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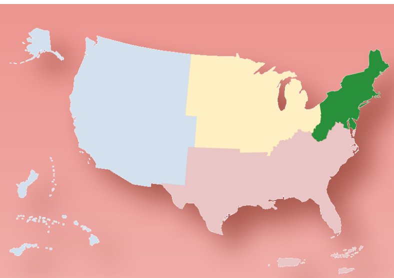

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Project Coordinators
Paul Cerosaletti
Cornell University Extension
(607) 865-7090; pec6@cornell.edu

Lisa Fields
LA Fields Consulting

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Written by Lisa Bauer.

Sustainable Agriculture Research & Education

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Alternative Continuous-Cover Dairy Forage System for Profitability, Flexibility and Soil Health

Geographic Adaptability: This project took place in New York, but the system could be implemented on dairy operations across the nation using locally adapted crops and planting dates.

Introduction

Small- to mid-sized Northeast dairy farmers face increasingly challenging labor, weather and economic constraints. For example, limited labor can make it difficult to carry out field operations. Extreme weather events that have recently led to heavy rainfall often prevent planting or harvesting during critical periods. And feed prices continue to rise. It has become essential for farmers to have a flexible system where they can grow their own high-quality dairy forage in corn- and alfalfa-based cropping systems.

In a SARE-funded study in New York, a cooperative team of farmers, researchers and consultants addressed these constraints in dairy farm rotations by developing an alternative forage cropping system with multiple options to produce high-quality forages. This system—Alternative Continuous-Cover Forage (ACCF) —produces high-quality dairy cattle forage with yields comparable to traditional cropping systems, and is based on soil health management, as opposed to the traditional crop

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COVER PHOTO: Dairy cows grazing winter rye for the third and final time on May 26. *Photo courtesy Lisa Fields*

rotation of corn silage for three or more years without the use of cover crops.

The SARE project used a case study model, engaging farmers to employ the ACCF system on their farms and gathering data on soil health, crop performance, forage quality, nitrogen leaching and economics.

The SARE project team found that the ACCF system can offer additional options to standard forage rotations of corn and alfalfa/grass mixes by including and/or substituting forages such as winter rye, oats, triticale and/or brown midrib sorghum sudangrass (BMR SS).

The ACCF system has multiple benefits for the grower:

- Broad flexibility in planting and harvesting times and methods—for example, the system works well with no-till methods;
- High-quality forage yield comparable to traditional systems;
- Extension of the growing season; and
- Forage production at times of the year when other crops are not producing or are not producing enough (such as pasture slumps in early spring and summer).

With its year-round soil cover and adaptability to no-till planting methods, ACCF also provides many environmental benefits:

- Living roots support soil health through increased soil porosity and resilience to machinery traffic;
- Continuous soil cover helps reduce soil erosion and keep nutrients on the field; and
- Soil quality is improved.

Last, but not least, ACCF also provides economic benefits. Researchers showed that ACCF can improve the bottom line by increasing milk production and potentially reducing the need to purchase supplemental grain and/or forage. In one of the SARE case studies, the ACCF system increased net farm income $531 per acre.

This fact sheet outlines the basic rotations and potential crop choices of the ACCF system, describes how to implement the system, and provides a summary of its environmental and economic benefits.

Implementing the ACCF System

The ACCF system can be implemented by using a variety of crops at various times throughout the growing season. Flexibility is key. The research team suggests the following general implementation guidelines for an ACCF system of winter rye, BMR SS, and oats and triticale. The system should be tweaked, and other crops substituted as needed, to fit specific regions, climates, farm resources and goals.

- In August or September, sow winter grains, such as winter rye or triticale, into either plowed ground that was an unproductive sod or disked ground that was in a summer annual, such as corn. If soil moisture is adequate to allow no-till equipment to penetrate the soil, sods can be chemically killed in the summer to allow for no-till planting of winter grains in late August/September.
- Graze winter grains in a vegetative growth stage in the fall (usually from late September into October) if there is sufficient growth, or wait until spring and graze when winter grains are still in a vegetative state. There may be instances when winter grains can be grazed both in the fall and in the spring, but plants will be less vigorous. Another option is, instead of grazing, to mechanically harvest for silage in the spring at flag-leaf stage.

TABLE 1. POTENTIAL TWO-YEAR ROTATION IN THE ACCF SYSTEM

SOIL/CROP CONDITION	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Stubble for > 2 yrs or unhealthy sod	1. COS or sod 2. winter rye or triticale	1. rye/triticale harvest 2. BMR SS/perennial (clover-grass)	sod	sod
High organic matter stubble or healthy sod, Option 1	1. BMR SS 2. winter rye or triticale	1. rye/triticale harvest 2. BMR SS + perennial seed	sod	sod
High organic matter stubble or healthy sod, Option 2	1. SS COS 2. winter rye or triticale	1. rye/triticale harvest 2. clover sod	sod	sod

COS = corn silage; BMR SS = brown midrib sorghum sudangrass; SS COS = short season corn silage; Triticale = winter triticale; 1, 2 = crop 1, crop 2 for that year

TABLE 2. POTENTIAL THREE-YEAR ROTATION IN THE ACCF SYSTEM				
SOIL/CROP CONDITION	**YEAR 1**	**YEAR 2**	**YEAR 3**	**YEAR 4**
Stubble for > 2 yrs or unhealthy sod	1. sod/corn 2. winter rye or triticale	1. rye/triticale harvest 2. BMR SS 3. rye/triticale plant	1. rye/triticale harvest 2. BMS SS/perennial seeding	sod
High organic matter stubble or healthy sod, Option 1	1. BMR SS or SS COS 2. winter rye or triticale plant	1. rye/triticale harvest 2. BMR SS or SS COS 3. rye/triticale plant	1. rye/triticale harvest 2. summer seeding or BMR SS + perennial seed	sod
High organic matter stubble or healthy sod, Option 2	1. SS COS 2. winter rye or triticale	1. rye/triticale harvest 2. SS COS 3. Rye/triticale	1. rye/triticale harvest 2. clover/grass sod	sod
SS COS = short season corn silage; Triticale = winter triticale; BMR SS = brown midrib sorghum sudangrass; 1,2,3 = crop 1, crop 2, crop 3 for that year				

- If desired, harvest a light-yielding straw crop from winter rye re-growth. If straw is the desired crop, then no prior grazing or harvest should occur.
- After straw harvest, till the field or use no-till methods to plant annual BMR SS or short-season corn. If you grow BMR SS, you can either use it as a grazing crop, typically grazing two to three times, or mechanically harvest it twice as a forage crop for silage. BMR SS may be interseeded with perennial clover and grass to establish a new seeding. If planted alone, follow BMR SS with another season of winter grain or a late-summer seeding of perennial forages.
- If you plant short-season corn into this slot, it should be harvested early to allow timely planting of winter grains.

In planning for the ACCF system rotation, pay attention to the soil and residue conditions in the field, and consider whether a two- (Table 1) or three- (Table 2) year rotation makes more sense.

In the SARE study, participating farmers had different needs and goals, and as a result experimented with a variety of crops, production practices, and planting and harvesting times in an ACCF system, as illustrated in the following two examples:

On one management-intensive-grazing dairy farm, farmers implemented ACCF on three dual-use fields that were in low-productivity native sods. In one field, the rotation was two years of BMR SS and winter rye, followed by one year of corn silage, with festulolium and ladino white clover seeding in year four. Another field was interseeded with BMR SS, ladino clover and grass. BMR SS was planted on the third field solely for grazing, and was followed with winter rye/clover interseeding.

In this case, BMR SS and winter rye crops provided forage when pastures were not yet ready or were in summer dormancy. Milk production was maintained or increased up to 3 lbs per cow per day, along with a decrease in baleage/haylage consumption. Grazing BMR SS provided ample, high-quality forage to cows in hot, dry weather. Varied times for planting, machine harvesting and grazing helped spread out labor resources.

On another mixed-livestock and -forage enterprise, the farmers were looking for a cost-effective way to replace existing tall fescue grass with something more palatable for cows while maintaining use of the land as pasture in their grazing system.

They plowed a native bluegrass pasture and planted it with BMR SS, followed by an August planting of winter rye. The BMR SS provided more than three weeks of grazing during a

Dairy cow finishing the first of three grazings of winter rye on April 11.
Photo courtesy Lisa Fields

TABLE 3. WINTER RYE GROWTH AND FORAGE QUALITY									
	DATE	HEIGHT (IN.)	DM (%)	CP (% DM)	NDF (% DM)	LIGNIN (% DM)	NDF-D 24 HR (% DM)	SUGAR (% DM)	NE-L (Mcal/LB)
Average (2 yrs, 6 samples)	May 1	16	20	18	44	6.3	72	25	0.77
Range	April 11 to May 26	12-24	15-23	13-26	40-48	2.1-3.7	58-90	11-30	0.74-0.79

DM=dry matter; CP=crude protein; NDF=neutral detergent fiber; NDF-D=neutral detergent fiber digestibility; NE-L=net energy for lactation; M(cal/lb)=megacalories/lb

time when tall fescue was not palatable. The rye was grazed three times from mid-April through June of the following year, providing very early grazing and extremely high-quality forage.

Crop Choices

The ACCF system offers flexibility in crop choices, depending on farm goals and resources. What follows are descriptions of winter rye, BMR SS and oats—the three main crops studied in the SARE project. Other options abound, and farmers should discuss possibilities with local Extension agents or crop advisors.

To successfully grow these and other crops, carefully consider:

1. soil and planting conditions
2. fertility
3. growth and harvest
4. re-growth

Winter Rye

Winter rye is a good option in the ACCF system for use as a dairy forage and as a unique rotation crop. In the SARE study, winter rye was used to reseed hay ground or double crop with summer annuals. Over two years of the study, rye was sampled six times, and growth and forage quality measurements were taken (Table 3).

Winter rye offers the following advantages:

- Extends the growing season, allowing crop production in the cooler spring and fall;
- Holds soil in place, preventing nutrient runoff and soil loss;
- Breaks up compaction with aggressive roots;
- Provides weed suppression with allelopathic properties;
- Produces high-quality forage (Table 3); and
- Presents a wider planting/harvesting window that spreads out the workload, allows for field rotation later in the season and allows for double cropping with summer annuals.

Dairy cows graze brown midrib sorghum sudangrass (BMR SS) on August 3 when perennial pastures are dormant. Foreground shows the next paddock section to be grazed, curling from heat and dry weather, yet producing ample high-quality forage. *Photo courtesy Lisa Fields*

TABLE 4. BMR SS GROWTH AND FORAGE QUALITY

	HEIGHT (IN.)	DM (%)	CP (% DM)	NDF (% DM)	LIGNIN (% DM)	NDF-D 24 HR (% DM)	SUGAR (% DM)	NE-L (Mcal/LB)
GRAZED[1,2]								
Average	46	13	17	57	3.6	63	12	0.60
Range	27-72	10-21	12-22	46-62	1.7-7.4	51-72	8-15	0.51-0.59
MECHANICALLY HARVESTED[2]								
Average	57	30	14	61	4.8	55	7.5	0.53
Range	54-65	25-37	11-16	56-65	2.2-6.7	49-61	5-11	0.50-0.59

DM=dry matter; CP=crude protein; NDF=neutral detergent fiber; NDF-D=neutral detergent fiber digestibility; NE-L=net energy for lactation; M(cal/lb)=megacalories/lb

[1] Grazed n=8, Mechanical n=4

[2] High and low value for each measure for all samples. Values for each measure may not be from the same sample.

Winter rye can be planted into plowed-down sod or no-tilled into a killed sod in late summer and harvested the following spring for forage and/or straw. The harvest can then be followed with summer seeding to a perennial forage. Another option is to double crop by following the rye with short-season corn or sorghum sudangrass. The double-crop system can stretch into a two-year rotation, particularly if short season corn follows the winter rye crop. In that scenario another winter rye crop could follow the corn crop, with a perennial seeding done the following year.

The soil pH requirement for rye is 5.8. Although soil preparation must be suitable for a grain drill, the seeds readily germinate. Seed at three bushels per acre to boost forage yields. Place seed about 1 inch deep, and no greater than 1.5 inches. Broadcast seed with light incorporation or no-till drill into corn stubble. Winter rye is susceptible to atrazine residue in fields that have received more than 1 lb per acre within the growing season; if you have used atrazine, consult an expert. When forage is a goal, a strong stand of winter rye must be established prior to killing frosts. Producers at elevations above 1,200 feet should plant by September 15, while those in valleys should plant by September 21. Planting can occur as early as the third week of August, allowing time to avoid labor conflict with other field work. If intended as a fall grazing crop, seed winter rye in mid-August.

Fertility requirements for winter rye include phosphorus (P) and potassium (K) nutrient levels in the medium range. Apply these nutrients with manure or fertilizer accordingly when levels are low. Late-summer rye plantings will take up nitrogen (N) from soil organic matter. Organic matter levels at or above 5 percent can supply sufficient mineralizable N to produce a good first-year crop. Producers can increase yields and protein levels of rye by applying 30 to 75 lbs of additional N in the spring, if they have not applied manure. This is valuable when planning two cuttings or multiple grazings. Winter manure applications, where environmentally safe, will not hinder rye's growth.

When considering growth and harvest, winter rye germinates fast, often within five days of planting. Tillers, or side shoots, appear within three weeks and indicate an established plant with potential for life after winter dormancy. Green-up occurs from late-March to mid-April, often under snow. Proper harvest timing is crucial in capturing winter rye's feed-quality potential. As days lengthen and warm, rye rapidly matures. Farmers should harvest in mid-May, prior to heads emerging when they are "in the boot," as with perennial grasses. When harvesting for silage, use wide swath cutting to achieve proper dry matter levels.

Producers will find that winter grains may be ready to graze 10 to 14 days sooner than perennial grasses. Typical yields for winter rye ranged from 1.5 to 2.5 tons of dry matter per acre across farms involved in the SARE project, in both grazed and mechanically harvested fields.

Rye regrowth can provide for one or two more grazings, depending on the date of first grazing and weather. As temperatures rise, regrowth after first harvest is less dense. When rye is mechanically harvested the first time, a second harvest should generally be used for straw. Seeds will germinate and volunteer rye or stubble regrowth may have undesirable allelopathic effects in the next crop. Producers should spray kill or plow down stubble.

Winter rye produces premium forage (see Table 3), even for lactating cows. Protein levels can be as high as well-managed grasses and, as with grasses, levels are higher when N is top-dressed in the spring. Fiber digestibility rivals corn and BMR SS. High digestibility provides cows with more energy and greater rumen protein production. Winter rye also pro-

Oats planted in August after the corn was destroyed by a flood, shown in late September prior to harvest as forage. *Photo courtesy Lisa Fields*

vides high sugar levels, helping ensure good fermentation and high energy.

This section adapted from *Winter Rye: Not just a cover crop anymore*, by Paul Cerosaletti and Lisa Fields. (See Resources).

BMR Sorghum Sudangrass

BMR SS is another dairy forage crop tested by farmers in the ACCF system. Over three years of the study, the grazed BMR SS trials were sampled eight times, while the mechanically harvested trials were sampled four times over two years (Table 4). BMR SS provides the following potential benefits:

- Produces high-quality forage;
- Yields comparable to corn silage, especially on less productive corn ground;
- Due to plant density, reduces soil erosion as compared to corn;
- Presents flexible planting dates in June, providing compatibility with other field work;
- Allows for manure spreading in summer when the risk of runoff and leaching is low;
- Offers more drought tolerance than corn;
- Offers double-cropping opportunities with winter rye/triticale; and
- Provides compatibility with existing hay equipment.

Consider soil and planting dates carefully, as BMR SS does not germinate in cold soils. Soil temperature must be above 60 degrees for rapid emergence and growth. BMR SS planted as late as July 15 can still produce one cutting in northern states.

BMR SS can be planted in the ACCF system either in a plowed down or chemically killed sod after the danger of frost passes. A first harvest of the existing sod crop could even be taken before planting BMR SS. BMR SS could also be planted after a winter rye or triticale crop is harvested either mechanically or grazed. Conventional-till or no-till methods can be used.

Drilling 65 to 70 lbs per acre of seed will give 2.5 to 3 tons more yield than lower seeding rates (30 to 50 lbs per acre) and will help produce a thicker stand to shade the ground and control weeds. Plant seeds ½ to ¾ inch deep. Broadcast, "air-truck" and cultipack seeders are less reliable than drills, but can work if there is good seed-soil contact and if the seed is not planted too deeply. No-till planting methods can be successful as long as there is proper kill of existing sods and adequate soil moisture to allow for proper planting depth and seed coverage.

For fertility management, apply P and K similar to corn silage (based on soil test levels). Nitrogen needs of BMR SS are similar to an intensively managed perennial grass. If no manure is applied, broadcast 110 to 130 lbs N per acre at planting. Top-dress the same amount soon after each cutting for higher yield and protein content. For BMR SS planted following sod plow-down or recent manure application, rates should not exceed 35 to 55 lbs N per acre per cut for optimum economic return and reduced N losses. Producers should apply manure within two days after cutting to minimize damage to re-growth.

Seedlings should emerge within one week in warm soils with adequate moisture, and may even grow 3 to 4 inches per day. Dry conditions may delay emergence by 10 to 14 days and/or result in uneven germination.

Under proper growing conditions, BMR SS will out-compete weeds, eliminating the need for herbicides. To kill most weeds, till the field 10 days before planting, let small weeds emerge, and harrow before planting. With adequate

TABLE 5. OATS GROWTH AND GRAZED FORAGE QUALITY								
	HEIGHT (IN.)	DM (%)	CP (% DM)	NDF (% DM)	LIGNIN (% DM)	NDF-D 24 HR (% DM)	SUGAR (% DM)	NE-L (Mcal/LB)
Average (2 yrs, 4 samples)	22	20	20	51	4.6	65	7	0.67

DM=dry matter; CP=crude protein; NDF=neutral detergent fiber; NDF-D=neutral detergent fiber digestibility; NE-L=net energy for lactation; M(cal/lb)=megacalories/lb

moisture and growing-degree-day units, the BMR SS may be ready for grazing or mechanical harvest 40 to 60 days after planting.

Harvest BMR SS at a height of 36 to 48 inches to yield energy levels similar to corn silage and crude protein levels of 15 to 20 percent. Fiber digestibility declines as the crop matures but is still high at taller heights relative to most other common forage crops. Delaying harvest could jeopardize a second cutting in crops planted after June 15 in cooler areas.

A light-yellow crop indicates N deficiency. Harvest it at 30 inches and correct yields with proper N fertilization. If grazing or green chopping BMR SS, wait until plants reach a minimum of 24 inches to avoid prussic acid poisoning (do not graze horses on BMR SS as it can cause cystitis syndrome). Green plants that are frosted should be completely dried before grazing or ensiled several weeks before feeding. The research team recommends strip grazing with portable fencing. BMR SS will be more effectively grazed when grazed less than 48 inches tall.

A key to harvesting high-quality BMR SS is rapidly drying the crop in the field. As the plant height increases, so does the challenge of moisture removal. Wet silage will result in lower-energy feed, improper fermentation, decreased dry matter intake and less potential milk production. To avoid this, consider the following:

1. Set mower heights at 5 to 6 inches to avoid stunting regrowth.
2. Harvest at stand height of 36 to 48 inches to best manage moisture removal.
3. Mow into a full-width swath (like hay) to rapidly remove moisture.
4. Windrow with a merger or properly adjusted rotary rake.
5. Most water is in the BMR SS stem. Intermeshing conditioning rolls fully crush the stems for rapid drying. Watch BMR SS closely, as it can dry more quickly than one might expect in good conditions. For bunk silos and tumble mixers, set the chopper length at ¾ to 1 inch. Uprights, baggers and auger mixers need a slightly longer cut to maintain effective fiber. Producers can also use BMR SS for round bale silage.

Regrowth of BMR SS takes roughly 40 days, although weather conditions will influence the rate of re-growth, so monitor harvest height to manage water in this high-yielding crop.

Adapted from the Cornell fact sheet *Brown Midrib Sorghum Sudangrass, Part I*. (See Resource section.)

Oats and Triticale

The SARE project also tested oats and spring triticale in the ACCF system. If planting is delayed beyond early July, these small grains are a better option than summer annuals to produce forage through the cooler fall temperatures. Both of these crops could be spring planted for an early summer harvest or planted in August following sod or after a BMR SS crop has been grown. These spring grains will not persist after a killing frost and hence will not provide the benefits of a winter small grain.

Oats and triticale have shown to exhibit excellent forage quality (see Table 5), rivaling high-quality alfalfa and the fiber digestibility of BMR crops. In the SARE trials, oats were sampled four times over two years, and growth and forage quality measurements were taken (Table 5).

Seed oats and triticale at 3 bushels per acre (approximately 100 lbs per acre for oats and 170 lbs per acre for triticale). This will maximize forage yield through high density. Small grains are not recommended as a companion crop for summer seedings of perennial forages since they out-compete perennial forages. Both conventional and no-till methods can be used to establish the crops. The proper killing of sods and adequate soil moisture in no-till situations are important for achieving proper seed depth, coverage and germination.

If manure has not been applied, fertility management for oats and triticale should include application of 50 lbs per acre of nitrogen fertilizer in accordance with nutrient management plans.

When planted in mid-August, these grains will remain vegetative, so harvest can occur at any point in late summer or fall. The crops will have high moisture content and will be difficult to dry in a cool, wet fall. Opening up windrow width and avoiding field traffic in wet areas can help.

Further Recommendations for Successful Implementation of the ACCF System

In order to successfully implement the ACCF system, keep in mind the following tips:

- Follow production recommendations for individual crops. For example, use a grain drill to plant BMR SS and select proper planting ground. BMR SS is a high-management crop with high nitrogen needs.
- Know the feed value of crops and stocking rate for your herd to realize the full economic benefits of reduced feed costs and/or increased milk production.
- Use optimal manure timing and rate management. For example, spreading manure too many days after a first cutting of BMR SS could crush plants that have already started to re-grow.
- Avoid field operation conflicts, such as a late corn-silage harvest when winter grains follow corn. Late-planted winter grains will not establish well, resulting in crop failure. Avoid late harvest of winter grains for forage in the spring to avoid low-quality feed.
- Ensure a timely planting of BMR SS. For example, avoid conflict with a hay-crop harvest to ensure it is planted early enough for more than one harvest.
- Ensure BMR SS is dry when harvesting. Wet silage results in lower energy feed, improper fermentation, decreased dry matter intake and lower milk production. Wet silage also makes it difficult to handle in storage.
- In higher elevations and cooler climates, pay attention to the variable growth potential in BMR SS, which can result in reduced yields.
- Avoid a late harvest of BMR SS, resulting in lower feed quality and reduced milk yield.

Economic Advantages

The SARE research study on ACCF showed that if dairy system corn growers planted a winter cover crop, they could realize a net gain in farm income. The budget in Table 6 illustrates the typical scenario when corn growers adopt a year-round cover using winter rye. With a reduced need for N fertilizer and added income from increased milk production, planting a winter cover crop resulted in a net gain when it was harvested for forage or straw.

Using the ACCF system on one particular farm in the SARE study translated into a $531 net increase per acre. On this farm, a partial budget analysis contrasted a traditional rotation of three years of corn silage and either alfalfa or clover-grass with an ACCF rotation of cows grazing BMR SS followed by winter rye. The same sequence of annuals was repeated and grazed again. The field was then combined with an adjacent corn silage field and seeded to festulolium and ladino clover, which yielded about 4 DM tons per acre per year as dual use for grazing and harvested haylage, more than double the original yields from the native sod.

TABLE 6. PARTIAL BUDGET ANALYSIS FOR WINTER RYE AS COVER AND FORAGE OR STRAW ON A PER ACRE BASIS	
Added Costs	
Winter rye cost of production[1] (one year)	$188
Reduced Returns	
None	$0
A. Total of Added Costs and Reduced Returns	**$188**
Added Income	
Winter rye forage @ 1.2 DM ton/acre, value of $150 per DM ton + Milk: 50 cows, 10 days rye forage yields 1 lb milk per cow, 500 lbs milk @ $20/cwt or rye straw at 66 30-lb bales per ton, 79 bales @ $4 per bale	$180 + $100 or $316
Total Added Income	$280 or $316
Reduced Expenses	
Reduced N fertilizer need of 20 lbs per acre: $6 @ $600 per ton fertilizer cost	$6
B. Total Added Income and Reduced Expenses	**$286 or $322**
Change in Net Farm Income (B - A)	**$98 or $134**

[1]Cost of production was based on one farm's actual machinery, fuel, maintenance and repair expenses, land ownership costs, annual input costs (seed, fertilizer, lime, pesticides as applicable), and a charge for operator labor of $15/hour.

TABLE 7. PARTIAL BUDGET ANALYSIS FOR USE OF THE ACCF SYSTEM ON "Y" FARM ON A PER ACRE BASIS[1]	
Added Costs	
BMR SS: two years production[2] Winter rye: two years production[2]	$346 $299.60
Total Added Costs	**$645.60**
Reduced Returns	
Corn silage: two years production, 14 tons per average annual field yield, value of $40 per ton (4.9 DM ton per year)	$1,120
A. Total of Added Costs and Reduced Returns	**$1,765.60**
Added Income	
Grazed rye forage, 2.37 DM ton[3], $150 per ton Grazed BMR SS forage, 6.5 DM ton[3], $150 per ton Increased milk income in year one[4]: BMR SS: 40 cows, 3 lbs/cow/day x 12 days: 14.4 cwt @ $20/cwt Winter rye: 35 cows, 3 lbs/cow/day x 5.5 days: 5.7 cwt @ $20/cwt	$355.50 $975 $288 $115.50
Total Added Income	**$1,734**
Reduced Expenses	
Corn silage production[2], two years	$562.60
B. Total Added Income and Reduced Expenses	**$2,296.60**
Change in Net Farm Income (B - A)	**$531**

[1]Analysis compares BMR SS/winter rye in two-year sequence, followed by one-year corn silage and one year of seeding, to the farm's practice of three years corn silage and year four seeding.
[2]Cost of production was based on one farm's actual machinery, fuel, maintenance and repair expenses, land ownership costs, annual input costs (seed, fertilizer, lime, pesticides as applicable), and a charge for operator labor of $15/hour.
[3]These yields were calculated via feed intake calculations and reflect low BMR SS yields in year two due to extreme wet conditions that prevented field access, and only one harvest of rye in year two as it was plowed down for corn planting.
[4]Milk response to both forages was determined with actual daily production records. This response was only realized in 2003 for the BMR SS and 2004 for the winter rye.

As seen in Table 7, the added income from using winter rye and BMR SS as forages, coupled with elimination of corn costs, offsets the added expenses of using the alternative crops and the reduced return from corn. ACCF farmers can potentially also see added income from milk production.

Table 8 presents predicted milk production from dairy cattle diets simulated with the Cornell Net Carbohydrate and Protein System Model. Diets containing winter rye or BMR SS were compared to diets with high-quality grass silage. Results showed that ACCF forages sustained similar or higher levels of milk production (as measured by protein-allowable and energy-allowable milk) compared to grass silage, despite having lower crude-protein levels. The research corresponds with the experiences of cooperating farmers: During the 10- to 14-day grazing periods that farmers grazed the ACCF crops in these SARE studies, they experienced no decrease in milk production, and in some cases saw up to 3 pounds more milk per cow per day compared to milk production immediately before grazing. Along with a decrease in stored feed, this spelled profit for participating farmers.

Environmental Benefits

In the ACCF system, winter covers, with their live-root system and growth prior to spring, improve those physical characteristics of the soil that enhance growth of subsequent crops. In Table 9, data from three farms show that soil health ratings were "very high" during rotations, with organic matter and aggregate stability showing minimal decreases, or even slight increases, during the ACCF rotation.

While difficult to quantify in dollars, soil health has a tremendous influence on crop performance.

The ACCF project team also saw this system as a way to re-establish perennial forages and a grass/legume mix, with reduced weed pressure and enhanced yields due to healthy soils.

SARE Research Summary

Seven farmers, primarily in Delaware County, New York, implemented versions of the ACCF crop-rotation system dur-

TABLE 8. PREDICTED MILK PRODUCTION COMPARISON FROM DIETS USING ACCF FORAGES VS. HIGH-QUALITY GRASS SILAGE[1]

FEED	POUNDS (LB) DRY MATTER PER DAY		
Corn Silage	13	13	13
Grass Silage: 18% CP, 52% NDF	10	—	—
Winter Rye Silage: 13% CP, 58% NDF	—	—	10
BMR SS Silage: 14% CP, 58% NDF	—	10	—
Grass Hay: 16% CP, 56% NDF	4.5	4.5	4.5
Grain Mix: 21.2% CP	19.5	19.5	19.5
Total DMI	47	47	47
PREDICTED MILK	**POUNDS (LB) PER DAY**		
Energy Allowable	73	70	72
Protein Allowable	67	68	70

[1]Predicted using Cornell Net Carbohydrate and Protein System CNCPS 6.1; 1,325-lb Holstein cow, 3.9% butterfat, 3.1% milk protein

ing a three-year period. The team gathered data on forage quality and yield, soil health, and cost of production.

The New York nitrogen-leaching index was applied to three sites. Soil samples were submitted for chemical and physical analysis. The team used the Cornell Net Carbohydrate and Protein System Model (CNCPS) to predict milk production. They also studied forage quality and fiber analysis of crops.

Soil samples were analyzed for quality and nutrients through the Cornell Nutrient Analysis Laboratory. The Cornell Nutrient Management Spear Program's web-based N leaching assessment tool was used for all fields in spring and fall. All project fields were monitored weekly or as appropriate throughout the growing season for growth, vigor and the presence of weeds, insects and diseases.

Yield measurements were completed for all mechanically harvested crops. Estimates for grazed crops were made wherever possible. All harvested forages were sampled at harvest and/or after fermentation or stabilization. Scientists performed NIR analysis with wet chemistry for minerals and fiber digestibility characteristics through the Dairy One Lab.

Cornell's Net Carbohydrate and Protein System Model were applied to the feeding of the forages to determine suitability for dairy production. Economic sustainability of the ACCF system was verified by cost-of-production analysis for two of the seven project farms. This analysis included expenses related to the individual's equipment, labor, land tax or rental fees, and the annual costs of seed, fuel, fertilizer, lime and other materials. Analysis was conducted using the partial budgeting process.

Winter rye and BMR SS were showed to meet neutral detergent fiber (NDF) thresholds for lactating dairy cattle. Fiber digestibility of both crops was excellent, exceeding 55 percent of NDF dry matter for 24-hour incubations for both crops. Crude protein levels were modest, averaging less than 15 percent of dry matter. Despite this, CNCPS predicted protein-allowable milk production was greater in diets containing ACCF forages when compared to the same diets using high-quality grass silage.

Soil in the ACCF systems maintained a "very high" soil health rating and intermediate nitrogen leaching levels. A modeling study of the effect of winter cover crops on corn acreage on a typical Delaware County farm indicated that sediment-bound phosphorus losses could be reduced by 49 percent, or an average of about 5.5 lbs per acre.

Intensive economic analysis conducted on two cooperating farms indicated that the ACCF system could produce an increase in net farm income between $250 and $530 per acre.

Resources

Cerosaletti, Paul and Fields, Lisa. *Winter Rye: Not just a cover crop anymore*. See www.ansci.cornell.edu/pdfs/pd2007october20.pdf.

Cornell University fact sheet, *Brown Midrib Sorghum Sudan grass, Part I*. See http://nmsp.cals.cornell.edu/publications/factsheets/factsheet14.pdf.

Cornell University Nutrient Management Spear Program: http://nmsp.cals.cornell.edu/.

Cornell University College of Agriculture and Life Sciences forage resource: http://forages.org/.

Delaware County Precision Dairy Feed Management Program: http://cornellpfm.org/.

References

Cerosaletti, Paul. Alternative Continuous Forage Covers. 2005-2008. USDA SARE program reports for project number LNE05-215

Fields, Lisa and Cerosaletti, Paul. Crop and Rotation Options for Quality Forage in Weather Extremes, Northeast Region Certified Crop Advisors (CCA) Conference. November 2006. Waterloo, New York.

Tables 1 and 2 adapted from: Fields, Lisa and Cerosaletti, Paul. *Crop and Rotation Options for Quality Forage in Weather Extremes,* Northeast Region Certified Crop Advisors (CCA) Conference. November 2006. Waterloo, New York.

Table 5 adapted from: Fields, Lisa and Cerosaletti, Paul. *Crop and Rotation Options for Quality Forage in Weather Extremes,*

TABLE 9. SELECTED SOIL-QUALITY FACTORS IN THREE FIELDS BEFORE AND AFTER IMPLEMENTATION OF ACCF ROTATIONS (ALL FIELDS PRIOR NATIVE PASTURE)

FARM AND ROTATION	SOIL TYPE	NITROGEN LEACHING INDEX[1]	SAMPLE YEAR	ORGANIC MATTER (%)	AGGREGATE STABILITY[2] (%)	SOIL HEALTH RATING[3]
C Farm						
2 yrs BMR SS/winter grain; year 3: spring oat, perennial seeding w/ oats	Valois	9.1	2005	6.5	89	Very High
			2008	7.1	—[4]	—
R Farm						
BMR SS/winter rye; year 2: perennial interseeded w/ BMR SS	Mardin	6.3	2005	6.7	99	Very High
			2007	6.7	85.9	Very High
Y Farm						
2 yrs BMR SS/winter rye; year 3: corn silage; year 4: perennial seeding	Appleton	5.8	2004	4.5	81.8	Very High
			2007	4.6	83	Very High

[1]New York Nitrogen Leaching Index is an indicator of the degree to which nitrate nitrogen will leach through the soil profile, potentially reaching groundwater. It is a qualitative measure highly correlated to soil type. The numerical scale indicates leaching potential as follows: <2=low, 2-10=intermediate and >10=high. Winter grains are a good choice to help prevent nitrate N leaching, as their surface growth and root systems capture nutrients and slow flow rate through the soil profile.
[2]Aggregate stability is an indicator of soil physical health. It measures the percent of soil aggregates that maintain their structure under the impact of rainfall. High aggregate stability indicates high permeability and good drainage. This provides an ideal physical environment for plant root development.
[3]Soil health rating is a summary of a group of soil health tests that include physical, biological and chemical factors. Physical resistance to pressure is measured in the field to assess degree of compaction present. Biological activity of nutrient-transforming biota and pathogen presence are assessed in the lab. The "Very High" rating indicates an ideal soil biological environment for plant growth.
[4]Missing data due to incomplete test results from the Cornell soil health lab. See http://soilhealth.cals.cornell.edu/index.htm for more information.

Northeast Region Certified Crop Advisors (CCA) Conference. November 2006. Waterloo, New York.
All other tables adapted from: Cerosaletti, Paul and Fields, Lisa. *Final Technical Report: Alternative Continuous Cover Forages 2*, August 2008. LN05-215.

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