ASSESSING THE BENEFITS OF DOUBLE CROPPING IN MIFFLIN COUNTY PENNSYLVANIA

Introduction

In Pennsylvania, many livestock operations have incorporated best management practices into their cropping strategies that benefit not only the environment and improve overall farm profitability. Two examples are no-till and cover crops. Both practices conserve soil and water quality. They do, however, require management strategies for manure nutrient conservation, crop termination, weed control, and pest control such as slugs. Planting a winter annual harvested for silage in the spring and then double cropped with corn, provides another environmental benefit. This practice provides additional forage to the livestock operation and potentially improves profitability by lowering total feed costs.

Livestock operations are affected by market volatility, especially with the recent developments related to Covid-19. The dairy industry has been subjected to extreme market volatility in grain and milk prices the past decade causing moderate to severe financial distress on dairy farms in Pennsylvania. According to the 2017 Census of Agriculture, Pennsylvania has lost almost 1000 dairies between 2012 and 2017. Unsustainable margins of less than $12/cwt for the past five years have been a hardship for many dairy operations. To improve margin and profitability, many dairies have increased herd numbers to improve milk income, but their land base no longer matches herd size. This has resulted in more nutrients imported through feed compared to nutrients exported in farm products contributing to a nutrient imbalance.

Double cropping has been widely adopted by farmers in the southern, central, and eastern parts of Pennsylvania to optimize forage and feed inventory on a limited land base. Competitive land rents and a longer growing season for full-season corn hybrids make this strategy financially sound. Other areas in Pennsylvania may be agronomically challenged due to shorter growing seasons. Investigating opportunities to adjust management practices to capture additional feed and the benefits to farm profitability and the environment are frequently worthwhile.

The Penn State Extension dairy team evaluated the practice of double cropping on 143 farms completing their cash flow plan in the winter of 2013. The average herd size was 124 milking cows, and they were located primarily in southeastern Pennsylvania with the rest of the farms in either the central or northern part of the state. The objective was to evaluate the influence of double cropping on farms showing a positive cash balance compared to farms in negative balance. The farms with a breakeven gross milk price less than $16/cwt utilized 26% of their acreage as a double crop. The next group of producers with a positive cash balance (breakeven milk price of $16-$18/cwt) utilized 48% of their acreage for double crops. Farms within these profit groups cropped 2.25 acres per total cows.

Farms in a negative cash balance (>$18/cwt breakeven) had a range of 21 to 38 percent of the acreage as a double crop. The farms exceeding $22/cwt breakeven cropped 2.5 acres per total cows with 34 percent of acres double cropped. They also spent the most money on purchased forages, which implies yield on these operations could use improvement. The farms with a negative cash balance spent an average $250 more per cow per year in purchased feed and $150 per cow per year more on home raised feed compared to the farms with a positive cash balance. There are multiple reasons to explain why this was happening. Forage quality and/or quantity was low requiring more purchased concentrates or forages to compensate. Other factors could be the growing season, soil health, and overall farm management influencing the farms' profitability.

Based on data compiled by the Extension Dairy Team on 238 dairy operations over three years, there is a lot of variability in yield of small grain silage. Table 1 shows the following as-fed tons per acre: 48 percent averaged 4.1; 24 percent averaged 6.4; and 28 percent averaged 8.9. The dry matter for the small grain silage on average ranged between 30 to 35 percent. With almost half of the operations with low yield, there appears to be opportunity for improvement. It is noteworthy that the herds with low yield also had the highest percentage (70 percent) of rented land used for small grain silage compared to 37 percent for the high yielding farms.

The average market price for small grain silage combined for 2018 and 2019 was $66/ton (Ishler V., 2020). The cost to produce small grain silage for the low yielding farms averaged $58/ton compared to the highest yielding farms of $31/ton. The higher yielding farms are investing more money in seed and fertilizer per acre, which appears to be paying off. Information not captured in this data set is the timing of manure application and the impact of custom hire to expedite a faster harvest, especially when the weather is not optimal.

Fertility management and the timing of harvest can affect the quality of small grain silage. Fiber content and fiber digestibility are two key metrics used for assessing the quality for the lactating cows (Table 2). Ideally neutral detergent fiber (NDF) should be in the low fifties on a dry matter basis and the NDF digestibility (30 hours) greater than 60 percent (as a percent of NDF). When the NDF exceeds 60 percent on a dry matter basis, this quality is better suited for beef cattle or dry cows and heifers. The protein percent suitable for lactating cows is greater than 15 percent on a dry matter basis. The type of small grain may result in slightly different quality metrics related to time of harvest. Some of the small grains have a broader optimal harvest window related to maturity compared to others.

Table 1. Small grain silage cost per ton for years 2018-2020.

Yield Group	**< 6 T/A**	**6-7 T/A**	**> 7 T/A**	**Average**
Yield per Acre	4.1	6.4	8.9	6.0
Acres Owned	25	37	82	44
Acres Rented	58	62	49	56
Total Acres	83	99	131	100
Seed/Acre	$27	$24	$34	$28
Fertilizer/Acre	$26	$26	$32	$28
Chemical/Acre	$2	$7	$9	$5
Custom Hire/Acre	$17	$32	$46	$29
*Land Rent/Acre	$62	$62	$66	$63
Total Direct Costs/Acre	**$165**	**$186**	**$233**	**$189**
Total Direct Costs/ Ton	$43	$30	$22	$34
Percent of Crop Labor	$0	$0	$0	$0
Total Overhead Costs/Acre	**$40**	**$40**	**$39**	**$39**
Total Overhead Costs/ Ton	$10	$6	$4	$8
Owner Draw/Acre	$14	$13	$12	$13
Loan Payments/Acre	$25	$23	$25	$24
Total Costs/Acre	**$239**	**$272**	**$276**	**$257**
Total Costs/ Ton	**$58**	**$43**	**$31**	**$43**
Number of Farms	**114**	**58**	**66**	**238**
Average % Rented Land	70%	63%	37%	56%
*Avg. Land Rent on Rented Acres	$71	$94	$86	$81

Source: Beck, T., and R. Goodling, 2020. Penn State Dairy Extension Business Management Team.

Table 2. Rye, small grain, and triticale silage analysis for the crop year 5/2019-4/2020

Rye silage

Item	Samples	Average	Normal Range		Standard Deviation
% Dry Matter	409	39.368	26.742	51.994	12.626
% Crude Protein	410	14.343	10.337	18.348	4.005
% Acid Detergent Fiber	409	38.246	33.348	43.145	4.898
% Neutral Detergent Fiber	284	57.913	50.769	65.056	7.143
% Ash	371	10.988	7.491	14.486	3.498
% Calcium	403	0.523	0.332	0.715	0.191
% Phosphorus	403	0.364	0.264	0.464	0.100
% Magnesium	403	0.195	0.142	0.249	0.054
% Potassium	403	2.744	1.976	3.513	0.768

Small grain silage

Item	Samples	Average	Normal Range		Standard Deviation
% Dry Matter	460	35.631	22.212	49.050	13.419
% Crude Protein	519	12.397	8.590	16.204	3.807
% Acid Detergent Fiber	440	37.188	32.078	42.298	5.110
% Neutral Detergent Fiber	379	57.384	50.112	64.656	7.272
% Ash	406	9.539	6.359	12.718	3.179
% Calcium	423	0.464	0.226	0.703	0.238
% Phosphorus	423	0.302	0.219	0.384	0.083
% Magnesium	423	0.187	0.119	0.256	0.068
% Potassium	423	2.141	1.188	3.094	0.953

Triticale silage

Item	Samples	Average	Normal Range		Standard Deviation
% Dry Matter	360	33.632	25.189	42.076	8.443
% Crude Protein	361	13.790	10.248	17.332	3.542
% Acid Detergent Fiber	362	38.410	33.902	42.918	4.508
% Neutral Detergent Fiber	298	57.497	51.570	63.424	5.927
% Ash	292	11.794	9.191	14.398	2.604
% Calcium	351	0.400	0.239	0.561	0.161
% Phosphorus	351	0.339	0.256	0.422	0.083
% Magnesium	351	0.162	0.107	0.218	0.056
% Potassium	351	2.893	2.025	3.762	0.868

Source: Dairy One Feed Composition Library,2020.

Water for and from Agriculture (Water4Ag) – Mifflin County Double Cropping Project

Pennsylvania must implement best practices to achieve reductions in nitrogen, phosphorus, and total suspended solids (sediment) as mandated by the U.S. Environmental Protection Agency by 2025 under the Chesapeake Bay's "Total Maximum Daily Load" allocation. Mifflin County needs to reduce its current nutrient pollution by 1.037 million pounds of nitrogen and 47,000 pounds of phosphorus. It is estimated that 63 percent of nutrients and sediment in Mifflin County originate from agricultural sources such as fertilizer and manure (Pennsylvania Department of Environmental Protection, 2020). Approximately 33,000 acres are devoted to row crops and 49 percent of the manure applied to fields is from dairy operations. Based on data compiled by the Pennsylvania Clean Water Academy 27,000 acres are not utilizing conventional cover cropping and 32,000 acres are not utilizing cover crops with fall applied nutrients. Dairy precision feeding and forage management ranks as the most cost efficient and effective practices to reduce nutrient loads in Mifflin County. Examples of forage management would include cover and double cropping strategies.

The USDA funded Water4Ag project brought together local partners in Mifflin County to identify issues related to water for and from agriculture. This project helped develop a "Local Leadership Team", which identified water quality concerns as a key issue in Mifflin County. After much discussion, the Local Leadership Team identified a critical question: could livestock operations in Mifflin County implementing double cropping be a way to achieve both high forage yields and quality in addition to improving water quality? Identification of what works, and the challenges could prove useful as an educational effort to encourage more producers to implement double cropping on their farms.

Three dairy operations and one beef farm volunteered for an on-farm project involving soil sampling, fresh forage analyses and a fermented silage analysis. Information was collected on cover crop practices such as manure application rate and date, planting date, harvest date, and plant species. The following figures and analyses are for illustration purposes only and are relevant to the individual farm. Due to the limited number of farms and the different plant species used on the various fields, there is inadequate data to make any significant interpretation, but there are trends that match what other research has shown. The following provides results of the pilot project. Soil tests, yield and quality are covered for the Mifflin County farms and their results compared with published research.

Soil type, soil tests and yields

Optimizing yield of small grain silage is a challenge on many farms. Ideally yields should surpass eight as-fed tons per acre. Figure 1 illustrates the Mifflin County farms with their soil types and yields. Binkerton soils are described as poorly drained while Hagerstown soils are well drained. It is possible this is one explanation for the lower yield relative to the Hagerstown soils. The soil series drainage difference could be a potential yield limiting factor for cooperator three.

The dairy farms applied manure right after seeding at a range between 7000 to 12,000 gallons per acre. The beef operation applied hog manure at 5000 gallons per acre before planting. Dairy number two was the only operation to apply spring fertilizer.

Soil organic matter provides many soil health benefits and potential organic matter levels vary with soil texture and climate (Hoover et al. 2019). This test is not always included in standard agronomic soil tests but was included for this project. Practices that reduce soil erosion and add organic matter include reducing tillage, leaving crop residue on the field, including perennial crops in rotations with annual crops, planting cover crops such as winter cereal rye after corn and soybeans, and applying manure and compost to fields.

All four operations' soils tested well for organic matter (Figure 2). The Penn State Agricultural Analytical Services Lab conducts Soil Organic Matter analyses on only a small percentage of agronomic soil samples, due to low demand. However, over a period of about 15 years they have conducted Organic Matter analyses of about 10,000 agronomic soil samples. Results indicate that the median of all such samples analyzed is about 2.8%, with a range between 2.3 to 3.7 percent. Fields sampled from the four farms tended to contain a higher Organic Matter Content than the typical agronomic soil samples analyzed by AASL. There was not a strong relationship between soil organic matter with yield or other parameters. There was a positive relationship ($p = 0.06$) between soil phosphorus and soil organic matter percent (Figure 3).

Available manure nutrients, particularly nitrogen, are important factors influencing crop yield that this project was not able to quantify and compare among the Mifflin County farms. However, other research in Pennsylvania and the northeast has shown that manure nitrogen content, how it's applied (surface broadcast, not incorporated or incorporated with injection or other tillage methods) and timing relative to crop establishment can significantly influence winter silage crop yield and protein content (Lyons et al., 2017; Milliron et al., 2019, Binder et al, 2020). Therefore, it is likely that differences in manure application rate, application time and method contributed to differences in small grain silage yield and quality, while also potentially reducing manure nutrient losses to the environment.

Figure 1. Soil type by cooperator and field tested.

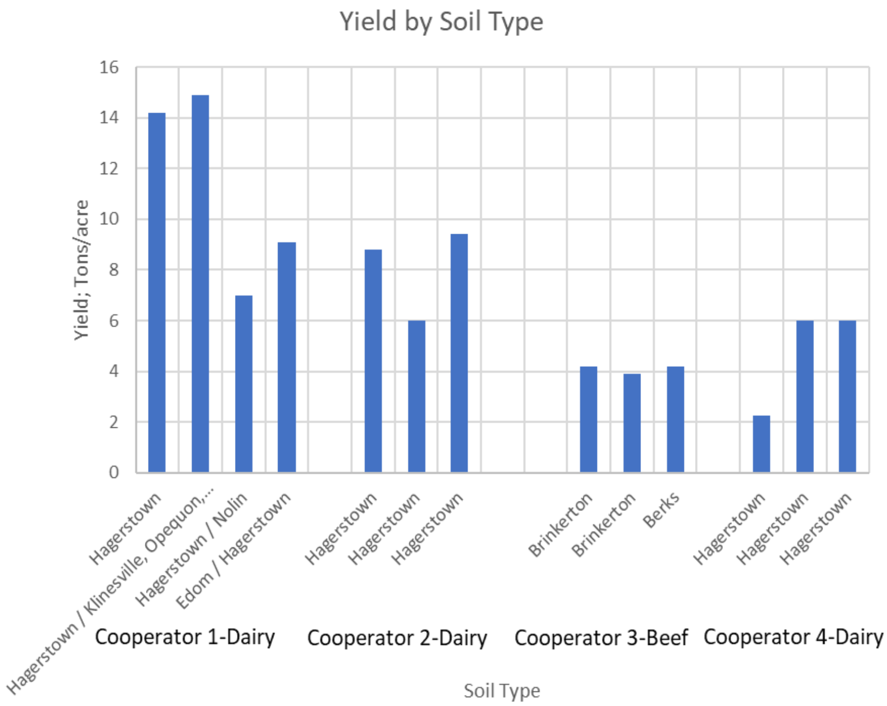


Figure 2. Soil organic matter by cooperator and field tested.

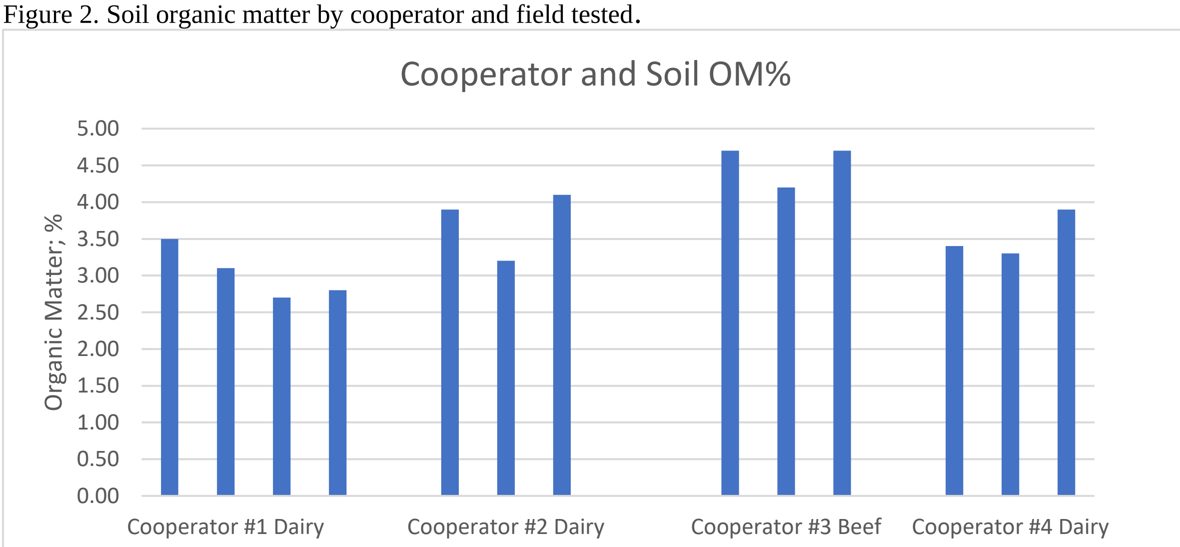
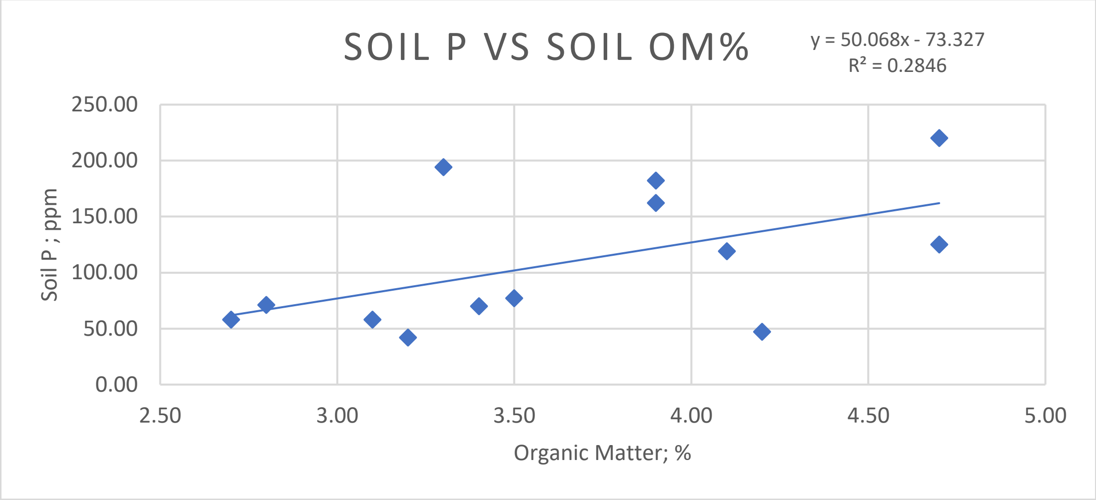


Figure 3. Soil phosphorus and organic matter.



Crop, planting and harvesting date and yields

The four livestock operations used rye, triticale, rye/triticale mix and one farm utilized an eight-way combination including legumes and small grains, Figure 4. Dairy farms one and two had variations among fields even with the same crop being harvested, however their yield for rye, triticale and their mixture fell within the profitable range. Farms three and four however, had much lower yield and this was consistent among their fields tested. Farms one and two planted their small grains in mid-September and farms three and four the beginning of October. Approximately 28 percent of the variation in yield can be explained by Days from Planting to Harvest ($p=0.066$), Figure 5. In this case, there is an increase in total yield of about 0.23 tons/acre per day between day 210 and day 245. The earlier the fall planting date the greater the biomass produced by a cover crop and the later the harvest, the greater the biomass produced. The farms harvested their small grain silage from the first week in May through the last week in May. It is assumed that the days from planting to harvest are representative of growing degree days. However, because of the different crops, soil yield potential, and nutrient application rates used, multiple factors most likely contributed to yield.

Lyons, et al (2017) found that earlier fall planting dates resulted in increased cover crop biomass at harvest. From the Mifflin cooperator data, planting date matters in terms of overall yield, although it should be noted that there were several fields planted at the earlier planting date (mid-September) and those fields reflected a wide variation in yield likely due to non-accounted for parameters such as soil conditions and soil type, crop establishment, general weather conditions of the area, nutrient application “management”, etc. As an example of variation due to factors other than planting date, the mid-September planting date provided yields ranging from 6 tons per acre to 15 tons per acre as-fed.

As shown in Figure 6a, there appears to be some impact of harvest date on yield. Initially, it appears that from early to mid-May the yields tended to increase with later harvest dates. However, after mid-May yield appears to decrease with date into late May. This may reflect crop species differences, advanced crop maturity and drying, as well as local climatic conditions that contributed to crop lodging and reduced biomass harvest. Any conclusions are tenuous, but results do seem to reflect the existence of an optimum harvest time.

Figure 4 Forage yield by crop

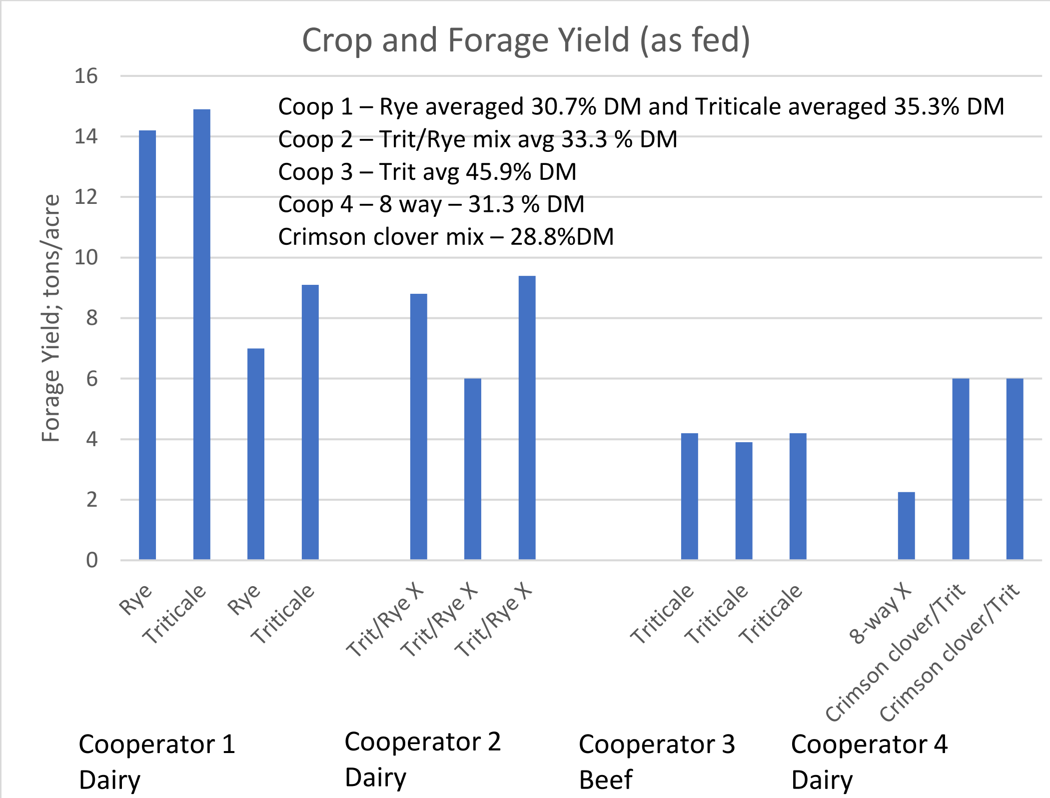
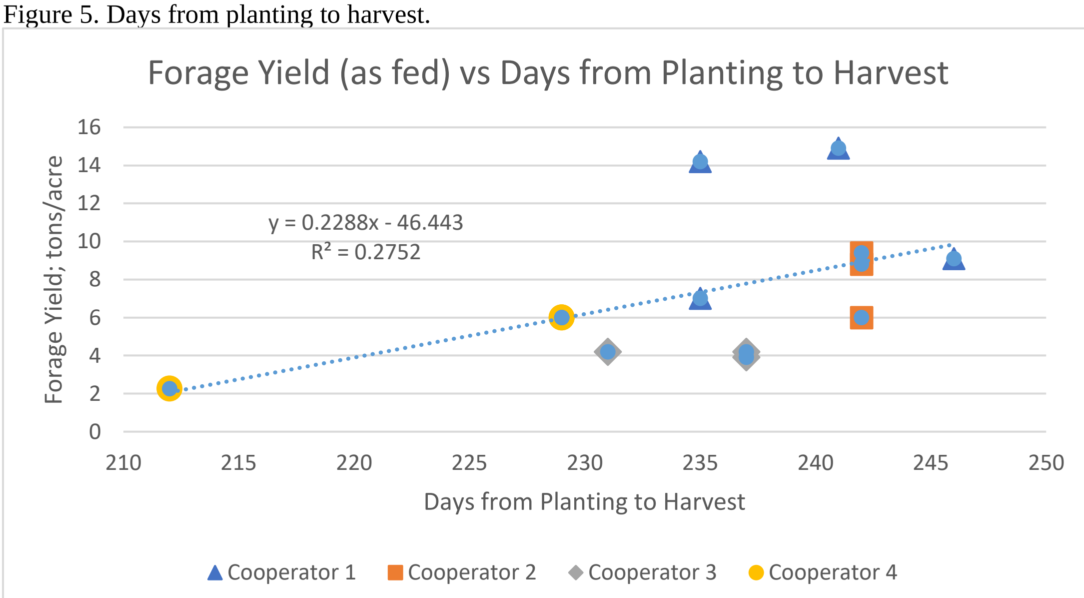


Figure 5. Days from planting to harvest.



It was shown by Mirsky et al (2011) that both spring and fall Growing Degree Days (cumulative growing degree days) matter in terms of total biomass production. Figure 6b demonstrates the impact of Growing Degree Days (data obtained for Belleville, PA area) on total yield. This approach demonstrates a stronger relationship between yield and GDD than exists between yield and days from planting to harvest.

Figure 6a. Forage yield as fed versus harvest date.

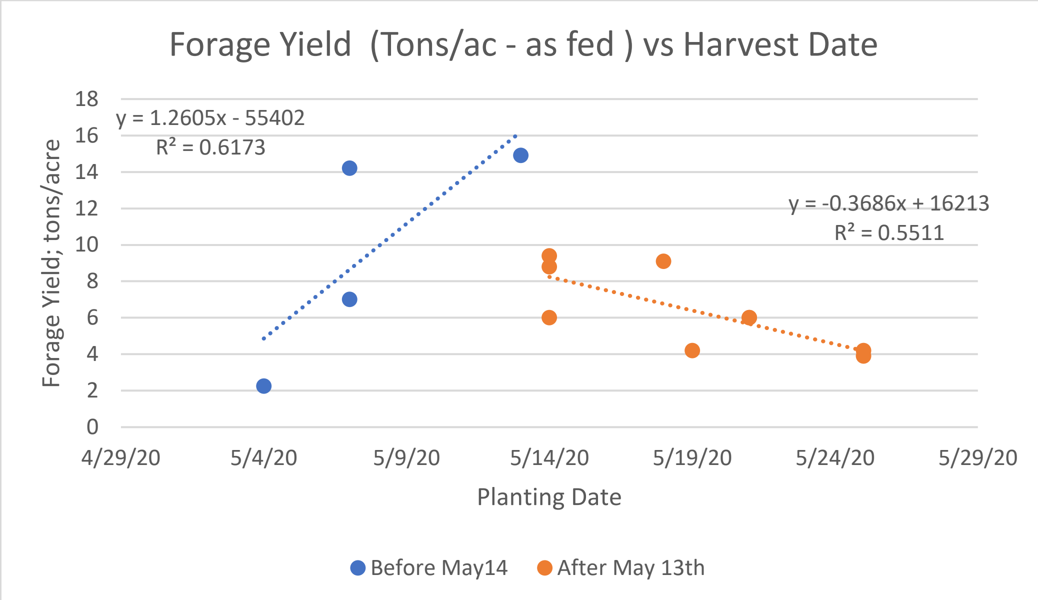
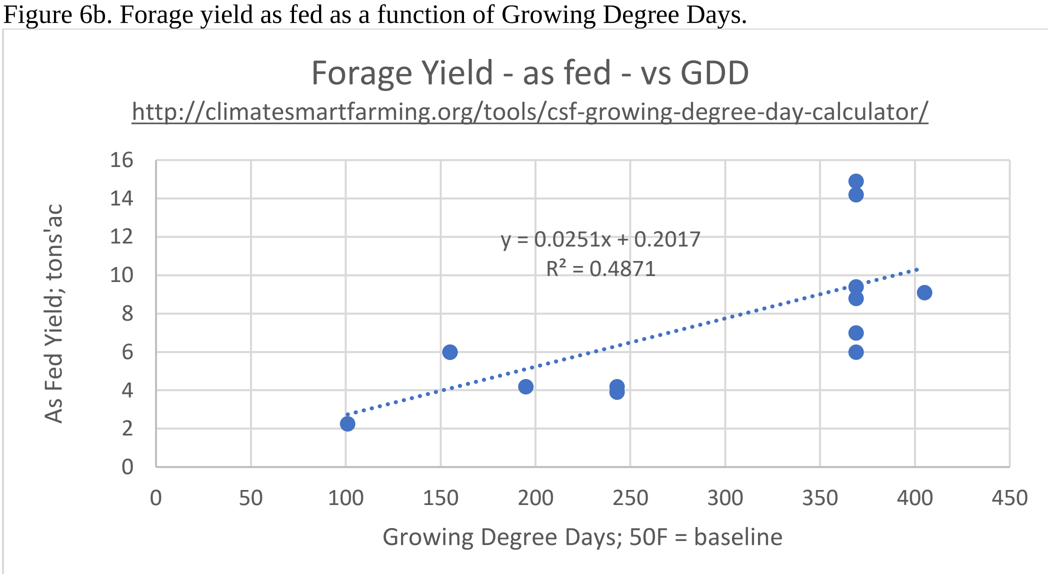


Figure 6b. Forage yield as fed as a function of Growing Degree Days.



Forage quality

The quality of small grain silage is an important indicator of feed value and potential use in the dairy ration. If the small grain silage is used for beef cattle, dry cows or heifers, yield may be more important than quality. Dairy farms are very sensitive to quality metrics as milk income is influenced by milk volume, which is influenced by the fiber content and digestibility. There can be a lot of variation in quality based on the crop species and harvest window. Table 3 shows the fresh and fermented analyses from the cooperating farms in Mifflin County. The protein and fiber levels are within the expected ranges that were listed in Table 2. These results also compare to recent work by Ranck et al. (2019) who evaluated 4 case-study commercial farms. The researchers worked with dairy producers in central, northern, and western regions of Pennsylvania. The different farms used a combination of either cereal rye, triticale, and winter wheat; triticale, annual rye, and crimson clover; winter rye and winter triticale, or 100 percent winter triticale. Their project was conducted in 2017 and two of the farms experienced very wet conditions resulting in very low dry matters and poor fermentation. The mean NDF from the four farms was 56.6 percent on a dry matter basis and crude protein was 14.2 percent on a dry matter basis.

Table 3. Forage quality from the participating farms in Mifflin County.

Nutrient	Dry matter	Protein	NDF	Ash	Ca	P	Mg	K
	%	---% of dry matter---						
Dairy #1								
Fresh rye forage	30.70	13.55	55.80	7.23	0.36	0.35	0.17	3.14
Fresh triticale forage	35.15	9.55	51.40	8.28	0.30	0.23	0.15	2.62
Fermented-Ag Bag	33.70	9.30	54.60	9.48	0.34	0.30	0.15	2.92
Dairy#2								
Fresh rye/triticale mix	33.30	10.17	43.93	8.30	0.24	0.30	0.16	2.79
Fermented-Bunk	33.15	12.15	43.25	7.91	0.35	0.33	0.15	2.81
Beef#3								
Fresh triticale forage	45.93	7.43	54.37	5.59	0.28	0.21	0.15	1.64
Fermented-Baleage	40.40	7.70	61.00	6.25	0.26	0.28	0.14	2.19
Dairy#4								
Fresh 8-way mix	31.30	20.10	40.90	8.53	0.91	0.40	0.25	2.94
Fresh crimson clover/ triticale mix	28.75	11.05	46.30	8.78	0.47	0.32	0.15	2.96
Fermented-Upright	26.80	13.40	52.10	9.00	0.74	0.37	0.21	3.46

NDF=neutral detergent fiber; Ca=calcium; P=phosphorus; Mg=magnesium; K=potassium.

The protein percent from the Mifflin County farms was examined (Figure 7). The longer the growing season the lower the percent protein. This observation is expected as the longer the growing season the more mature the crop, and protein levels decline. Approximately 43 percent of the variation in forage protein can be explained by days from planting to harvest ($p=0.014$). In this case, there is a decrease in protein percent of about 0.27% per day between day 210 and day 245. However, care must be exercised when interpreting this data, as the single 8 way mix strongly determines the slope of the line. Figure 8 shows protein percent decline with later harvest dates, but nitrogen amendments and other factors such as local weather conditions can also influence crop protein concentration. However, this trend is consistent with other observations that as a crop matures its protein percentage declines (Harper et al. 2017).

Another way of examining quality is combining both yield and percent to determine the tons of protein harvested. Figure 9 illustrates the tons of protein harvested considering the yield and protein percent. There can be large variations in total protein even with the same crops and the same producer.

Managing protein content for small grain silage is relative to the livestock being fed. For the cooperator feeding beef cattle, the protein content may be appropriate. The three dairy operations utilized their small grain silage for the lactating herd, however, if the goal was for dry cows and heifers, then a lower protein content would be appropriate. The goals of the producer for both quality and quantity should be considered before implementing any major crop management practice.

Summary

Double cropping winter annuals planted in the fall after corn silage and harvested in the spring for forage is becoming a common best management practice. It benefits the environment by taking up more on-farm manure and soil nutrients and reducing nutrients and sediment loss to the environment. It also offers a potential economic benefit to the producer by providing a quality forage to the livestock operation, which in turn can help reduce purchased feed and nutrient imports. There are opportunities for making improvements with double cropping.

Many factors such as soil types, climate, small grain type, and nutrient management influence an individual farm's potential forage quality and quantity and return on investment. However, working with a crop consultant, nutritionist, or extension specialist to identify bottlenecks to improvement is a first step to successfully implement this cropping strategy.

Figure 7. Forage protein percent versus total days from planting to harvest.

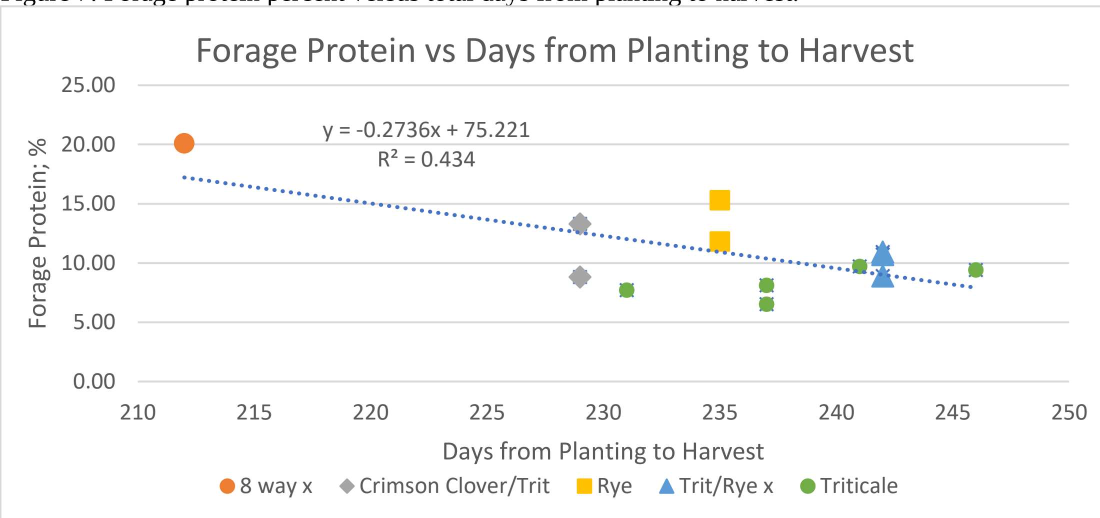


Figure 8. Protein percent by harvest date by crop.

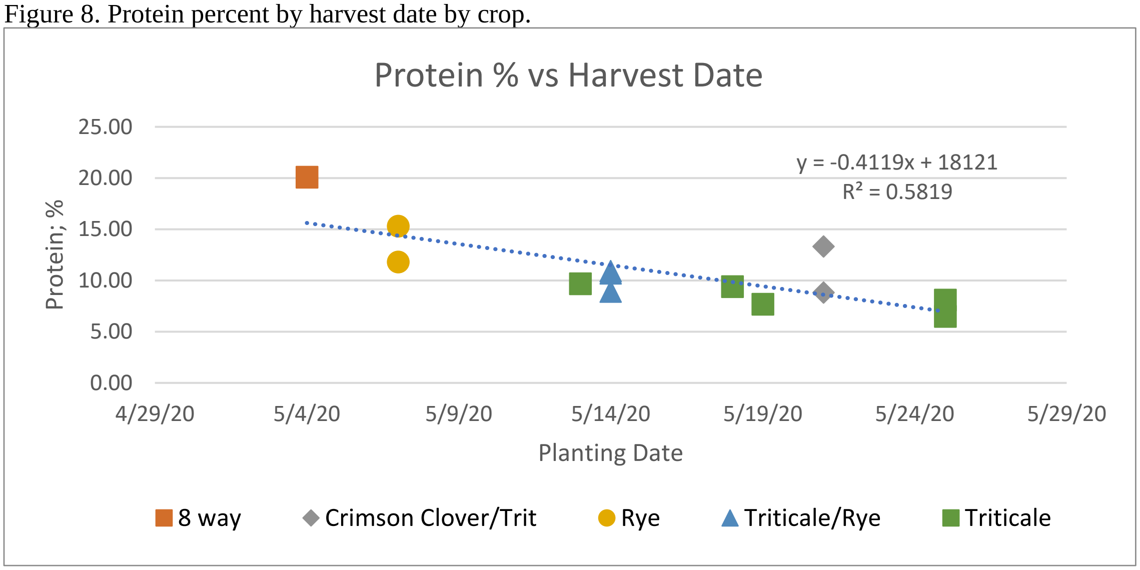
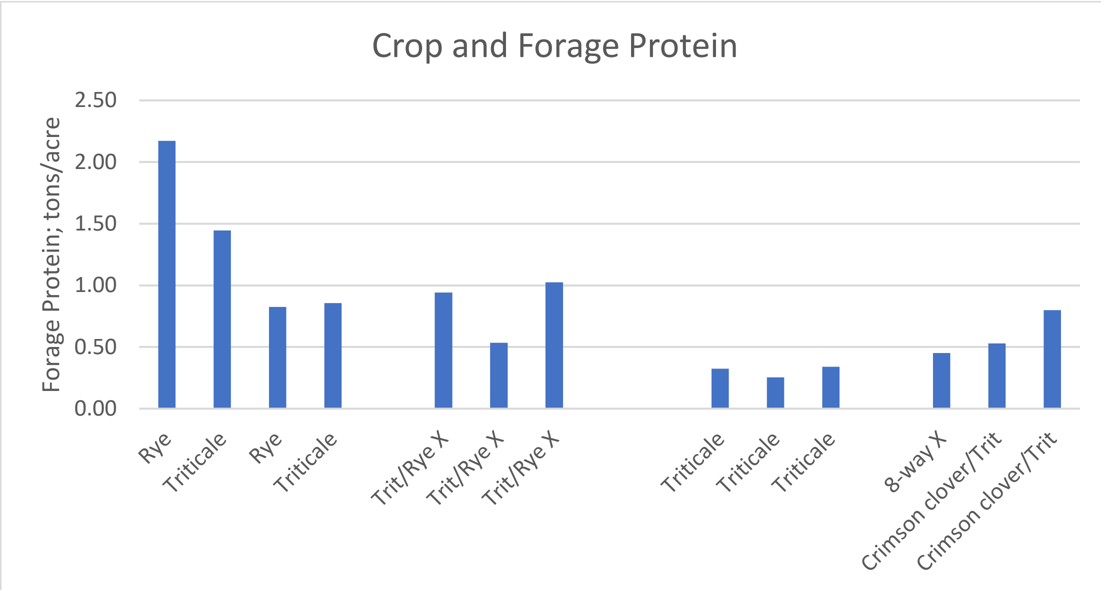


Figure 9. Total forage protein by crop



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