The harvested samples were weighed then cleaned with a small seed cleaner. Moisture and volume weight were then measured.

Italian ryegrass plants were counted in two quadrats per plot in December 1999 or January 2000 after which glyphosate was applied at 840 g/ha to the no-tillage plots and conventional tillage plots were disked 15 cm deep.

Conventional tillage plots were cultivated again in February and immediately prior to seeding the early season soybeans. Dekalb CX367C RoundUp Ready®, group III soybeans were planted at 358,000 seeds/ha using the methods previously described. The same herbicide treatments used in the double-cropped soybeans were applied to the early season soybeans except that the no-tillage untreated did not receive glyphosate. Glyphosate was not included with the PRE treatments at site 1 because no weeds were present. No Italian ryegrass remained in the conventional tillage plots immediately after seeding the early season soybeans. Italian ryegrass plants were counted in the no-tillage plots. Because the PRE treatments failed to completely control Italian ryegrass in the no-tillage soybean plots, glyphosate at 840 g/ha was applied POST except in the untreated. Two rows of the early season soybeans were harvested and processed using the same methods as the double-cropped soybeans.

Sites 2 and 3 had 28 kg/ha of urea (46-0-0) banded with the double-cropped soybeans. At site 3, lambda-cyhalthrin at 28 g ai/ha was applied to both soybean crops to control grasshoppers (order: Orthoptera). Both soybean crops were rotary hoed in conventional tillage plots at site 2 due to soil crusting. No-tillage double-cropped soybeans were replanted at 415,000 seeds/ha due to poor emergence at site 2 on July 19, 1999.

Final Wheat Crop. The procedures used in this crop are sequenced in Table 1. After wheat harvest in June 2000, continuous wheat – conventional tillage treatments were chiseled twice and disked during the summer, and field cultivated immediately prior to seeding the final wheat crop. The no-tillage treatments received 840 g/ha of glyphosate in mid-summer.

After the early season soybeans were harvested in the wheat-soybean system, conventional tillage treatments were chiseled and field cultivated once before planting the final wheat crop.

The final wheat crop was planted with '2137' hard red winter wheat using the wheat planting methods mentioned earlier. Sites 1 and 3 were planted at 67 kg/ha and site 2 was planted at 100 kg/ha due to a late planting date caused by persistent rainfall. Urea (46-0-0) at 190 kg/ha was broadcast with a spinner type spreader at sites 1 and 3 and 250 kg/ha at site 2 during tillering. Italian ryegrass spikes were counted in two quadrats in each plot before wheat harvest. The final wheat crop was harvested and cleaned using the same methods as with the 2000 wheat crop. In addition to analysis of variance of treatment means, Italian ryegrass plant and spike density was regressed against wheat yield at each site to estimate the effect of spike density on wheat yield.

Economic Data. Net returns were calculated for each treatment at all locations using custom rates and local market values (Table 2) (Baker 1999-2000; Kletke and Doye 1999-2000). Although tilled plots were planted with a no-till grain drill or no-till row crop planter, the extra cost of using no-till seeding equipment was not included in the conventional tillage treatments. The technology fee for the Roundup Ready® soybeans was not included in the conventional tillage treatments and the no-tillage untreated in the early season soybeans not utilizing glyphosate. The technology fee for the double-cropped soybeans was $18.00/ha and $17.00/ha for the early season soybeans.

RESULTS AND DISCUSSION

Treatment by location interactions prevented data pooling across locations, thus data are reported by site. Because of a very wide range in some weed density data, square root transformation was conducted prior to analyses of variance (Steel et al. 1997). However, it did not change the data interpretation, thus untransformed data are presented.

Continuous Wheat System. Tillage affected the presence of other weeds. Seedling elm (*Ulmus pumila* L.) was present at sites 1 and 2 only in the no-tillage main plots at 0.3 to 0.6 plants/m^2. Prairie cupgrass (*Eriochloa contracta* Hitch.) at 0.1 plants/m^2 was present only in the no-tillage plots at site 2 and tumble pigweed (*Amaranthus albus* L.) was present at 0.1 plants/m^2 at site 3 only in the conventional tillage. At seeding, these weeds were dead due to tillage or glyphosate applied at 840 g/ha in late September.

Italian ryegrass densities in the continuous wheat system in September 1999, prior to seeding, confirmed that all sites were severely infested. Italian ryegrass densities in mid September were much higher in the no-tillage main plots than in the conventional tillage main plots at all sites (Table 3). This Italian ryegrass was killed by glyphosate or tillage prior to seeding. However, when selective herbicides were applied in December or January, no-tillage plots in particular, had substantial densities of Italian ryegrass that emerged in October or later. In contrast, at site 1 where wheat seeding was delayed until November 18, only 20 Italian ryegrass plants/m^2 were present in January in the untreated tilled plots.

At sites 1 and 2, Italian ryegrass control with tralkoxydim and sulfosulfuron was greater in conventional tillage than in no-tillage (Table 4). Diclofop was considerably more effective than the other herbicides in no-tillage and the effect of tillage on control was not evident with diclofop. Grazeout did not appear to reduce Italian ryegrass density.

At sites 1 and 2, wheat yields for all treatments were consistently greater in tilled plots than in no-tillage plots (Table 4). Wheat stand density in the conventional tillage plots (820,000 plants/ha) was higher (P=.05) than the density in no-tillage plots (493,000 plants/ha) at site 1. High Italian ryegrass densities in no-tillage caused yields to be lower than in conventional tillage at site 2. At site 3, wheat yield was not affected by tillage.

Except in conventional tillage at site 1, where Italian ryegrass density was low, all the herbicide treatments at all sites increased wheat yields regardless of tillage (Table 4). At site 3, diclofop increased wheat yield more than the other herbicides. Substantial wheat yield increases occurred when visible Italian ryegrass control in May was relatively low. Early spring visual evaluations of Italian ryegrass control with tralkoxydim and sulfosulfuron were frequently higher than the visual evaluation in May (data not shown). Thus, temporary suppression of Italian ryegrass by these herbicides was sufficient to increase wheat yield, even though the weed recovered by May.

At sites 1 and 2, dockage in the untreated was much higher in the no-tillage than in the conventional tillage. All herbicides reduced wheat dockage caused by

Italian ryegrass at all sites, except at site 1 in the conventional tillage where weed density was low (Table 4).

Wheat-Soybean System. Double-cropped soybean stand density was approximately 132,000 plants/ha at sites 1 and 2 and was not affected by tillage system. At site 3, the soybean stand density in the no-tillage plots (170,000 plants/ha) was less (P=.05) than the density in tilled plots (280,000 plants/ha). At all three sites, the double-cropped soybean yields were limited due to lack of soil water. At sites 1 and 2, total rainfall during the growing season (July thru October) was 27 cm and at site 3, 17 cm.

Seedling elm (2.5 to 5 cm tall) was present in the no-tillage plots at sites 1 (1 plant/m^2) and 2 (5 plants/m^2) in September 1999. At site 1 in May 2000, seedling elm (2.5 to 5 cm) was present in the no-tillage plots of replication one at 1 plant/m^2. This can be attributed to new seed being dispersed from nearby mature elm trees.

There was not a consistent yield advantage for no-tillage management of the double-cropped soybeans (Table 5). At site 1, soybean yields were greater in the no-tillage than conventional tillage. The opposite occurred at site 3 and tillage did not affect yield at site 2. At site 3, higher soybean stands in the conventional tillage, may have contributed to higher yields. At all sites, only one herbicide treatment increased yield compared to the untreated. The lack of any other yield response from weed control may be attributed to sparse rainfall.

At all sites in January after the double-cropped soybeans were harvested, Italian ryegrass was approximately 100 times more dense in no-tillage than in conventional tillage (Table 6). These greater densities of Italian ryegrass in no-tillage were attributed to high establishment rates of seed closer to the soil surface than of seed buried. At sites 1 and 3, compared to the untreated, Italian ryegrass was less dense in the no-tillage treatments that received alachlor or metolachlor PRE on the double-cropped soybeans. This suggests that under dry conditions, these herbicides persisted long enough to control some fall emerging seedlings.

The April – May 2000 Italian ryegrass densities were analyzed within each tillage because Italian ryegrass densities in conventional tillage were counted at a later date since pre-plant tillage had controlled the weed (Table 6). At site 1, there was no Italian ryegrass present in the no-tillage indicating that no emergence had occurred after January. In the conventional tillage at site 1, all the herbicides except glyphosate reduced Italian ryegrass density indicating that the treatments applied PRE to soybeans had a negative impact on the Italian ryegrass seed bank. At site 2, no herbicide reduced Italian ryegrass density in either tillage system. At site 3, only two herbicides in no-tillage and all herbicides in conventional tillage reduced Italian ryegrass density.

Tillage, averaged over herbicide treatment, did not affect yields at sites 1 and 3. None of the herbicides consistently increased early season soybean yields at all sites (Table 7). At site 1, only two herbicide treatments increased yields. All herbicides in no-tillage increased soybean yields where only one herbicide increased yield in conventional tillage at site 2. At site 2, soybean yields were higher in conventional tillage than in no-tillage. This was attributed to deer feeding only on the no-tillage plots. At site 3, three herbicides increased yield.

Final Wheat Crop. None of the treatments, at all sites, eliminated Italian ryegrass from the final wheat crop. Since the grazeout treatment did not receive 840 g/ha of glyphosate soon after mowing, it was not effective on controlling Italian ryegrass. At all sites, the conventional tillage untreated of the continuous wheat system had as much or more Italian ryegrass in November 2000 as in September 1999. This was also evident in the conventional tillage untreated of the wheat-soybean system where Italian ryegrass densities in November 2000 were a little higher than those in January 2000. Thus, tillage alone was not effective in reducing Italian ryegrass.

None of the Italian ryegrass management treatments consistently reduced Italian ryegrass density at all sites (Table 8). Of the Italian ryegrass management treatments applied in the 2000 wheat crop, three treatments at site 1 and all treatments at site 2 in the no-tillage reduced Italian ryegrass density in the final wheat crop. Of the Italian ryegrass management treatments applied in the double-cropped and early season soybeans, all treatments reduced Italian ryegrass density in the no-tillage at sites 1 and 2. None of the treatments in conventional tillage reduced Italian ryegrass density. At site 3, of the Italian ryegrass management treatments applied to the 2000 wheat crop and double-cropped and early season soybeans, all reduced Italian ryegrass density.

A logarithmic relationship was found between Italian ryegrass plant density in November 2000 and wheat yield at sites 1 ($y = 6295.1 - 553.74Ln(x)$, $R^2 =$

0.8292) and 3 ($y = 7947.9 - 1146.2Ln(x)$, $R^2 = 0.6745$) (Figure 1). Wheat yield was reduced 30% when Italian ryegrass density increased from 20 to 240 plants/m^2 at site 1. At site 3, wheat yield was reduced 77% when Italian ryegrass density increased from 30 to 840 plants/m^2. Tillages were analyzed separate at site 2 and no-tillage was not reported due to low wheat stand densities. Conventional tillage had a linear relationship ($y = 2655.6 - 3.6202x$, $R^2 = 0.8442$). Wheat yield was reduced 78% when Italian ryegrass density increased from 20 to 610 plants/m^2.

A linear relationship was found between Italian ryegrass spike density and wheat yield at site 1 ($y = 4884.1 - 9.4203x$, $R^2 = 0.9258$) (Figure 2). Wheat yield was reduced 32% when Italian ryegrass spike density increased from 10 to 170 spikes/m^2. Site 2 had a quadratic relationship ($y = 2908.6 - 5.9494x + 0.003x^2$, $R^2 = 0.9764$). Wheat yield was reduced 99.9% when Italian ryegrass spike density increased from 30 to 1260 spikes/m^2. At site 3, tillage systems were analyzed separate due to differences in wheat stands. The conventional tillage had a quadratic relationship ($y = 4846 - 12.39x + 0.0091x^2$, $R^2 = 0.9717$) and no-tillage had a poor linear relationship. Wheat yield in the conventional tillage was reduced 85% when Italian ryegrass spike density increased from 60 to 780 spikes/m^2.

None of the Italian ryegrass management treatments consistently reduced Italian ryegrass dockage in the final wheat crop (Table 10). Five of the Italian ryegrass management treatments in no-tillage reduced dockage at site 1. None of the treatments reduced dockage in conventional tillage at site 1 and in no-tillage at site 2. All of the Italian ryegrass management treatments in conventional tillage except tralkoxydim and grazeout reduced dockage at site 2. All the Italian ryegrass management treatments applied in the double-cropped and early season soybeans decreased dockage at site 3. Site 3 also had dockage due to jointed goatgrass (*Aegilops cylindrica* Host). None of the Italian ryegrass management treatments applied in the 2000 wheat crop decreased jointed goatgrass dockage in the final wheat crop but all treatments applied in the double-cropped and early season soybeans did (data not shown).

Economic Data. Of the Italian ryegrass management treatments applied in the 2000 wheat crop, grazeout in the no-tillage at sites 1 and 2 and diclofop, tralkoxydim, and sulfosulfuron in conventional tillage at site 2 increased net returns (Table 11). Of the Italian ryegrass management treatments involving double-cropped and early season soybeans, all but metolachlor in no-tillage at site 1, all treatments in conventional tillage at site 2, and all treatments in both tillages at site 3 increased net returns. Metolachlor was the only treatment with which net returns were consistently higher in conventional tillage than in no-tillage. None of the Italian ryegrass management treatments in conventional tillage at site 1 increased net returns.

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Table 1. Sequence of field activities in conventional and no-tillage continuous wheat, wheat-soybean system, and the final wheat crop.

Method	Tillage[a]		Site 1	Site 2	Site 3
Continuous wheat system					
Broadcast glyphosate		NT	08-17-99	08-16-99	08-05-99
Cultivated plots	CT		08-09-99	08-12-99	08-06-99
Weeds counted	CT	NT	09-17-99	09-09-99	09-09-99
Ryegrass counted	CT	NT	09-17-99	09-21-99	09-21-99
Broadcast glyphosate		NT	10-21-99	09-30-99	09-30-99
Cultivated plots	CT		11-18-99	10-19-99	10-19-99
Planted wheat	CT	NT	11-18-99	10-19-99	10-19-99
Broadcast selective herbicides	CT	NT	01-11-00	12-15-99	12-15-99
Ryegrass counted	CT	NT	01-11-00	12-15-99	12-15-99
Broadcast 110 kg/ha 28-0-0	CT	NT	02-08-00	02-08-00	02-03-00
Wheat stands counted	CT	NT	04-14-00	03-28-00	03-28-00
Clipped and mowed grazeout	CT	NT	05-01-00	04-13-00	04-13-00
Applied glyphosate to grazeout		NT	05-23-00	05-23-00	05-23-00
Visual rating (% control)	CT	NT	04-14-00	05-17-00	05-16-00
Harvested wheat	CT	NT	06-07-00	06-05-00	06-02-00
Chiseled plots (points)	CT		06-07-00	06-05-00	06-06-00
Chiseled plots (duckfeet)	CT		07-11-00	07-10-00	07-10-00
Broadcast glyphosate		NT	07-27-00	08-02-00	08-02-00
Disked plots	CT		08-10-00	08-10-00	08-10-00

Table 1. Continued.

Wheat-soybean system					
Planted DC soybeans[b]	CT	NT	07-13-99	07-08-99	07-07-99
Broadcast PRE herbicides	CT	NT	07-13-99	07-08-99	07-07-99
Broadcast POST herbicides	CT	NT	08-17-99	08-16-99	08-16-99
Weeds counted	CT	NT	09-17-99	09-09-99	09-09-99
Harvested DC soybeans	CT	NT	10-21-99	11-01-99	11-01-99
Ryegrass counted	CT	NT	01-11-00	12-15-99	12-15-99
Disked plots	CT		01-11-00	01-07-00	01-07-00
Broadcast glyphosate		NT	01-11-00	02-08-00	02-08-00
Cultivated plots	CT		02-29-00	02-29-00	02-28-00
Cultivated plots	CT		04-14-00	04-10-00	04-04-00
Planted ES soybeans	CT	NT	04-14-00	04-10-00	04-05-00
Broadcast PRE herbicides	CT	NT	04-14-00	04-10-00	04-06-00
Ryegrass counted		NT	04-14-00	04-10-00	04-08-00
Ryegrass counted	CT		05-15-00	04-25-00	04-21-00
Broadcast POST herbicides	CT	NT	06-07-00	05-16-00	06-06-00
Broadcast glyphosate		NT	06-07-00	05-16-00	06-06-00
Harvested ES soybeans	CT	NT	08-25-00	09-01-00	08-22-00
Chiseled plots	CT		10-02-00	10-15-00	10-19-00
Final wheat crop					
Cultivated plots	CT		10-02-00	11-22-00	10-19-00
Planted wheat	CT	NT	10-02-00	11-22-00	10-19-00

Table 1. Continued.

Ryegrass counted	CT	NT	12-01-00	11-15-00	11-13-00
Wheat stands counted	CT	NT	12-01-00	04-03-01	11-13-00
Applied fertilizer (46-0-0)	CT	NT	02-06-01	02-07-01	02-07-01
Ryegrass spikes counted	CT	NT	05-09-01	05-10-01	05-10-01
Harvested wheat	CT	NT	06-06-01	06-12-01	06-04-01

[a]NT = no-tillage, CT = conventional tillage.

[b]DC = double-cropped, ES = early season.

Table 2. Cropping systems budget.

Budget parameter[a]	Unit of measure	Price	Quantity	Value Tillage[a] NT	CT
		$/unit	units/ha	—— $/ha ——	
Receipt sources					
1999 wheat grain	kg	0.09			
2000 wheat grain	kg	0.11			
Soybean	kg	0.19			
Wheat forage	kg	0.05			
Operation inputs					
Moldboard plowing	ha				23.99
Disking	ha				14.80
Field cultivating	ha				11.56
Planting soybeans	ha			25.95	20.53
Spraying herbicides	ha			7.34	7.34
Rotary hoeing	ha				10.08
Combining soybeans	ha			44.92	44.92
Chisel plowing	ha				18.51
Seeding wheat	ha			20.86	14.33
Applying liquid fertilizer	ha			6.67	6.67
Applying dry fertilizer	ha			6.13	6.13
Spraying insecticide	ha			7.39	7.39

Table 2. Continued.

Midland soybean seed	kg	2.59	25.4	65.73	65.73
Dekalb soybean seed	kg	2.89	24	69.41	69.41
Inoculant	ha			0.62	0.62
Wheat seed	kg	0.20	67	13.59	13.59
Alachlor	g	0.01	2240	24.12	24.12
Imazethapyr	g	0.50	70	34.72	34.72
Metolachlor	g	0.03	1430	43.04	43.04
Metolachlor+					
metribuzin (5:1)	g	0.02	2520	38.97	38.97
Cloransulam	g	1.00	35	35.24	35.24
Glyphosate	g	0.03	840	22.16	22.16
Lambda-cyhalthrin	g	0.54	28	15.15	15.15
Diclofop	g	0.06	1120	62.54	62.54
Tralkoxydim	g	0.20	270	54.07	54.07
Sulfosulfuron	g	0.77	35	27.03	27.03
28-0-0	kg	0.53	110	58.12	58.12
46-0-0	kg	0.26	varied		

[a]Values obtained from Baker 1999-2000, Kletke and Doye 1999-2000, and local markets.

[b]NT = no-tillage, CT = conventional tillage.

Table 3. Effect of tillage on Italian ryegrass densities in September 1999 prior to final seedbed preparation and in December 1999 prior to application of selective herbicides in the continuous wheat system.

	September 1999			December 1999		
Tillage[a]	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
	plants/m^2					
NT	14800	15000	12300	90	550	160
CT	0	500	300	20	60	70
LSD (0.05)	10800	3600	11600[b]	5	340	NS

[a]NT = no-tillage, CT = conventional tillage.

[b]LSD (0.10).

Table 4. Tillage by treatment interactions on Italian ryegrass control in May 2000, June 2000 wheat yields, and dockage due to Italian ryegrass seed.

	May 2000 Italian ryegrass control					2000 Wheat yield					2000 Dockage				
	Site 1		Site 2		Site 3	Site 1		Site 2		Site 3	Site 1		Site 2		Site 3
	Tillage[a]														
Treatment	NT	CT	NT	CT	Mean	NT	CT	NT	CT	Mean	NT	CT	NT	CT	Mean
	%					kg/ha					%				
Untreated	0	98	0	0	0	1180	2800	500	2000	1430	11	2	57	20	31
Diclofop	95	99	86	97	94	2280	2840	2250	3550	3070	4	2	14	4	3
Tralkoxydim	55	98	24	54	55	2090	3090	1710	3460	2500	5	2	28	6	11
Sulfosulfuron	69	99	13	50	33	1910	2690	1920	3560	2330	3	3	16	6	11
Grazeout	0	0	0	0	0	—	—	—	—	—	—	—	—	—	—
LSD (0.05)	18		19		21	530		350		650	2		7		14

[a]NT = no-tillage, CT = conventional tillage

Table 5. Tillage by treatment interactions in yields of the double-cropped soybeans at sites 1 and 3 and mean yields pooled over tillage at site 2.

	Site 1		Site 2	Site 3	
	Tillage[a]				
Treatment	NT	CT	Mean	NT	CT
	kg/ha				
Untreated	400	90	190	100	590
Glyphosate[b]	510	160	190	140	790
Alachlor	430	120	200	100	920
Imazethapyr	430	100	285	160	1050
Metolachlor	380	110	270	160	800
Metolachlor + metribuzin	420	120	200	—[c]	—
Cloransulam	390	90	210	—	—
LSD (0.05)	100		90	450	

[a]NT = no-tillage, CT = conventional tillage.

[b]All no-tillage treatments received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[c]Treatments not included at site 3.

Table 6. Tillage by treatment interactions on Italian ryegrass densities in January 2000 at three sites and Italian ryegrass densities in April – May 2000 at three sites with tillages analyzed separate in the wheat-soybean system.

	January						April – May 2000					
	Site 1		Site 2		Site 3		Site 1		Site 2		Site 3	
	Tillage[a]											
Treatment[b]	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
	plants/m²											
Untreated	5680	60	17400	120	13600	70	0	4	220	2	150	8
Glyphosate[c]	5210	70	16100	120	12100	60	0	5	360	3	150	6
Alachlor	3630	50	16900	100	12100	60	0	2	280	3	130	3
Imazethapyr	4810	50	17300	130	12400	80	0	1	240	2	80	5
Metolachlor	3240	10	16900	20	11500	30	0	0	350	2	70	1
Metolachlor + metribuzin	3790	10	16100	40	—[d]	—	0	0	250	1	—	—

Table 6. Continued.

Cloransulam	3470	70	17100	110	—	—	0	2	310	2	—	—
LSD (0.05)	—— 1870 ——		—— 2200 ——		—— 1400 ——		0	1	60	1	50	1

[a]NT = no-tillage, CT = conventional tillage.

[b]Treatments applied to double-cropped soybeans in July, 1999 and repeated on early season soybeans in April, 2000.

[c]All no-tillage treatments received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[d]Treatments not included at site 3.

Table 7. Tillage by treatment interactions on yields of the early season soybeans at site 2 and mean yields pooled over tillage at sites 1 and 3.

	Site 1	Site 2		Site 3
	Tillage[a]			
Treatment	Mean	NT	CT	Mean
	kg/ha			
Untreated	1510	370	1780	1640
Glyphosate[b]	1440	850	2130	2450
Alachlor	1680	830	2230	2100
Imazethapyr	1630	890	2480	2300
Metolachlor	1640	980	2200	2150
Metolachlor + metribuzin	1740	890	1950	—[c]
Cloransulam	1770	980	1980	—
LSD (0.05)	220	450		480

[a]NT = no-tillage, CT = conventional tillage.

[b]All no-tillage treatments received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[c]Treatments not present at site 3.

Table 8. Tillage by treatment interactions on Italian ryegrass density at sites 1 and 2 and mean Italian ryegrass density pooled over tillage at site 3 in November 2000 in the final wheat crop.

Italian ryegrass management		Site 1		Site 2		Site 3
		Tillage[a]				
Treatment	Cropping system[b]	NT	CT	NT	CT	Mean
		plants/m^2				
Untreated	CW	240	20	21160	580	300
Diclofop	CW	100	40	8870	110	200
Tralkoxydim	CW	250	40	10820	290	200
Sulfosulfuron	CW	120	30	12680	300	250
Grazeout	CW	100	70	8970	610	250
Untreated	WS	60	40	14720	180	680
Glyphosate[c]	WS	120	30	9260	100	100
Alachlor	WS	80	30	9750	70	80

Table 8. Continued.

Imazethapyr	WS	110	20	5360	50	130
Metolachlor	WS	90	30	7610	20	90
Metolachlor +						
metribuzin	WS	70	20	6140	20	—[d]
Cloransulam	WS	60	20	4580	100	—
LSD (0.05)		——— 60 ———		——— 5270 ———		180

[a]NT = no-tillage, CT = conventional tillage.

[b]CW = continuous wheat, WS = wheat-soybean.

[c]All no-tillage treatments of the double-cropped soybeans and all treatments of the early season soybeans except the untreated received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[d]Treatments not included at site 3.

Table 9. Tillage systems by Italian ryegrass management system interactions on Italian ryegrass spike densities in May 2001 and yield of the final wheat crop, with cropping system considered part of the Italian ryegrass control treatment.

Italian ryegrass management		Italian ryegrass spikes						Wheat yield					
		Site 1		Site 2		Site 3		Site 1		Site 2		Site 3	
		Tillage[a]											
Treatment	Cropping system[b]	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
		no./m²						kg/ha					
Untreated	CW	170	60	1260	450	160	780	3160	4450	60	830	810	620
Diclofop	CW	90	40	620	280	140	390	3880	4550	90	1740	1370	1260
Tralkoxydim	CW	150	50	850	240	160	490	3220	4470	70	1330	1530	1070
Sulfosulfuron	CW	110	40	960	340	160	360	3750	4580	70	1160	970	1140
Grazeout	CW	100	120	920	540	310	460	4070	3930	140	590	1460	1380
Untreated	WS	130	70	1140	220	270	540	3560	4260	10	1810	1640	950
Glyphosate[c]	WS	150	40	780	80	80	70	3570	4540	60	2520	3090	4310

Table 9. Continued.

Alachlor	WS	130	50	1100	80	120	80	3870	4230	80	2780	2800	4180
Imazethapyr	WS	110	40	890	30	90	60	3830	4600	130	2910	2810	3990
Metolachlor	WS	150	20	1070	30	100	80	3640	4640	70	2650	2660	3600
Metolachlor +													
metribuzin	WS	110	10	840	30	—[d]	—	3840	4650	90	2720	—	—
Cloransulam	WS	110	40	970	90	—	—	3720	4520	110	2030	—	—
LSD (0.05)		—— 45 ——		—— 400 ——		—— 240 ——		—— 510 ——		—— 390 ——		—— 760 ——	

[a]NT = no-tillage, CT = conventional tillage.

[b]CW = continuous wheat, WS = wheat-soybean.

[c]All no-tillage treatments of the double-cropped soybeans and all of the early season soybean treatments except for the untreated received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[d]Treatments not included at site 3.

Table 10. Tillage by treatment interactions on dockage in the 2001 wheat yields at sites 1 and 2, and mean dockage pooled over tillage at site 3.

Italian ryegrass management		Site 1		Site 2		Site 3
		Tillage[a]				
Treatment	Cropping system[b]	NT	CT	NT	CT	Mean
		%				
Untreated	CW	5	2	91	57	37
Diclofop	CW	3	2	92	35	28
Tralkoxydim	CW	5	2	94	49	26
Sulfosulfuron	CW	3	2	90	42	28
Grazeout	CW	3	5	86	69	31
Untreated	WS	4	3	98	33	28
Glyphosate[c]	WS	5	2	91	18	6
Alachlor	WS	3	2	86	16	7
Imazethapyr	WS	4	2	87	12	8

Table 10. Continued.

Metolachlor	WS	4	1	90	15	9
Metolachlor + metribuzin	WS	3	1	91	13	—[d]
Cloransulam	WS	5	2	88	29	—
LSD (0.05)		—— 1 ——		—— 11 ——		13

[a]NT = no-tillage, CT = conventional tillage.

[b]CW = continuous wheat, WS = wheat-soybean.

[c]All no-tillage treatments of the double-cropped soybeans and all of the treatments of the early season soybeans except the untreated received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[d]Treatments not included at site 3.

Table 11. Tillage by Italian ryegrass management system interactions on net returns at the three sites.

Italian ryegrass management		Site 1		Site 2		Site 3	
		Tillage[a]					
Treatment	Cropping system[b]	NT	CT	NT	CT	NT	CT
		$/ha					
Untreated	CW	101	357	(354)[c]	(151)	(144)	(186)
Diclofop	CW	211	298	(255)	20	(32)	(2)
Tralkoxydim	CW	132	324	(301)	(23)	(10)	(112)
Sulfosulfuron	CW	199	325	(254)	(3)	(103)	(55)
Grazeout	CW	339	237	(236)	(189)	(32)	45
Untreated	WS	299	348	(442)	93	41	17
Glyphosate[d]	WS	229	286	(439)	156	272	528
Alachlor	WS	269	306	(489)	237	125	477
Imazethapyr	WS	219	329	(483)	304	118	551

Table 11. Continued.

Metolachlor	WS	172	322	(504)	202	124	342
Metolachlor +							
metribuzin	WS	242	343	(510)	137	—[e]	—
Cloransulam	WS	228	346	(477)	80	—	—
LSD (0.05)		——— 110 ———		——— 101 ———		——— 188 ———	

[a]NT = no-tillage, CT = conventional tillage.

[b]CW = continuous wheat, WS = wheat-soybean.

[c](#) = loss.

[d]All no-tillage treatments of the double-cropped soybeans and all of the treatments of the early season soybeans except the untreated received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha of glyphosate POST.

[e]Treatments not included at site 3.

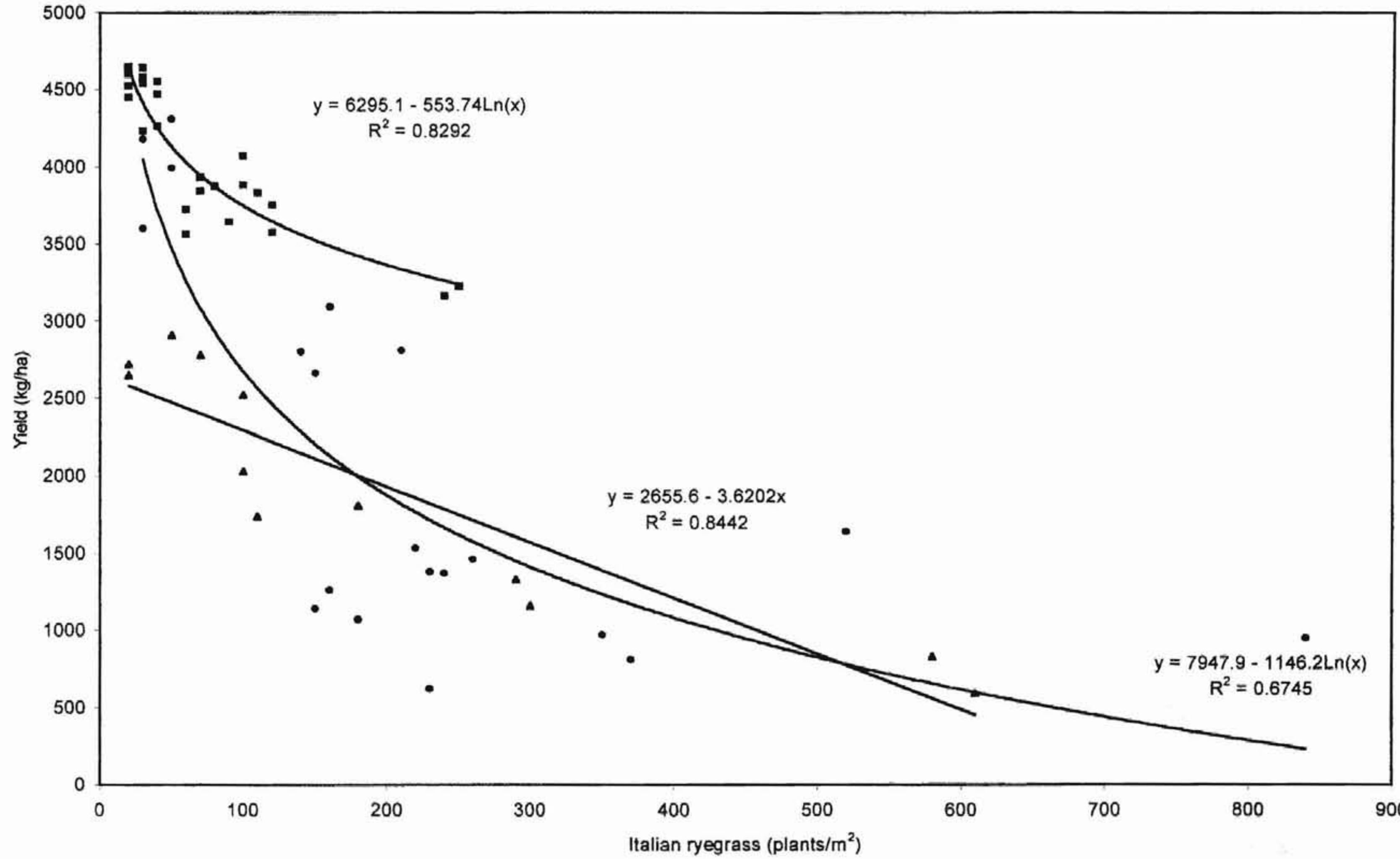

Figure 1. Effect of Italian ryegrass plant density on wheat yield. Site 1 (■), site 2 conventional tillage (▲), and site 3 (●).

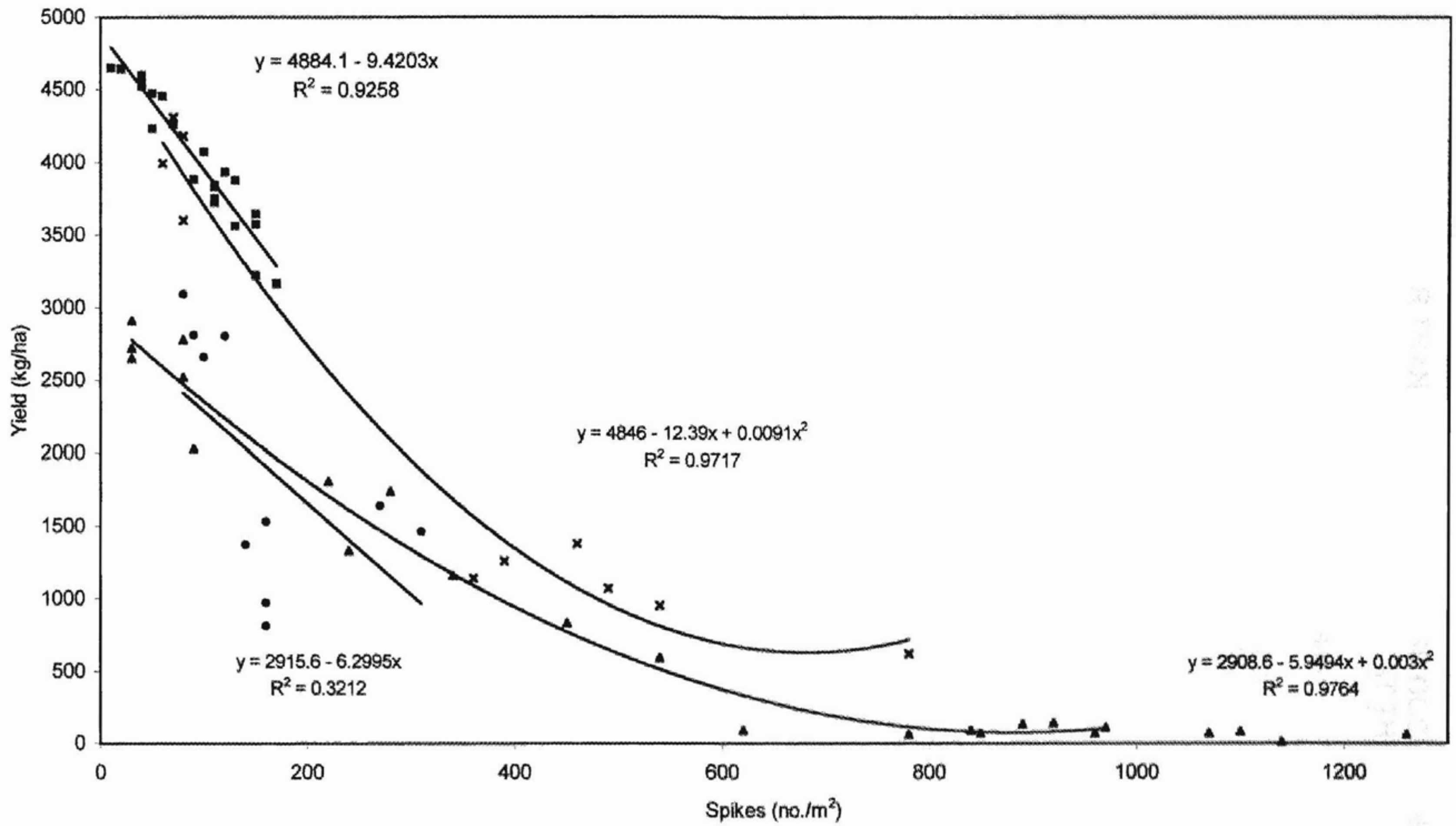

Figure 2. Effect of Italian ryegrass spike density on wheat yield. Site 1 (■); site 2 (▲); site 3, no-tillage (●); site 3, conventional tillage (x).

APPENDIX A

WEED SPECIES OTHER THAN ITALIAN RYEGRASS OCCURRING IN THE TILLAGE SYSTEMS OF THE CONTINUOUS WHEAT AT THE THREE SITES.

	Site 1		Site 2		Site 3	
	Tillage[a]					
Species[b]	NT	CT	NT	CT	NT	CT
	plants/115m^2					
Common goldenweed	1	—[c]	—	—	—	—
Common purslane	—	—	—	—	—	1
Common waterhemp	—	—	—	10	—	—
Curly dock	2	—	—	—	—	—
Large crabgrass	—	—	—	—	—	1
Marestail	2	—	—	—	—	—
Prairie cupgrass	1	—	13	—	—	—
Prickly lettuce	1	—	—	—	—	—
Prickly sida	—	—	—	—	—	4
Siberian elm	26	—	66	—	—	---
Smooth pigweed	1	—	—	—	—	2
Tumble pigweed	—	—	—	2	—	11

[a]NT = no-tillage, CT = conventional tillage.

[b]WSSA-approved common names.

[c]Weed species not present.

APPENDIX B

WEED SPECIES OTHER THAN ITALIAN RYEGRASS IN THE DOUBLE-CROPPED SOYBEANS IN SEPTEMBER 1999 AT THREE SITES, AVERAGED ACROSS HERBICIDE TREATMENTS AND TILLAGE.

Species[a]	Site 1	Site 2	Site 3
	plants/100m^2		
Carpetweed	1	—	6
Common purslane	—[b]	—	4
Common waterhemp	—	1	—
Barnyardgrass	1	—	—
Large crabgrass	—	—	4
Mairstail	1	—	2
Prairie cupgrass	3	—	—
Prickly sida	—	—	11
Prostrate spurge	2	—	—
Purple nutsedge	—	200	—
Siberian elm	31	250	—
Tumble pigweed	—	1	11

[a]WSSA-approved common names.

[b]Weed species not present. No tillage or herbicide treatment main effects nor interaction were found.

APPENDIX C

TILLAGE BY TREATMENT INTERACTIONS ON ITALIAN RYEGRASS CONTROL IN WHEAT IN MARCH 2000 AT SITE 2 AND MEAN ITALIAN RYEGRASS CONTROL IN MARCH 2000 POOLED OVER TILLAGE AT SITE 3.

	Italian ryegrass management		
	Site 2		Site 3
	Tillage[a]		
Treatment	NT	CT	Mean
	%		
Untreated	0	13	27
Diclofop	95	97	91
Tralkoxydim	55	93	71
Sulfosulfuron	61	83	56
Grazeout	0	0	0
LSD (0.05)	17		26

[a]NT = no-tillage, CT = conventional tillage.

APPENDIX D

DOCKAGE DUE TO JOINTED GOATGRASS IN THE WHEAT HARVESTED IN 2001 AT SITE 3 POOLED OVER TILLAGE.

Cropping system	Treatment	Applied to	Mean
			— % —
Continuous wheat	Untreated	2000 wheat	47
Continuous wheat	Diclofop	2000 wheat	35
Continuous wheat	Tralkoxydim	2000 wheat	32
Continuous wheat	Sulfosulfuron	2000 wheat	42
Continuous wheat	Grazeout	2000 wheat	36
Wheat-soybean	Untreated	1999 and 2000 soybeans	32
Wheat-soybean	Glyphosate[a]	1999 and 2000 soybeans	7
Wheat-soybean	Alachlor	1999 and 2000 soybeans	8
Wheat-soybean	Imazethapyr	1999 and 2000 soybeans	9
Wheat-soybean	Metolachlor	1999 and 2000 soybeans	11
LSD (0.05)			18

[a]All no-tillage treatments of the double-cropped soybeans and all treatments of the early season soybeans except the untreated received 840 g/ha of glyphosate broadcast PRE. The glyphosate treatment also received 840 g/ha POST.

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