RYE COVER CROP MANAGEMENT IN CORN

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ABSTRACT

Rye cover crops can have multiple environmental benefits, such as erosion control, reduced nitrate leaching, soil organic matter increases, moisture savings in summer, and supplemental weed control. Recent research suggests that late killing of a rye cover crop is possible without corn yield losses. We planted corn 7-10 days after killing a rye cover crop in early and late boot stage, and compared the results with a control (no rye cover crop) in central Pennsylvania. We also investigated the benefits of in-row cultivation (zone-tillage), and compared weed control with full and half rates of pre-emergence herbicides as well as a complete post-emergence herbicide program. In this study we determined that approximately 4 times more rye biomass can be expected if rye cover crop kill is delayed from early to late boot stage. We did not observe a benefit to zone-tillage in recently killed rye cover crop. The root system of the rye was still completely intact at the time of zone-till, which made preparation of the zones with the coulter system challenging. This problem was exacerbated in late-killed rye. Weed control programs did not differ in efficacy, showing it may be possible to reduce reliance on pre-emergence herbicides in no-till if weed pressure is low. We observed no significant differences between corn yields with or without a cover crop or due to planting date if straight no-till was used. The use of late-killed rye cover crop seems therefore possible without a yield penalty in no-till. Multiple environmental benefits would be accompanying the higher rye biomass production in this system that may pay off in the long run. They include: better erosion control, higher residue input for organic matter increases, and reduced bulk density due to high rye root biomass input.

INTRODUCTION

Rye is the most common cover crop in Pennsylvania because of its ability to withstand low winter temperatures (Duiker and Curran, 2003). Rye helps reduce erosion, especially after low-residue crops such as soybean and corn silage, and protects nitrate from leaching (Brandi-Dohrn et al. 1997, Kessavalou and Walters, 1997). The addition of above and below ground rye residue contributes to increases in soil organic matter and soil aggregation (Oades 1984; Tisdall and Oades, 1982). Moisture conservation by a dead rye mulch cover can help alleviate main crop moisture stress in the summer. Rye cover crops have been found to reduce weed populations and weed growth (Reddy, 2003). Because of its multiple benefits, many producers are already using rye as a cover crop and environmental organizations are actively promoting it to protect water quality.

Most rye is followed by corn in Pennsylvania. The Penn State Cooperative Extension Service recommends farmers in the center of the state to finish corn planting by the 10th of May, which allows for limited rye biomass accumulation (Roth and Beegle, 2003). A threat associated with high rye biomass production is surface moisture depletion, which might harm the corn crop (Ebelhar, et al., 1984; Raimbault et al., 1991). In a recent study in Maryland, however, late kill of rye was not found to be detrimental to corn yield and beneficial for moisture conservation (Clark et al., 1997).

Compared to early killed rye, a mulch of rye killed late will last much longer and provides more environmental benefits.

Rye cover crop management has not always been without problems. Eckert (1988) observed significant stand reductions when planting into a living rye cover crop that was subsequently desiccated. Raimbault et al. (1990) observed 11-17% corn yield reduction after rye, which they attributed to phytotoxic (allelopathic) compounds released by rye. In a subsequent study, they found that the allelopathic effect was eliminated if the rye was killed some 2 weeks prior to planting and if in-row cultivation preceded planting operations (Raimbault et al., 1991).

Rye mulch retained on the surface can physically and chemically suppress weeds (Mohler and Teasdale, 1993). The rye mulch will reduce light penetration to the soil surface and lower soil temperatures, slowing weed seed germination and early growth. Rye is also known to release allelopathic compounds that can inhibit weed germination and growth. Although very high weed control has been reported (Putnam and DeFrank, 1983; Shilling et al., 1985) there are also reports in the literature of insufficient weed control as well as weed increases due to a rye cover crop (Masiunas et al., 1995; Koger et al., 2002; Reddy, 2003).

The objectives of the present study were to evaluate (1) early versus late planted corn into small and large amounts of rye residue; (2) benefits of in-row tillage with small and large amounts of rye mulch; (3) effectiveness of pre- and post- herbicide programs with no, small and large quantities of rye mulch.

MATERIALS AND METHODS

Field Operations

The experiment was conducted from 2001-2003. A different field was used each year. The fields were in close vicinity of each other on the Russell E. Larson Agricultural Research Center in Rock Springs, central Pennsylvania. The soil was a Hagerstown silt loam (fine, mixed, semiactive, mesic Typic Hapludalf) in 2001 and 2002 and a Murrill channery silt loam (fine-loamy, mixed, semiactive, mesic Typic Hapludult) in 2003. The previous crop was oats in all years. Cereal straw and grain was removed before rye cover crop establishment. The experiment was a split-split-plot design with four replicates. Two planting dates were main, 3 rye management treatments sub-, and 3 herbicide programs sub-sub-plots. Sub-sub-plots were 15 ft wide by 30 ft long. Early and late planting dates for corn were respectively: May 9th and 22nd 2001, May 1st and 11th 2002, and May 2nd and 22nd 2003. Agway 5206 was planted in 2001 and 2002 and Pioneer 34H31 in 2003. The two planting dates were approximately 7-10 days after early and late booting stage of rye, when rye was dessicated with 1 lb/A glyphosate for early and late planting of corn. The three rye treatments were no-till corn without a rye cover crop (NO-RYE), no-till corn into a rye cover crop (RYE-NT) and zone-till corn into a rye cover crop (RYE-ZT). To obtain these treatments, the whole experimental area was planted to rye (Secale cereale, L.) with a no-till drill in the fall (100 lbs/A seeding rate). The No-Rye plots were sprayed with Roundup shortly after the rye came up, resulting in no rye being left at planting. The whole experimental area was topdressed each spring with nitrogen (65 lb/A N). Zone-tillage was done with the Rawson Zone Tillage system, each row unit consisting of three 17.5”, 13-wave fluted coulters that till up a 6” wide, 4” deep zone in which corn is planted. In 2001, the zone-till coulters were mounted on the frame of the no-till planter. Results of zone-till were poor that year because the zone-till coulters did not penetrate the soil adequately (most significantly in the late-killed rye treatments). This resulted in poor corn plant populations. To avoid further problems, zone-till was performed prior to planting with a zone-till cart in 2002 and 2003.

The three herbicide treatments were FULLPRE (full rate of pre-emergence herbicide applied at planting), HALFPRE (half rate pre-emergence herbicide applied at planting), and POST (full rate of post-emergence herbicide applied in June). Herbicide applications for the FULLPRE program were 2.25 fl oz Balance Pro plus 1.5 lbs/A Atrazine in 2001 and 2002. In 2003, 0.75 pt/A Dual II Magnum was added to these products for better yellow nutsedge control. Half these rates were applied in the HALFPRE program. Herbicide applications for the POST program were 14 fl oz/A Basis Gold plus 4 fl oz/A Clarity in a 0.25% nonionic surfactant and 2% urea ammonium nitrate solution. Both PRE and POST herbicide mix target a wide spectrum of both annual and perennial grass and broadleaf weeds and are commonly used in Pennsylvania. The herbicides were applied at different times depending on the corn planting date. Pre-emergence herbicides were applied shortly after planting. The post emergence herbicides were applied approximately 4 weeks after planting.

The whole experimental area was treated uniformly except for the treatments in each year. Corn was planted with a 6-row John Deere Max Emerge no-till planter on 30” row spacing, at a seeding rate of 28,000 seeds/A. Force soil insecticide was applied with the corn seed at planting time every year. Fertilizer application followed Penn State Cooperative Extension recommendations, based on soil fertility tests. Starter fertilizer was injected 2” besides and 2” below the corn seeds at planting.

Data Collection and Analyses

Above-ground rye dry matter production at early and late boot stage was measured by harvesting 5-8 5.4 ft^2 areas in the alleys between the plots. The rye was dried at 94 F until dry prior to weighing. Soil dry bulk density and water content in the top 8 “ was measured 8 weeks after planting in No-Rye and Rye-NT treatments with a Troxler moisture/density gauge in 2001. Three moisture/density measurements were taken in the center of each plot (4 reps). Corn yield was determined with a plot combine harvesting 25 ft of the three center rows of each plot. Results were analyzed with SAS.

RESULTS AND DISCUSSION

Rye Biomass Production

Rye biomass production differed greatly between years, despite the fact that rye was killed at approximately the same growth stage in each year (early and late boot) (Fig.1). Lowest rye biomass accumulation was in 2001, and the highest biomass accumulation occurred in 2003. Growth of rye was probably limited in 2001 because of low precipitation in January, February and March. The high biomass production at the late planting date of 2003 was because the kill date was delayed by one week due to extremely wet field conditions. These results indicate the challenges of rye cover crop management due to weather conditions. A one week delay in kill date can mean easily a doubling of the rye biomass the producer will have to deal with. On average, approximately 1000 lbs/A biomass accumulation can be expected at early boot stage, and 4000 lbs/A at late boot stage. Based on other work we estimate that the C:N ratio for early and late killed rye will be approximately 20 and 40, respectively. The succulent early killed rye will decompose quickly whereas the late killed rye mulch will be present for a prolonged period, possibly until the end of the corn growing season. The late planting date therefore offered increased benefits associated with mulch, such as protection against erosion, reduction of evaporation losses during the growing season, and increased (below and above-ground) biomass inputs for soil organic matter increases.

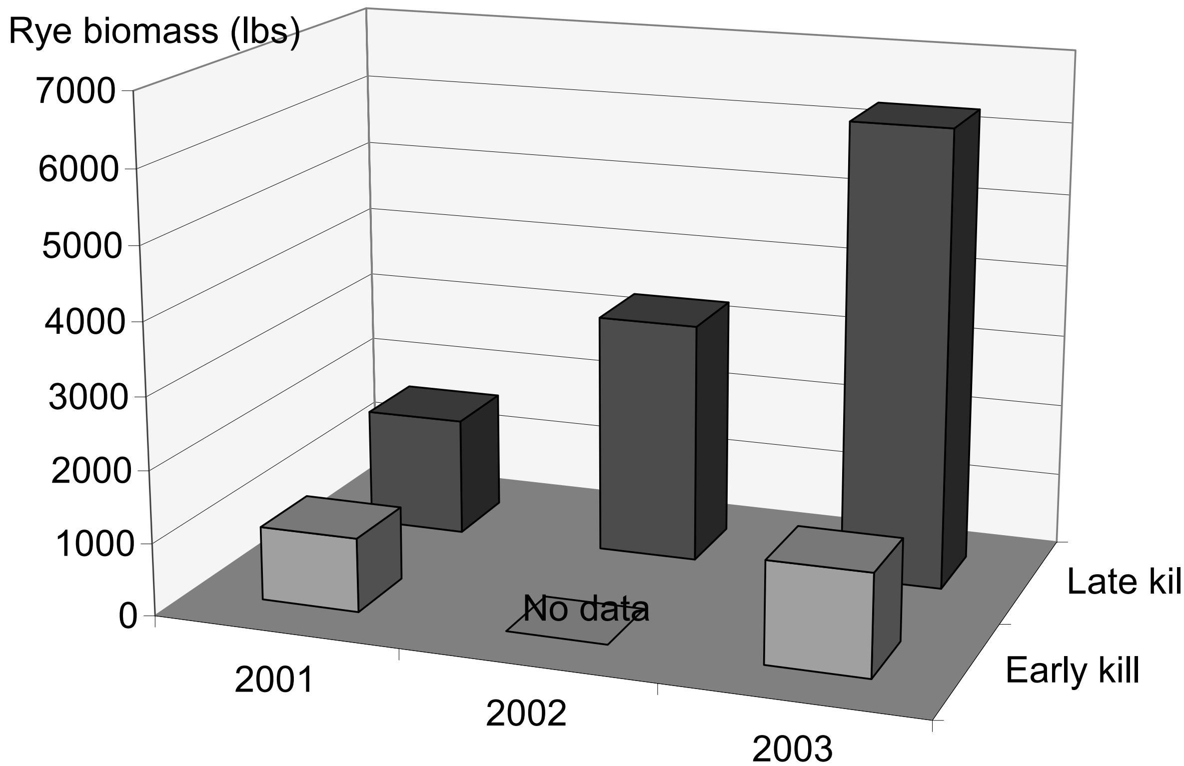

Figure 1. Above-ground rye biomass production killed at early and late boot stage.

Corn Yields

Corn yields were significantly different in each year, and they were affected by planting date and rye management. There were significant year x planting date x rye management interactions. However, yields did not differ between herbicide programs. The absence of a herbicide program effect is probably due to the very low weed pressure in these fields at the onset of our trials. Over the three years of the study (which included a dry, a wet and an optimal year), NO-RYE and RYE-NT produced similar yields but RYE-ZT produced significantly lower yields. On average over the three years of this study, there was no planting date effect for the NO-RYE and RYE-NT treatments, but a significant reduction in yield due to later planting in the RYE-ZT treatment. The average yield reduction in RYE-ZT was only due to its poor performance in the first year of this study (results not shown). RYE-ZT produced significantly lower yields than the other rye management treatments in 2001, and the highest yield reduction was obtained at the second planting date in this year. In 2001, NO-RYE and RYE-NT produced the same yields irrespective of planting date. Poor ZYE-ZT performance was due to a low plant population and shallow planted corn with the Rawson Zone-Till coulters mounted on the planter. The reduced soil moisture content due to water uptake of late killed rye in 2001 caused poor coulter penetration with zone-tillage. It was evident that extra weight should have been placed on the planter for good performance with zone-till. A general challenge of zone-till in rye cover crop is that the root system of the rye is still completely intact at the time of zone-till. This makes preparation of the zones with the coulter system challenging. This problem is exacerbated in late-killed rye.

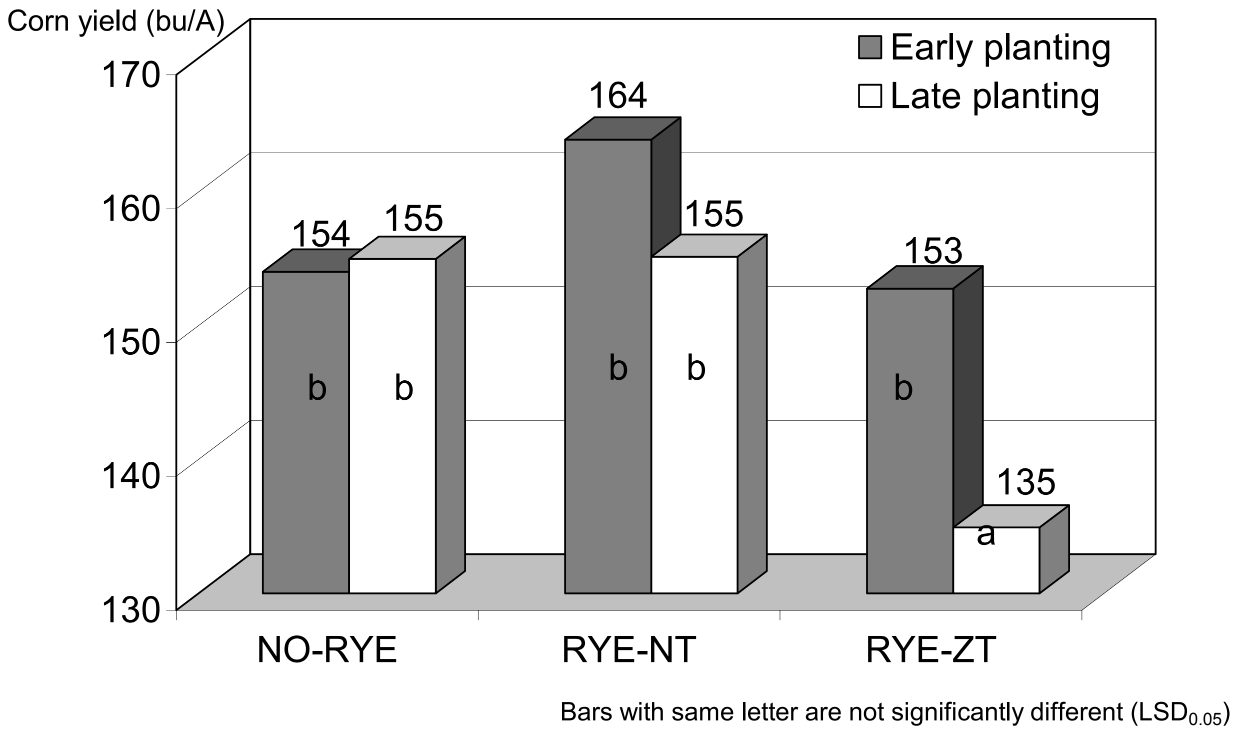

Figure 2. Rye management effects on average corn yields in Central Pennsylvania (2001-2003).

Our results show a non-significant 10 bu/A yield increase due to no-tilling corn into rye killed at the early boot stage compared to not using a rye cover crop. These results contrast with studies in Ohio and Ontario, where a rye cover crop resulted in significant yield reductions of the following no-till corn crop (Eckert, 1988; Raimbault et al., 1990). In the Ohio study corn yield was not reduced, and occasionally increased, if the rye cover crop followed soybeans instead of corn (Eckert, 1988). Thus we suggest that an early killed rye cover crop will boost yields if corn follows low-residue crops in our agro-climatic zone. Allelopathic effects of rye on corn such as those reported in Ontario (Raimbault et al., 1990) and Nebraska (Kessavalou and Walters 1997) were not observed in our study. In Ontario, in-row tillage techniques and residue removal from the row resulted in yield increases compared to straight no-till (Raimbault et al., 1991). In our study we did not see a benefit to zone-tillage, even in the years when zone-tillage performance was not compromised due to problems at planting time. Our results also show that it is possible to delay corn planting two weeks in central Pennsylvania without a significant yield penalty, which allows growth of a rye cover crop to the late boot stage. These results are similar to those obtained with rye in Maryland (Clark et al., 1997).

Bulk Density

There was a planting*rye interaction effect on bulk density. Dry bulk density in the 0-4"depth was significantly lower in the late planted RYE-NT treatment compared to the other planting*rye combinations. The bulk density of the soil under late-killed rye was 1.40 Mg m^{-3}, whereas the bulk density of the soil without rye, or with rye that was killed early, was 1.48 Mg m^{-3}. A similar trend was present in the 4-8" depth. We suggest that the reduction in bulk density was due to the large root system of the rye cover crop that grew to late boot stage. (Raper et al. 2000) reported a reduction in penetration resistance due to rye mulch, but no reduction in bulk density. The potential to reduce soil compaction by letting a rye cover crop grow to late boot stage deserves further attention.

CONCLUSIONS

In this study we determined that approximately 4 times more rye biomass can be expected if rye cover crop kill is delayed from early to late boot stage. We did not observe a benefit to zone-tillage in recently killed rye cover crop. The root system of the rye was still completely intact at the time of zone-till, which made preparation of the zones with the coulter system challenging. This problem was exacerbated in late-killed rye. Weed control programs did not differ in efficacy, showing it may be possible to reduce reliance on pre-emergence herbicides in no-till if weed pressure is low. We observed no significant differences between corn yields with or without a cover crop or due to planting date if straight no-till was used. The use of late-killed rye cover crop in no-till seems therefore possible without a yield penalty. Multiple environmental benefits would be accompanying the higher rye biomass production in this system that may pay off in the long run. They include: better erosion control, higher residue input for organic matter increases, and reduced bulk density due to high rye root biomass input.

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