Four-Year Study Offers Recommendations for Using Companion Crops with No-Till Silage Corn

John Grabber and Lori Bocher, U.S. Dairy Forage Research Center

In many regions of the country, corn silage is the predominant forage fed to confined ruminant livestock. But its production can leave cropland vulnerable to nitrate leaching and runoff of water, nutrients, and sediment. Therefore, a variety of companion cover crops or living mulches are recommended for corn to reduce runoff and nitrate leaching from cropland and to maintain or improve crop yields, nutrient cycling, and soil quality.

Figure 1. Five no-till cropping systems that were compared.

1. **Corn/Red Clover Rotation** - Alternating years of corn and red clover production with red clover established by interseeding into 12-inch tall corn.
2. **Corn/Kura Clover Rotation** - Alternating years of corn and kura clover production with corn planted into herbicide-suppressed/strip-killed kura clover living mulch.
3. **Continuous Corn with Italian Ryegrass** - Italian ryegrass interseeded yearly into 12-inch tall corn.
4. **Continuous Corn with Winter Rye** - Winter rye seeded yearly in the fall after corn harvest.
5. **Continuous Corn with No Companion** - Corn grown yearly without companion cover crops or living mulch.

Different systems have been studied and used in the past – grasses or legumes, cover crops or living mulches – but there have been few direct comparisons among systems. Also, few if any studies have examined how late fall versus spring manure application affects the growth and nitrogen uptake by cover crops or living mulches and, in turn, the growth of corn. This is an important aspect because silage corn and other forages are often grown on or near livestock farms and usually are heavily manured to recycle nutrients and to reduce fertilizer inputs.

At the U.S. Dairy Forage Research Center, a 4-year study was conducted to compare five different companion crop systems for no-till silage corn amended annually with fall versus spring manure. The study looked at three important aspects:

- How much cover was provided for the soil?
- How much forage was produced?
- What is the effect on soil quality?

Overall, no system was clearly superior in all attributes; but some were advantageous under certain circumstances. This article will explain those advantages in an effort to help producers select appropriate companion crop and manure management systems for no-till silage corn that will meet feed production needs, while reducing soil and nutrient loss from cropland. Producers should, however, alternate companion crop systems and pest control methods over time to help control weeds, insects, and disease and to help maintain high crop yields.

The five cropping systems used in the study are explained in Figure 1. The study was carried out over 4 years, with generally favorable growth conditions during the first 2 years followed by poor growth conditions (very dry or wet with increasing weed pressure) during the last 2 years.

Table 1. Average forage dry matter yields and crude protein yields of cropping systems during favorable growth conditions (Years 1 and 2) and poor growth conditions (Years 3 and 4). Yields are averaged across fall and spring manure application times.

Cropping System	Dry Matter Yield		Crude Protein Yield	
	Years 1-2	Years 3-4	Years 1-2	Years 3-4
	---------tons per acre--------			
1. Corn-Red Clover Rotation	6.8	6.6	0.70	0.71
2. Corn-Kura Clover Rotation	6.4	5.5	0.66	0.66
3. Continuous Corn-Italian Ryegrass	8.0	6.2	0.52	0.45
4. Continuous Corn-Winter Rye	8.4	6.3	0.54	0.44
5. Continuous Corn-No Companion	8.7	6.3	0.57	0.45

As illustrated in Table 1, corn-clover rotations (systems 1 and 2) provided similar to 26% less forage dry matter (corn silage and clover forage combined), but 26-60% more crude protein yield than continuous corn (systems 3-5); these systems would be especially advantageous to producers wanting to reduce protein supplementation costs.

The corn-red clover rotation (system 1; Figure 1) produced the highest and most stable yields of silage corn across years and often the highest clover yields. The nitrogen supplied by terminated red clover stands, combined with relatively low competition from red clover and weeds, likely contributed to high corn yields. Greater nitrogen inputs for corn grown with red clover did not unduly increase the residual fall nitrate levels in the soil profile, and red clover production the subsequent year appeared to draw down nitrate that had accumulated at the soil surface during corn production. Modest growth following corn and preceding forage production, however, made red clover less effective than the other companion crops for limiting runoff from cropland.

Table 2. Suggested companion crop systems (Figure 1) depending on producer's management goals.

If the primary goal is to...	...study results recommend this companion cropping system
Maximize total forage DM yield	Continuous corn (3-5)
Maximize crude protein yield with good DM yield	Corn-red clover rotation (1)
Maximize spring cover, reduce run-off	Corn with winter rye (4)
Maximize fall cover, reduce run-off	Corn with ryegrass (3)
Maximize total off-season cover, reduce run-off	Corn with ryegrass (3) or corn-kura clover rotation (2)
Reduce risk of nitrate leaching during the off season period	Corn with ryegrass (3)
Reduce nitrogen fertilizer use	Corn-clover rotations (1 and 2)
Improve soil quality	All companion crop systems (1-4)

Unfortunately, red clover forage production was hampered by frequent stand failures during its establishment in corn. Improved methods for establishing red clover in corn could boost rotation dry matter yield to levels comparable to continuous corn, but with substantially greater crude protein yield and lower nitrogen fertilizer inputs. Therefore, ARS is developing improved interseeding methods for red clover (and for alfalfa as well) to improve the profitability of short rotation sequences where only one or two years of forage legume production is desired before rotation to one or more years of corn production.

At the onset of this study under favorable growth conditions, the corn-kura clover rotation (system 2; Figure 1) produced silage corn yields similar to the corn-red clover system. Among the five systems examined, the corn-kura rotation came the closest to providing reliable year-round groundcover for protecting soil.

Later in the study, however, corn yields were reduced by poor growth conditions and by excessive spring growth of kura clover living mulch, while slow regrowth of kura clover following corn limited subsequent clover forage production and permitted substantial ingress of weeds. Corn grown in kura clover living mulch had relatively high levels of residual fall nitrate at the soil surface, but kura clover production the following year appeared to draw down nitrate throughout the soil profile to levels far below continuous corn. Thus, the corn-kura clover system may have a lower risk of nitrate leaching than continuous corn, but this must be confirmed by additional studies.

As with kura clover, yields of continuous corn treatments declined during the second half of the study, due in part to poor growth conditions and increasing weed pressure. Ryegrass was more effective than rye for reducing residual fall soil nitrate, particularly at the soil surface. The vigorous spring growth of fall-seeded rye, however, made it the most effective companion crop examined for limiting spring runoff following corn production, but greater fall growth by interseeded ryegrass might make it a better choice to reduce runoff throughout the off season period. Recently applied manure overrode the beneficial effects of grass companion crops on spring runoff and substantially increased the amount of phosphorus in runoff.

Unlike other cropping systems examined, yields of corn grown with annual grasses were sensitive to the timing of manure application. Yields of corn grown with ryegrass were greatest with fall manure application while spring manure application favored high yields of corn grown with rye.

Finally, the use of kura clover, red clover, ryegrass, or rye as companion crops improved several chemical, physical, and microbial soil properties and overall soil quality in a no-till silage corn system. 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 in the four-year study.

In conclusion, no one companion cropping system is advantageous under all conditions or for all goals. Table 2 provides guidelines as to which systems might best help producers reach certain goals.