ALFALFA, CLOVERS, AND GRASSES AS COMPANION CROPS FOR SILAGE CORN

John H. Grabber [1/]

Introduction

Corn silage is commonly fed to dairy cattle and other types of ruminant livestock, but its production can leave cropland vulnerable to nitrate leaching and runoff of nutrients and sediment. As result, a wide variety of cover crops or living mulches (collectively referred to here as "companion crops") have been developed and promoted to mitigate the adverse environmental impacts of corn production and to improve crop yields, nutrient cycling, and soil quality. Based on a review of the literature, a few of the more promising companion crops for corn in north-central states such as Wisconsin include winter rye, Italian ryegrass, red clover, alfalfa, and kura clover.

Winter rye is commonly seeded in the fall after corn harvest. Although it often provides little ground cover in the fall and winter, fall-seeded rye grows vigorously during the spring to protect soil and remove residual soil nitrate. Rye can be grazed or harvested for forage prior to a late planting of corn, but earlier spring termination is often used because more mature rye can in some cases deplete soil moisture, immobilize nitrogen, and depress corn yields.

Italian ryegrass is usually interseeded in June about 4 to 6 weeks after corn planting to permit establishment without excessive competition with corn. In the fall, interseeded ryegrass usually provides greater ground cover and soil nitrate scavenging than fall-seeded rye and it can be grazed or harvested for forage. Ryegrass often winterkills to provide short-lived mulch for spring-seeded crops such as corn and it tends to have a neutral effect on corn yields unless its growth and uptake of soil nitrate are too vigorous.

Red clover or alfalfa are also typically interseeded in June to prevent excessive competition with corn, but such seedings are prone to fail during dry summer conditions or if corn growth is especially vigorous. If successfully established, interseeded red clover or alfalfa will normally overwinter to provide moderate ground cover and uptake of soil nitrate during both the fall and spring. Red clover and alfalfa cover crops supply nitrogen and often boost yields of subsequent corn crops. A seemingly overlooked option would be to keep interseeded red clover or alfalfa in production for at least one year after corn to provide high quality forage and to further boost subsequent corn yields through greater nitrogen and non-nitrogen rotational effects. This system would be most workable if forage legumes could be interseeded immediately after corn planting, but new approaches are needed to lessen yield-killing competition between the co-planted crops.

Kura clover may also serve as a dual-purpose crop that can be used one year as a living mulch for corn and then kept in production in following years as a forage crop. Corn grown in kura clover can produce yields comparable to corn grown after killed kura clover, but excessive competition from the living mulch can depress corn yields. Following corn production, kura clover living mulch can recover to full forage production by midsummer of the following year. The performance of the kura-corn system has not, however, been directly compared to other companion crop systems for corn.

Objectives and Methods

Experiment 1

Although the abovementioned corn-companion crop systems are often recommended to producers, few if any studies have directly compared their agronomic and environmental performance across several cropping seasons. Therefore in a four-year study on a silt loam soil near Prairie du Sac Wisconsin, we compared two rotations where Roundup-Ready corn was no-till planted in early May and grown one year with herbicide-suppressed/strip killed kura clover living mulch or with June drill interseeded red clover. After a September silage corn harvest, the legume companion crops were kept in production and harvested the following year for forage before rotating back to corn. These rotations were also compared to Roundup-Ready continuous corn, which was planted no-till in early May, harvested for silage in September, and grown each year with June drill-interseeded Italian ryegrass, September-seeded winter rye, or no cover crop. Crops were planted at normal recommended seeding rates and weeds during corn production were controlled primarily with glyphosate. Manure slurry was band-applied yearly on a phosphorous basis to all crops yearly in November or early April. In addition to manure nitrogen credits, continuous corn plots received additional fertilizer at planting to supply recommended levels of nitrogen (160 lb per acre) while manure plus legume credits provided excess nitrogen for rotated corn (225 lb per acre) at the site. Additional experimental details are provided in Grabber and Jokela (2013) and Grabber et al. (2014).

Experiment 2

Our goal in a second study was to identify plant growth regulator (PGR) treatments that would boost successful establishment of interseeded alfalfa while limiting yield depression of corn. An initial screening of foliar-applied PGRs suggested that prohexadione-calcium might be useful for limiting excessive top growth of interseeded alfalfa during its establishment in corn. (Prohexadione is currently labeled for several orchard crops, peanuts, and grass seed production to limit shoot growth.) Field studies were therefore carried out for four years on a silt loam soil near Prairie du Sac Wisconsin to evaluate prohexadione applications on alfalfa that was planted with Clearfield or Roundup-Ready corn. Each year, corn was planted no-till in early to mid May at about 35,000 seeds per acre and conventional or Roundup-Ready alfalfa was drill interseeded one or two days later, usually at a seeding rate of 16 lb per acre. Depending on the herbicide tolerance of corn and alfalfa, weeds were controlled with post-emergence spray applications of imazethapyr or glyphosate. Recommended rates of nitrogen were applied to corn (160 lb per acre), but 50% was banded with starter fertilizer at planting and the balance was sidedressed in June to favor uptake by corn. Prohexadione-calcium was sprayed at 10 to 40 oz per acre with drop nozzles onto alfalfa seedlings about 4 to 6 weeks after planting. Whole plant corn yields were determined in September and alfalfa yields were determined the following year using a three-cut harvest management. Alfalfa topgrowth and stand density was evaluated 4 weeks after prohexadione application, 4 to 6 weeks after corn harvest, and after the final alfalfa harvest the following year.

Results and Discussion

Experiment 1

The results of this study were reported and discussed in recent publications (Jokela et al., 2009; Grabber and Jokela, 2013; Grabber et al., 2014). Below is a summary of our major findings.

The corn-interseeded red clover system produced the highest and most stable yields of silage corn across years and often the highest clover yields. Relatively low competition from red clover

and weeds likely contributed to high corn yields. Unfortunately, red clover forage production was often hampered by late summer stand failures during its establishment in corn. Modest growth following corn and preceding forage production also made red clover less effective than other companion crops for limiting runoff from cropland. Under favorable growth conditions at the onset of our study, the corn-kura clover rotation produced silage corn yields similar to the corn-red clover rotation, and among the systems we examined, it came the closest to providing reliable year-round groundcover for protecting soil. As the study progressed, corn yields were reduced by excessive spring growth of kura clover living mulch, while slow regrowth of kura clover following corn limited its forage production potential and permitted substantial ingress of weeds that further limited forage yields. Excessive nitrogen credits for corn grown with either clover resulted in only modest increases in total residual fall nitrate to a depth of 4 ft, likely because excessive nitrogen was incorporated into the organic nitrogen pool. Clover production the following year also appeared to draw down nitrate throughout the soil profile to levels far below that of continuous corn. Consequently, the manured corn-clover systems may have a lower risk of nitrate leaching than continuous corn systems. Draw down of nitrate during clover production, however, contributed to low pre-sidedress nitrate test estimates of available nitrogen, particularly for corn grown with kura clover living mulch.

Manured continuous corn grown with or without annual grass companion crops usually produced greater overall dry matter yields than corn-clover rotations, but crude protein yields of rotations exceeded continuous corn treatments. Unlike other cropping systems we examined, yields of corn grown with grasses were sensitive to the timing of manure application; fall manure promoted higher yields with ryegrass while spring manure favored higher yields with rye. As with kura clover, yields of continuous corn treatments declined over rotation cycles, due in part to increasing weed pressure. Continuous corn systems had relatively high pre-sidedress nitrate test concentrations that were not affected by the presence or absence of grass companion crops. The presence or absence of grass companion crops also did not appreciably influence the total quantity of residual fall nitrate in soil to a depth of 4 ft.

Among the companion crops examined, surface runoff and losses of phosphorus and sediment in the spring were least with rye followed by ryegrass if manure was applied in the fall. Shifting surface-applied manure application to spring in this no-till system largely negated companion crop effects on spring runoff and substantially increased loading of dissolved reactive phosphorus. The use of kura clover, red clover, ryegrass, or rye as companion crops for corn improved several chemical, physical, and microbial soil properties and overall soil quality. While some specific companion crops performed better for individual soil properties, none stood out as better for the whole range of soil attributes or for overall soil quality. Taken as a whole, no companion crop or manure management system was clearly superior in all attributes related to forage production, nitrate leaching potential, runoff, and soil quality. Thus the most appropriate choice of companion crops and manure management for no-till silage corn will depend on producer requirements for feed production and on site-specific requirements to remediate nitrate leaching and runoff of soil and nutrients from cropland.

Experiment 2.

Prohexadione-calcium applied at 10 to 14 oz per acre to interseeded alfalfa in June typically reduced alfalfa top growth by about 20% in July and doubled or tripled alfalfa seedling stand density by mid October compared to non-treated controls. Alfalfa interseeding reduced dry matter yields of silage corn by about 10% compared to corn grown without interseeded alfalfa. Prohexadione application on alfalfa had no effect on corn yields. First-year yields of alfalfa established the previous year by interseeding were two-fold greater than alfalfa conventionally

spring-seeded after corn. Prior year prohexadione applications increased first year alfalfa yields by about 12% and fall stand densities by 37 to 130% compared to untreated interseeded controls. Higher rates of prohexadione did not further improve alfalfa top growth suppression, stand density, or forage yields. Overall as illustrated in Figure 1, the primary benefit of prohexadione treatment was to substantially improve stand establishment of interseeded alfalfa and this would be expected to markedly improve the reliability and forage yield potential of this cropping system. Additional studies with prohexadione and other PGRs are, however, needed to find ways of lessening yield reductions in corn and to develop workable production systems for farms. We are, for example, now conducting studies with Mark Renz and Joe Lauer (Agronomy Department, UW-Madison) to see if lower, more economical rates of prohexadione in single or split applications can be effective for boosting stand density and subsequent yields of interseeded alfalfa. Finally, an economic analysis suggests a reliable and cost-effective method for establishing interseeded alfalfa in corn could improve the profitability of first year alfalfa by about $100 per acre compared to conventional spring-seeded alfalfa (Grabber and Vadas, 2011, unpublished).

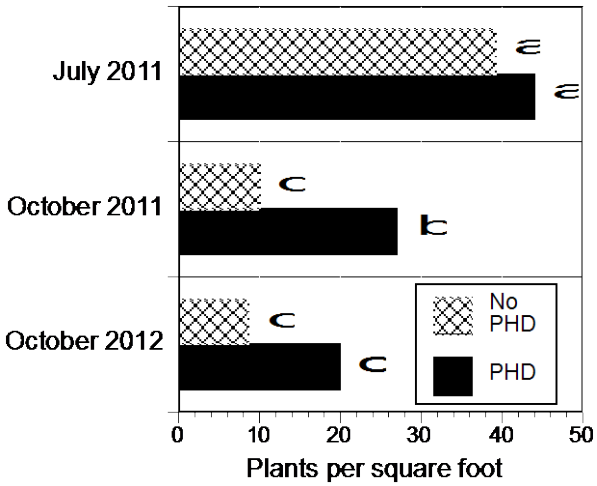

Figure 1. Impact of prohexadione (PHD) spray treatment on plant density of conventional alfalfa interseeded into Clearfield corn in 2011. Bars followed by unlike letters differ at P = 0.05.

References

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