

# What's Cropping Up?

A NEWSLETTER FOR NEW YORK FIELD CROPS & SOILS

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Research has demonstrated (summarized by van Es et al., 2007) that soil and crop management practices, combined with weather conditions during the early growing season, greatly affect N losses and are therefore critical factors in determining optimum N rates. The difference in fertilizer N needs from one year to the next could easily be 100 lb N, and generalized N recommendations are inherently imprecise. In a recent case study, we highlighted the impact of early- vs. late planting on recommended N rates ([What's Cropping Up?, Vol. 21, No 4](#)).

It is not possible to accurately determine at the beginning of the growing season how much N fertilizer will be needed for that year's crop, because some critical processes that affect N losses have not yet passed. Most growers fertilize for a worst-case scenario and apply "insurance fertilizer" – they put on in excess of what is needed in most years. This reduces farm profits and causes high environmental losses. Seasonal corn N needs can be estimated much better in the late spring to guide sidedress applications. Adapt-N is an online decision support tool (<http://adapt-n.cals.cornell.edu>) designed to help farmers precisely manage nitrogen (N) inputs for grain, silage, and sweet corn. It uses a well-calibrated computer model, and combines user information on soil and crop management with high resolution weather information, to provide N sidedress recommendations and other simulation results on nitrogen gains and losses. We have completed the first year of beta-testing through on-farm strip trials

## Adapt-N Increased Grower Profits and Decreased Environmental N Losses in 2011 Strip Trials

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in New York, which are presented in this article.

### Methods

We completed 18 replicated strip trials on commercial and research farms throughout New York during the 2011 growing season. They involved grain and silage corn, with and without manure application,

and different rotations (corn after corn, corn after soybean, and corn after a clover cover crop; Table 1). Treatments involved two rates of nitrogen, a conventional "Gower-N"

Table 1. 2011 Replicated field-scale strip trials implemented in NY to compare current Grower N application rates with N rates recommended by the Adapt-N tool. N rates represent total N in lb/acre applied as inorganic fertilizer in 2011.

Trial Info				Fertilizer N Treatments (lb N/acre)		
Field Trial	Harvest	Manure	After soy	Grower	Adapt-N	Difference (A-G)
NY3	grain	no	yes	179	97	-82
NY4	grain	no	no	242	102	-140
NY5*	silage	yes	no	180	165	-15
NY6	grain	yes	no	150	120	-30
NY7	silage	yes	no	84	34	-50
NY8	grain	no	no	175	132	-43
NY9	grain	no	no	158	92	-66
NY11	grain	no	no	172	141	-31
NY12*	grain	no	clover cc	85	45	-40
NY12b*	grain	no	clover cc	95	45	-50
NY18	grain	no	yes	180	65	-115
NY21	silage	yes	no	109	66	-43
NY22	grain	no	yes	183	60	-123
NY24*	grain	no	no	198	146	-52
NY25	silage	no	no	140	106	-34
NY26	silage	no	no	140	119	-21
NY27	grain	no	no	175	100	-75
NY28	grain	no	no	175	100	-75

\* Not used to assess model performance due to improper model/trial implementation.

## Nutrient Management

rate based on current grower practice and an "Adapt-N" recommended rate. A simulation was run for each field prior to sidedressing to determine the Adapt-N rate. In 2011, due to seasonal weather conditions, all Adapt-N rates were lower than conventional N rates (by 15 to 140 lbs/ac; Table 1). Growers then implemented field-scale strips with 3 or 4 replications for each treatment (except NY8 and NY9, where only single yield strips were implemented due to time and equipment constraints).

Yields were measured by weigh wagon, yield monitor, or in a few cases by representative sampling (two 20 ft x 2 row sections per strip). Partial profit differences between the Adapt-N recommended and Grower-N management practices were estimated through a per-acre partial profit calculation:

$$\text{Profit} = [\text{Adapt-N yield} - \text{Grower-N yield}] * \text{crop price} - [\text{Adapt-N N use} - \text{Grower N use}] * \text{price of N}$$

Yields were used as measured, regardless of statistical significance, since the statistical power to detect treatment effects is inherently low for two-treatment strip trials. For corn, a grain price of \$5.50/bu was assumed (\$6.50/bu minus \$1.00/bu for drying, storing and trucking from PA Custom Rates; USDA, 2011). For silage, \$50/T was assumed based on reported NY silage prices of \$25-75/T. The price of N fertilizer was assumed at \$0.60/lb N (prices ranged from \$0.49 - \$0.75/lb N in NY). Total N losses to the environment (atmosphere and water) and N leaching losses were estimated for each treatment by running model simulations with all N inputs through the end of the growing season (30 October). Agronomic, economic and environmental outcomes of these trials were then used to assess Adapt-N performance.

### Results

Errors were made in model and/or trial implementation in a few cases (labeled with \* in Table 1): A clover cover crop was improperly simulated as an incorporated sod, resulting in a low Adapt-N recommendation and substantial yield losses. In

other cases, Adapt-N fertilizer and manure inputs did not reflect real field applications, or N applications were made too late in the season. The lesson here is that correct input information is, of course, needed for Adapt-N to provide an accurate recommendation. The resulting yields and simulations from the above four trials were not representative of 2011 Adapt-N performance, and these trials were therefore removed from further analysis.

Agronomic, economic and environmental comparisons between Grower-N and Adapt-N treatments for each trial are provided in Figure 1, and as averages in Table 2. A comparison of grain and silage harvest data (Fig. 1a & 1b) shows that differences in yields were negligible and statistically not significant for almost every trial, despite substantially reduced N rates applied for the Adapt-N treatment (Tables 1 and 2). A case study describing one of these trials, conducted at Donald & Sons Farm, in Moravia, NY, where 140 lb of N were saved without yield loss, is described in a companion article in this issue of *What's Cropping Up?*.

When the previous crop was soybean (3 trials), yield losses were found in every case (Fig. 1a), although the grower N rates were well above economic optimum N rates. We

Table 2. Agronomic, environmental and economic assessment of model performance. Values are average differences resulting from Adapt-N use (Adapt-N minus Grower-N treatment), such that a negative number indicates a decrease due to Adapt-N, a positive number indicates an increase due to Adapt-N. Profit calculations assume \$5.50/bu grain, \$50/T silage, and \$0.60/lb N.

Average Change due to Adapt-N Use in:		Corn grain	Corn grain	Silage
		after corn	after soy	corn
Average (Adapt-N - Grower-N)*	N fertilizer input (lb/ac)	-66	-107	-37
	Yield (grain: bu/ac; silage: T/ac)	-1	-14	0.3
	Simulated N leaching losses (lb/ac)	-39	-38	-11
	Simulated total N losses (lb/ac)	-52	-69	-19
	Profit (\$/ac)	\$34.74	-\$11.08	\$38.76

## Nutrient Management

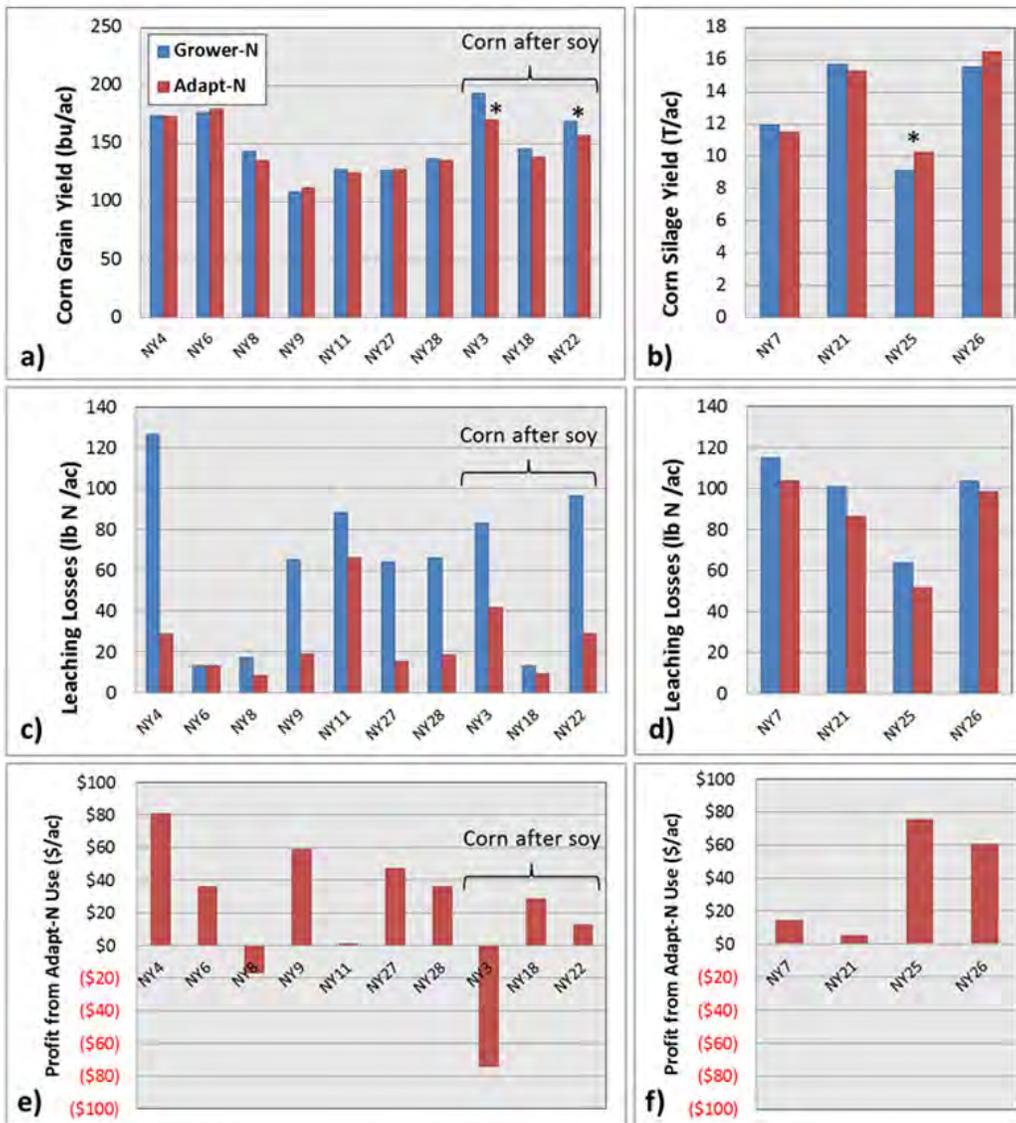


Figure 1. Yield and N leaching losses from Grower-N vs. Adapt-N treatments. Partial profit gain (positive) or loss (negative) from using the Adapt-N recommendation, relative to grower's current practices. (\*Yields were statistically different at  $p < 0.05$ )

determined that Adapt-N overestimated the soybean N contribution, and thus provided low N recommendations in these three cases. The 2011 version of Adapt-N used a flat 30 lb soybean N credit, but also simulated immobilization of N in stover in corn-after-corn rotations, effectively almost doubling the N credit for corn following soybean. We believe that part or all of the soybean 'N credit' should mostly be regarded as an absence of an immobilization penalty for corn-corn rotations. Changes will be made to the Adapt-N tool to reflect these findings for the 2012

growing season.

Estimated leaching losses (Fig. 1c & d), as well as total N losses (Table 2) decreased as a result of reduced N application rates for the Adapt-N treatment. On average, leaching losses decreased by 38 lb N/ac in grain trials, and by 11lb/ac in silage trials. There was less room for improvement in silage trials because lower fertilizer rates were used after manure applications.

Most trials resulted in profit gains from the use of Adapt-N, ranging from \$1 - \$80/acre, (Fig. 1e & f). Average profit gains were \$35/acre for corn after corn and \$39/acre for silage corn (Table 2). Corn after soybean trials registered an average loss of \$11/acre due to one trial with high yield loss (NY3). This was the only trial out of 14 (7%) where profit loss was significant. Fig. 2 indicates the low risk of profit loss (<14% overall before the correction of the soybean N credit), and high probability of improved profits (86%) of using Adapt-N in 2011.

Our data suggest that after minor adjustments of the Adapt-N tool, it will be even better equipped to give accurate recommendations. Growers who tend to use high amounts of nitrogen will realize large savings. In a much wetter year, increased profitability would come from appropriately applying more N at sidedress time in order to prevent yield reductions from N losses. In the long term we expect that environmental losses will decrease in both dry and wet years, because this tool provides strong incentives to shift N applications to sidedress time.

## Nutrient Management



Figure 2. Proportion of trials showing profit gains (green) or losses (red) as a result of using the Adapt-N recommendation compared to current grower N management. Profit calculations assume \$5.50/bu grain, \$50/T silage, and \$0.60/lb N.

### Conclusions

From beta-testing on commercial farms throughout NY State in 2011, we determined that the value of the Adapt-N tool was substantial. The tool was quite successful in adjusting for the effects of seasonal conditions to accurately recommend N fertilizer needs. Also,

- N application rates were significantly reduced (15 to 140 lb/acre).
- Grower profits increased on average by \$35/acre, except in corn after soybean (due to model inaccuracies that are being corrected for the 2012 growing season).
- N losses to the environment were decreased substantially (5 to 120 lb/acre).

Adjustments to the Adapt-N tool will improve ease of use and accuracy for the 2012 growing season. The Adapt-N tool and information about it is accessible to stakeholders through any device with internet access (desktop, laptop, smartphone, and tablet) at <http://adapt-n.cals.cornell.edu/>, where information on account setup is also available.

### Acknowledgements

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# Field-Scale Row Spacing by Seeding Rate Studies in Soybeans

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Crop  
Management

Soybean acreage continues to expand in New York with many first-time growers now planting the crop. Many new growers plant soybeans with a corn planter instead of a grain drill, which has been the almost exclusive planter for soybeans in NY over the last 30 years. Also, some experienced soybean growers, who no longer plant wheat, have switched to a corn planter to save on equipment costs. In addition, some growers are purchasing new row crop planters with inter-units allowing for corn planting in 30-inch rows and soybean planting in 15-inch rows. With that in mind, we conducted field-scale row spacing by seeding rate studies in 2010 and 2011 on farms in Cayuga and Livingston Counties to evaluate soybeans planted with a drill in 7.5 inch rows vs. planting with a row crop planter in 30-inch or 15-inch rows. The Cayuga County farm was a no-till site and the Livingston County farm was a chisel tillage site. The growers performed all management practices and we took numerous measurements, of which early stand counts and yield (with a Weigh Wagon) will be presented here.

Early stand establishment at Cayuga Co. averaged about 72% (107,287 plants/150,000 average seeding rate) for the drilled soybeans in 7.5 inch rows (Table 1). In contrast, early stand establishment averaged about 83% in 30-inch rows at Cayuga Co. Likewise, drilled soybean in 7.5 inch rows had much lower stand establishment at the Livingston Co. site. Drilled soybeans in 7.5 inch rows averaged 69% early stand establishment (103,645/150,000) compared to about 81% in 30 inch rows at the chisel tillage site. Apparently, under actual grower practices, stand

establishment is much better in 30-inch rows when planted with a corn planter compared with drilled beans in 7.5 inch rows.

Poorer stand establishment for drilled beans may partially explain the yield data from these field-scale studies. Previous small-plot research at the Aurora Research Farm in the mid-1990s and in the late 2000s indicated that drilled beans yielded anywhere from 7 to 15% greater than 30-inch beans planted with a corn planter. In these field-scale studies, however, row spacing did not affect soybeans at the no-till Aurora site. At the chisel tillage site, drilled beans yielded only about 4% greater than beans in 30-inch rows, if planted at 170,000 seeds/acre (Table 1). Some wheel traffic damage from post-emergence pesticide applications may also have damaged the drilled soybeans more than the 30-inch soybeans, which could have reduced any yield advantage for drilled or narrow row soybean.

## Conclusion

Row spacing had much less of an impact on soybean yield than expected in these field-scale studies. At a no-till site, row spacing did not affect yield. At a chisel tillage site, drilled soybean planted at 170,000 seeds/acre yielded about 4% more than 30-inch soybean at 130,000 seeds/acre. Apparently, growers can plant soybeans in 30-inch rows without much of a yield loss, especially in years or fields where yields are in the 50-65 bushel/acre range. At sites or in years where growth is slow and yields are low, the yield advantage for drilled soybeans may be greater than reported in this study.

Table 1. Row spacing and seeding rate effects on early stands (mid to late June) and yield of AG2002 soybean variety in field-scale studies on farms in Cayuga and Livingston Counties in NY, averaged across the 2010 and 2011 growing seasons.

SEEDING RATE (seeds/acre)	EARLY STAND ESTABLISHMENT (%)					
	Cayuga County			Livingston County		
	7.5"	15"	30"	7.5"	15"	30"
130,000	72	83	83	69	81	81
170,000	72	83	83	69	81	81
Average	72	83	83	69	81	81
130,000	72	83	83	69	81	81
170,000	72	83	83	69	81	81
Average	72	83	83	69	81	81

## Planting Soybeans....Should I Buy a Grain Drill?

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Soybean acreage has more than doubled in NY over the last decade. In 2000, NY growers planted about 135,000 acres of soybeans, but planted about 280,000 acres in both 2010 and 2011. More importantly, total annual value of soybeans has averaged about \$145 million over the last 2 years, almost 40% of the value of all commercial vegetable crops in NY, indicating that soybeans are no longer a minor crop. Increased acreage comes from a combination of long-time growers planting more acres and new growers adding soybeans to their rotation. Some new growers are from regions in NY where wheat is not in the rotation. Consequently, these new growers, who do not own a grain drill, are seeding soybeans with a standard row crop planter (30 inch rows). An obvious question is should these new growers purchase a grain drill or continue to seed soybeans with a corn planter in 30-inch rows?

We conducted **field scale** studies in 2010 and 2011 on cooperator farms in Central (Cayuga County) and Western New York (Livingston County) in order to investigate the effect of row spacing on soybean yield using actual grower management practices. The cooperating farmers performed all field operations including tillage, planting, chemical application and harvest. We used a Weigh Wagon to record yield and also took other measurements including stand counts, weed counts, lodging, plant height, disease incidence, and moisture at harvest. The Cayuga Co. farm was planted no-till in both years while the Livingston Co. farm was chisel plowed in both 2010 and 2011.

Economic analysis was conducted for costs associated with purchasing a grain drill appropriate for planting 300 acres

(15 ft. drill-list price \$20,000), 600 acres (20 ft. drill-list price \$25,500) and 1200 acres (30 ft. drill-list price \$46,000) of soybeans. The results are reported in real 2012 dollars, based on the average soybean price of \$11.50/ bushel and seed cost of \$52/ bag (150,000 seeds) in 2010 and 2011.

### Cayuga Co.

As reported in the previous article, there were no differences in yield among the three row spacing's (*What's Cropping Up?* vol. 22, No.2, p. 5). Consequently the grower at this location, who practices a corn-soybean-wheat rotation, can use either a no-till grain drill or row crop planter to plant soybean into high-residue corn conditions. If the grower switches to an exclusive corn-soybean rotation, the grower can continue to use the grain drill but not purchase a new drill once it requires replacement. Instead, the grower should only maintain a row crop planter without inter-units and plant corn and soybean in 30-inch rows.

### Livingston Co.

At this location we did see differences in yield. The drilled (7.5 in) soybeans at the recommended seeding rate of 170,000 seeds/acre showed a 2.4 bushel/acre or about a 4% yield advantage compared to 30-inch rows at a seeding rate of 130,000 seeds/acre (64.1 vs. 61.7 bushels/acre). For this farm that already owns a grain drill, the relative profit of drilling soybeans in 7.5 inch rows at the higher seeding rate compared to planting in 30 inch rows at the lower seeding rate would be a function of the market price received for the harvested soybean crop minus the seed cost associated with the higher seeding rate. So, if the

grower paid an average price of \$55/bag for seed and marketed the crop at \$11.50/bushel in the 2010 and 2011 growing seasons, the farmer at this site would have realized an increase in net farm profitability of about \$13.30/acre by planting with a grain drill (Table 1). If seed costs increase and prices received for the crop decrease in the future, profit will shrink (Table 1).

Table 1. The expected change in net farm profitability per acre at multiple market prices and seed costs of planting soybean in 7.5 inch rows at 170,000 seeds/acre vs. 30 inch rows at 130,000 seeds/acre. Values in the table are determined by multiplying the market price by the yield advantage (2.4 bushels/acre) and subtracting the product of the seed cost and additional seed (40,000 seeds/acre) needed for the higher seeding rate for the drilled soybeans.

		Seed cost (\$/ bag)								
		40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00
Market Price (\$/bushel)	10.00	13.60	12.30	11.00	9.70	8.40	7.10	5.80	4.50	3.20
	10.50	14.80	13.50	12.20	10.90	9.60	8.30	7.00	5.70	4.40
	11.00	16.00	14.70	13.40	12.10	10.80	9.50	8.20	6.90	5.60
	11.50	17.20	15.90	14.60	13.30	12.00	10.70	9.40	8.10	6.80
	12.00	18.40	17.10	15.80	14.50	13.20	11.90	10.60	9.30	8.00
	12.50	19.60	18.30	17.00	15.70	14.40	13.10	11.80	10.50	9.20
	13.00	20.80	19.50	18.20	16.90	15.60	14.30	13.00	11.70	10.40
			<b>Expected change in net farm income (\$/acre)</b>							

## Crop Management

For farms that do not own a grain drill, should they purchase one if there is a 2.4 bushel/acre yield advantage? We considered the annual fixed costs of owning a grain drill, including depreciation, interest, shelter and insurance. Likewise, we considered the annual variable costs of ownership, including repair costs, harvest and hauling costs and the cost of the extra seed (40,000/150,000 x \$52/bag = \$13.87/acre) needed to drill soybeans at 170,000 seeds/acre compared with 130,000 seeds/acre when planted with a corn planter. The breakeven point for purchasing a grain drill to seed soybeans based on prices and costs in 2010 and 2011 and a 2.4 bushel/acre yield advantage is around 300 acres. The grower would realize an increase in net farm profitability by purchasing a grain drill if planting 600 or 1200 acres of soybeans (Table 2). As expected the more soybean acres planted, the greater the increase in net farm profitability.

### Conclusion

Our economic analyses indicate, given 2010 and 2011 seed costs and market prices and a 2.4 bushel/acre yield advantage for drilled beans, growers who own a grain drill would have reaped a profit of about \$13-14/acre if seeding soybeans with a grain drill. For growers who don't own a grain drill, buying a grain drill would be profitable at 2010 and 2011 prices, if planting more than 300 acres of soybeans. On farms with less soybean acreage or no yield advantage, buying a grain drill does not provide an economic advantage. The net farm profitability, however, will vary significantly when the yield advantage for drilled soybeans, the price of soybean seed, and the price received by the farmer for their crop vary.

Table 2. Partial budget analyses for farms that produce 300 acres (15 ft. Grain Drill), 600 acres (20 ft. Grain Drill), and 1200 acres (30 ft. Grain Drill) of soybean annually in a corn-soybean rotation, based on added fixed (ownership) and variable (operating) costs when switching from planting soybeans in 30 inch rows with a corn planter to 7.5 inch rows with a drill at the average soybean market price (\$11.50/bushel) and soybean seed cost (\$52/bag) for the 2010 and 2011 growing seasons, and differential soybean production (2.4 bushel/acre yield advantage) from switching to 7.5 inch from 30 inch rows.

Partial Budget	300 acres	600 acres	1200 acres
<u>Income Change</u>			
Value of annual revenue difference	8,280	16,560	33,120
<u>Annual new equipment costs</u>			
Annual fixed costs			
Depreciation	1,714	2,185	3,942
Interest	700	892	1610
Insurance	170	216	391
Shelter	400	510	920
Annual variable costs			
Repairs	800	1,020	1,840
Seed cost	4,160	8,320	16,440
Harvest	348	695	1,390
Hauling	141	283	566
<u>Total annual new equipment costs</u>	8,433	14,121	27,099
<u>Expected change in annual net profit</u>	-153	2,439	6,021

## Nutrient Management

### A Case Study: Donald & Sons Farm Sees Money-Saving Potential in Adapt-N Tool for Corn N Rate Recommendations

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Growers across the country have used a wide range of methods to decide on nitrogen (N) application rates for corn, from mass balances to a variety of soil and plant tissue tests, to maximum return to nitrogen curves, to... simply... rules of thumb. But most are frustrated by the lack of accuracy of these methods. Early-season weather can greatly impact how much N fertilizer is needed year to year, and this variability has been difficult to manage. The amount of N fertilizer required could easily differ by 100 lbs from one year to the next. This variability results in average N recommendations that are higher than needed in many years, leading to profit loss for growers and environmental damage through N losses to water as nitrate and to the air as nitrous oxide, a potent greenhouse gas.

The web-based Adapt-N tool has the potential to change the way N management is done. Soil data, along with crop and soil management information are supplied by the grower. The Adapt-N tool uses these data in combination with newly available high-resolution climate data to simulate N availability and losses due to weather, and thus provide more accurate sidedress N recommendations. The tool is undergoing beta-testing in on-farm strip trials across New York and Iowa in the 2011 and 2012 growing seasons. Once fully validated, Adapt-N will, over the long term, help reduce N losses to the environment that contribute to air and water pollution, while saving farmers money through the optimization of fertilizer purchases and application rates.

One of the New York agricultural enterprises collaborating with the Adapt-N team is Donald and Sons Farm located in Moravia, NY. The farm has been in the family for several generations and currently encompasses 1500



Robert Donald with his soil sampling cart equipped with RTK-GPS, used for soil sampling by management unit.

acres of land. In 2011, 1050 acres were in corn and 250 in soybeans.

The Donald brothers, Robert and Rodney, are no strangers to on-farm research and have collaborated with Cornell University and private companies many times over the years. When asked why they keep getting involved in research Rodney replied, "Money! Some [projects] take you down a dead end street, but if we see, for example, that we can save putting 100 lbs [of N] on, that's a lot of money." So, although the on-farm research can be time consuming for Robert and Rodney, they see the value in the important benefits it can generate.

The Donald brothers' acreage varies greatly in soil type, and organic matter contents range from about 1 to 5%. The farm currently bases its N application rates on recommendations from A&L Great Lakes Laboratories, generated based on soil tests by management unit. Robert and Rodney practice variable rate application, taking advantage of their RTK-GPS system for soil sampling, input application and yield monitoring. The bulk of their fertilizer N application occurs at sidedress time, as they have found that early season applications run the risk of losses during wet springs. They experimented for a few years with putting anhydrous ammonia on at preplant, and considered slow-release and inhibitor technology, but decided to return to sidedressing. The amount the Donalds spend on N fertilizer has nearly quadrupled since 2000, and in 2011 they spent \$107,000 – a strong incentive for them to seek new tools to help optimize application rates. As Rodney puts it, "money

## Nutrient Management

talks ... and with what we are getting in corn for what we are putting on in ammonia, we're not gaining."

This past spring, Robert and Rodney identified 10 acres of a 100-acre field to implement a replicated strip trial to test the Adapt-N tool. The field was planted with corn on May 21st with 22lbs of N from monoammonium phosphate starter. In early June, Keith Severson of Cayuga Cooperative Extension used Adapt-N, inputting the Donald brothers' field information, such as organic matter content, expected yield, tillage, fertilizer inputs, etc., to generate an N sidedress recommendation of 80 lb N/acre.

When asked what he thought when he heard of the 80 lb recommendation, Rodney said, "it was hard for me to chew on 80. ... It was a little hard for me to chew on!" On June 19th, two sidedress treatments were applied in eight, 16-row-wide strips. Four of the strips received the standard N rate based on the recommendation from A&L labs, which was 220 lbs, and the remaining 4 strips received the Adapt-N rate of 80 lbs. Throughout the growing season, the brothers still felt very unsure about the low Adapt-N rate compared to their usual practice. They kept their eyes on the field after sidedressing, taking note that the Adapt-N strips appeared to be a lighter shade of green. "We thought, uh oh, this is going to be a blow, here we go."

However, as the season came to a close the results indicated otherwise. There was no loss in yield despite the 140 lb application rate difference. The Donald's yield monitor data showed spot-yields between about 120 and 230 bu/ac. The average yields for the conventional plots

were 174.1 bu/ac, while Adapt-N average yield was 173.6 bu/ac. Robert and Rodney were shocked by the results stating, "it wasn't until we were combining that we realized the yield wasn't really different even though there was a 140 lb N difference [in sidedress rate]".

The results show great promise for the Adapt-N tool and for the Donald brothers' ability to save on N fertilizer. Assuming that the trial field was fairly representative of the rest of the farm, the Donalds would have saved approximately \$70,000 in fertilizer in 2011. A post-season Adapt-N simulation estimated that they had also reduced their N leaching losses in 2011 by about 77%, from 142 to 32 lbs/ac.

Robert and Rodney intend to collaborate on more extensive testing of the Adapt-N tool next year and see whether different weather conditions affect the recommendations. In addition to another fully replicated strip trial, they may use variable-rate recommendations provided by Adapt-N in strips next to those provided by A&L Laboratories on multiple fields. When discussing variable rate application with the brothers, using rates with drastically higher N amounts than needed by the crop was likened to "aiming for the bull's eye in the opposite direction of the target," to which Rodney laughingly replied, "I've been doing that all my life." Variable rate application using Adapt-N should allow for a more accurate AND precise accounting of the effects of organic matter-derived N and texture in interaction with that year's weather on overall N availability.

Overall the trial suggests that more accurate N recommendations based on weather impacts, in addition to soil and management information, could lead to substantially higher profits for farmers, while reducing environmental losses in most years. This creates a win-win situation as farmers face higher costs for fertilizer and we search for feasible and effective ways to reduce detrimental losses to the environment.

### Acknowledgements

This work was supported by grants from the NY Farm Viability Institute and the USDA-NRCS. Thank you to Robert and Rodney Donald for their cooperation in diligently implementing this trial, and taking the time to share their thoughts. For more information about the Adapt-N tool, visit <http://adapt-n.cals.cornell.edu/>.



Taking a look at Robert and Rodney's current variable rate application recommendations.

## Weed Management

# Life Cycles Affect Timing of Thistle Control in Grass Pastures

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Two thistles common to New York State are bull thistle (*Cirsium vulgare*) and Canada thistle (*Cirsium arvense*). Both were introduced from Eurasia and became naturalized in Canada and the United States. Although closely related and somewhat similar in appearance, these thistles exhibit some differences in form and have very different life cycles. These life cycle differences play an important role in timing of control measures.

### Bull Thistle

Bull thistle is a biennial weed that reproduces by seed only. All biennials require two growing seasons to complete their life cycle. In the first year, bull thistle germinates from seed and forms a rosette or basal cluster of leaves (see photo) with a large fleshy taproot. After overwintering in this stage, the plants complete their life cycle by forming a flowering stalk and setting seed during the second growing season. The stems of bull thistle may be 3 to 6 feet tall, are often branched, and are more or less hairy. The leaves are deeply cut, spiny, and run down the stem (Figure 1). Deep purple or rose flower heads are formed during the



Bull Thistle (photo R. R. Hahn)

second growing season. These heads are 1 to 2 inches in diameter and are surrounded by numerous spiny tipped bracts. Bull thistle is found in pastures, meadows, and waste areas. Although it is an aggressive weed in these situations, it does not survive in tilled fields.

### Canada Thistle

Canada thistle is a perennial weed that reproduces by seeds and horizontal roots. These roots extend several feet deep, some distance horizontally (Figure 2), and allow individual plants to live for more than two years. Canada thistle stems are grooved and are 2 to 5 feet tall with branching only at the top. The stems are somewhat hairy when mature. The leaves are smooth, somewhat lobed, and usually have crinkled edges and spiny margins (see photo). The flower heads are numerous, compact, and are borne in clusters. The lavender heads are  $\frac{3}{4}$  inch or less in diameter. Male and female flowers are usually in separate heads and on different plants. As a result, some patches of this weed never produce seed. Canada thistle is found throughout the northern half of the United States. Like bull thistle, it can be problematic in pastures, meadows, and waste areas. In addition, its' perennial nature allows it to thrive in cropland as well.

### Control Recommendations

Both of these thistles are somewhat sensitive to growth regulator herbicides (synthetic auxin/Group 4 herbicides) such as 2,4-D and Banvel/Clarity. These readily translocated herbicides are recommended for control or suppression of both species in grass pastures, however application rates and timing differ.

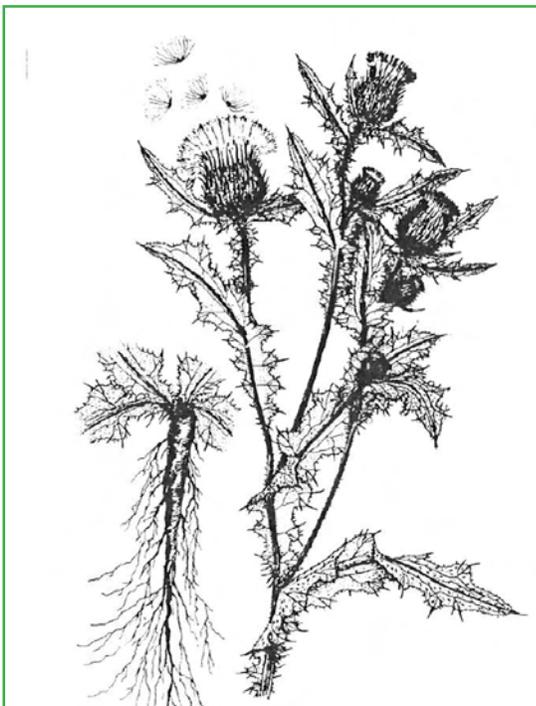


Figure 1. Bull Thistle. (Illustration Agriculture Handbook No. 366, "Selected Weeds of the United States". 1970. Agriculture Research Service, USDA )

## Weed Management

For bull thistle control, application of 3 pt/A of 2,4-D (3.8 lb/gal formulation) or 1 pt/A of Banvel or Clarity to the rosette stage in fall or early spring before the plants send up the flower stalk is recommended. For Canada thistle, the ideal timing would be during periods of active growth after weeds have reached the bud stage in mid- to late summer, but before killing frost. At this time, the plants have maximum leaf area to absorb herbicides and begin moving carbohydrates into the rootstocks. These stored carbohydrates allow the plants to survive winter and emerge again in the spring. Herbicide movement into these rootstocks is facilitated by this process. Application of 4 pt/A of 2,4-D (3.8 lb/gal formulation) or of 2 pt/A of Banvel or Clarity are recommended for Canada thistle suppression in grass pastures. Repeated applications of these herbicides would likely be needed to bring this tough weed under control.

### Grazing Restrictions

With both 2,4-D and Banvel/Clarity, label instructions specify grazing and harvesting restrictions for pasture situations. Lactating dairy animals should not graze 2,4-D



Canada Thistle (photo R. R. Hahn)

treated areas for 7 days following application and meat animals must be removed from 2,4-D treated areas for 3 days before slaughter if less than 14 days have elapsed since treatment. Lactating dairy animals should not graze for 7 days after treatment with up to 1 pt/A, and for 21 days after 2 pt/A of Banvel or Clarity. Meat animals should be removed from areas treated with Banvel or Clarity 30 days before slaughter. Applications made at the end of the grazing season in late summer or early fall can minimize concerns about these grazing restrictions.

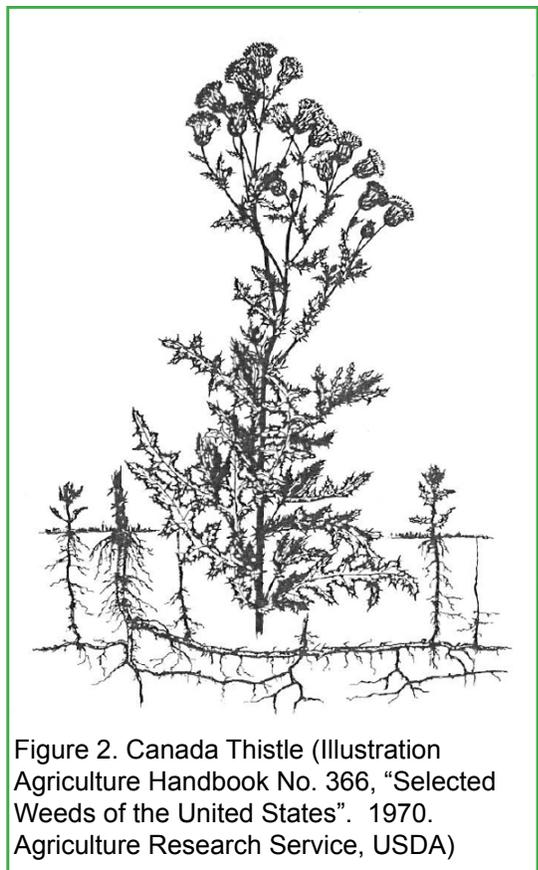


Figure 2. Canada Thistle (Illustration Agriculture Handbook No. 366, "Selected Weeds of the United States". 1970. Agriculture Research Service, USDA)

## Sulfur for Alfalfa in New York State

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### Introduction

Following the passing of the Clean Air Act in 1970 and the introduction of sulfur (S)-free phosphorus fertilizer and pesticides, incidental addition of S to fields through atmospheric deposition (from powerplant discharges and other sources) and fertilizer application has decreased drastically in New York. For example, total S deposition at the Aurora Research Farm was estimated to be 14 lbs/acre in 1979-1981 versus 6 lbs/acre in 2008. Sulfur is an essential plant nutrient for processes such as photosynthesis and nitrogen (N) fixation. Therefore, it is important to re-evaluate S needs for crops like alfalfa, which removes an estimated 5 lbs S/ton of hay (DairyOne Forage Laboratory, 2010). Soil organic matter mineralization, crop residue and manure addition can all supply S. In past NY studies (Klausner et al., 1982; 1984), S supply from organic sources and S deposition was sufficient to meet alfalfa S requirements but current deposition data indicate that S removal by an average alfalfa crop now exceeds S deposition at all 11 weather monitoring locations in the state (NADP/NTN, 2010), raising the question whether soil S supply alone can meet crop S demands, especially for light textured, low organic matter soils with limited S supplying capacity.

Tissue testing has been the preferred tool for determining S deficiencies. It is commonly accepted that 0.25-0.50% S in the top 6 inches of the alfalfa plants at late bud to early blooming is optimal. This means the critical tissue S level below which a deficiency is expected is 0.25%. Some laboratories offer a soil S test as an additional test if requested by growers. However, both laboratory and field research were needed to determine the effectiveness of these tests in determining S availability across the wide range of soils in New York State.

Laboratory and field studies were conducted to determine (1) the accuracy and effectiveness of six different soil S extraction methods in detecting S fertilizer addition; (2) the difference in soil test S as impacted by laboratory equipment use (ICP-AES versus turbidimetric-spectroscopy); (3) effectiveness of tissue S testing in determining S deficiency; and (4) impact of S addition on alfalfa yield.

### How was the research conducted?

#### **Part 1: soil testing methodologies**

Four NY soils were incubated in a growth chamber with one of six S application rates (0, 25, 50, 75, 100 and 150 lbs S/acre) applied as CaSO<sub>4</sub> (gypsum). Samples were

incubated in the dark for four weeks at room temperature and water was added weekly to maintain moisture content of 60 to 75% of field capacity throughout the incubation. Samples were remixed 14 d after initiation of the incubation to stimulate aeration and ensure thorough contact between the soil and the gypsum. After the 4-wk incubation, samples were oven-dried and ground to pass 2 mm and analyzed for extractable S using six extracting solutions: (1) 1.0 M ammonium acetate (Vendrell et al., 1990); (2) 0.016 M potassium phosphate (Jones et al., 1972); (3) 0.01 M monocalcium phosphate (Schulte and Eik, 1988); (4) 0.01 M calcium chloride (Williams and Steinberg, 1959), (5) Morgan sodium acetate (Morgan, 1941); and (6) Mehlich-3, a mixture of acetate, ammonium-nitrate, ammonium fluoride, nitric acid and EDTA (Mehlich, 1984). The four soil types were: Adams, Knickerbocker, Sunapee and Stafford.

#### **Part 2: Alfalfa response to S addition**

An eight farm comparison of yield and quality of alfalfa with and without S fertilizer was conducted to evaluate the effects of a single S fertilizer application on alfalfa yield, residual S, and the effectiveness of soil and tissue testing in identifying S responsiveness over a 2-yr period. The farms included four in northern NY (sites 1 through 4), and one each in central (site 5), eastern (site 6), southern (site 7), and western NY (site 8). The locations were selected to include at least four S deficient sites (based on tissue testing). Treatments included a no-S control and two S sources (CaSO<sub>4</sub> and K<sub>2</sub>SO<sub>4</sub>·2MgSO<sub>4</sub>), both applied at 150 lbs S/acre. The two S sources were chosen (1) to separate a Ca, Mg or K response from an S response; and (2) to be consistent with similar NY trials conducted by Klausner in 1981-1983. The S rates were high to assess residual effects of the fertilizer application in the second year after application, addressing the question if a single S application can benefit alfalfa for up to two years. Each field trial was conducted in four replications. The treatments were applied directly after the 1st cutting. One field (site 3) received an (accidental) liquid manure application on 10 June 2009, after the 1st cutting. No manure was applied to any of the other locations. Soil samples were taken prior to S addition, after the final cutting of the season in 2008 (the 3rd or 4th cutting), at green-up (end of March or early April) in 2009, and at the 3rd and final cutting (August or early September) in 2009. Soils were analyzed for CaCl<sub>2</sub> extractable S (the test that was most promising as a predictor for S availability in the incubation study). Tissue samples (top 6 inches) were taken on the same day as the 3rd cutting in both years, and consisted of sampling 30-35 individual plants within the plot (treatment) area but just

# Nutrient Management

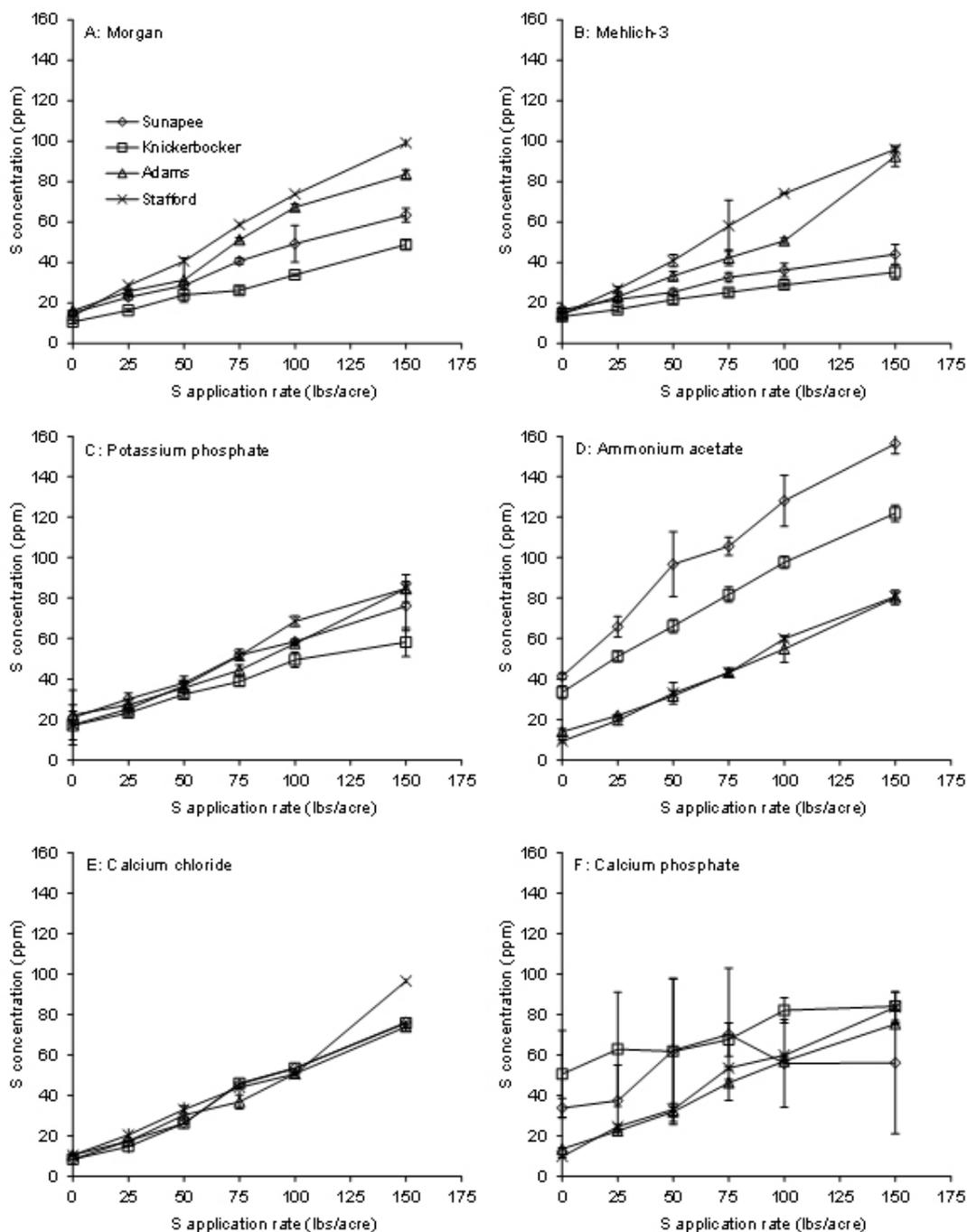


Figure 1: Relationship of the mean and standard deviation (n=4) of S concentration obtained by six different extracting methods with inductively-coupled plasma atomic emission spectroscopy (ICP-AES) detection of S in solution. Sulfur was applied as  $\text{CaSO}_4$  to four different soils. Adapted from Ketterings et al. (2011).

# Nutrient Management

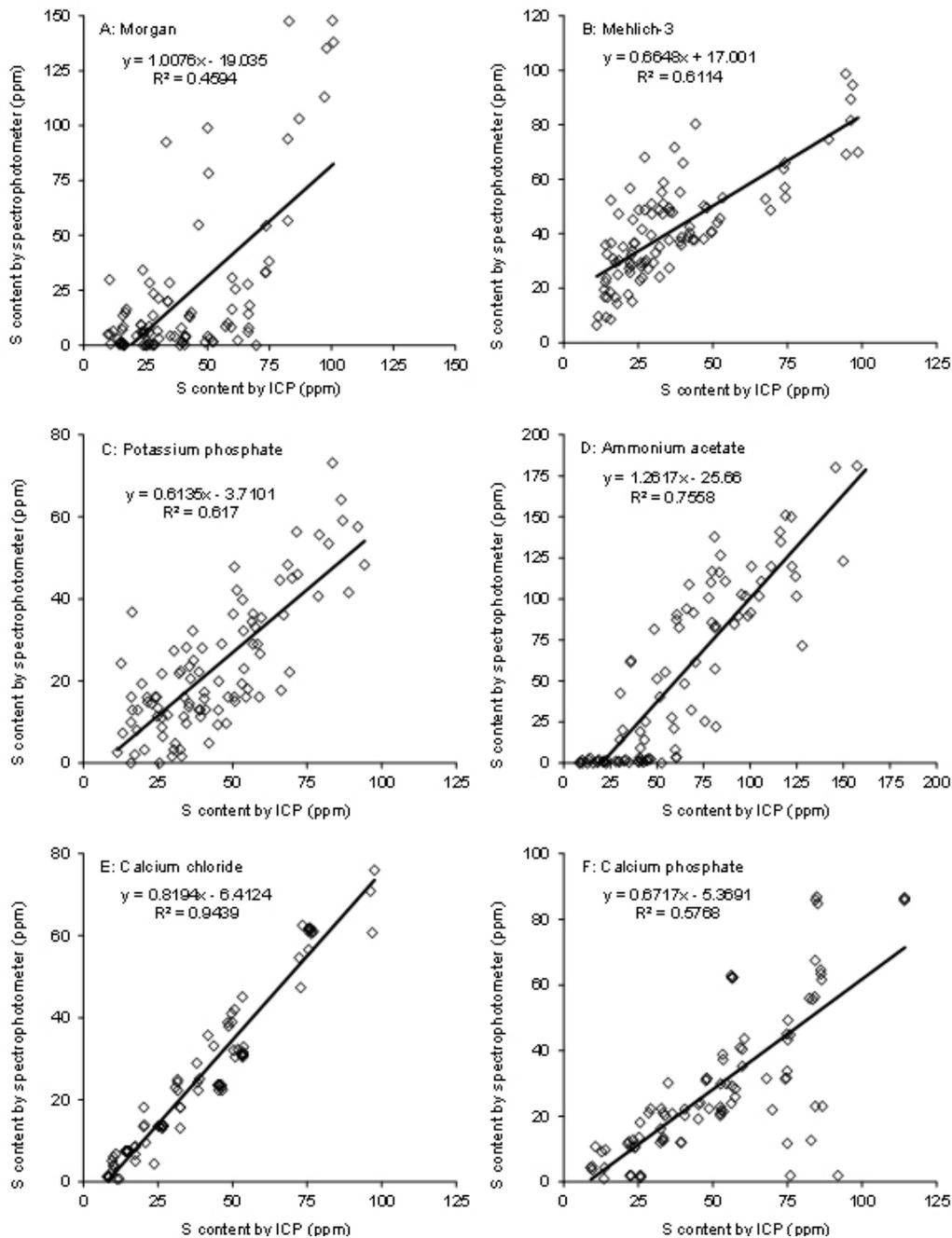


Figure 2: Comparison of S concentration in six different extraction solutions determined with inductively-coupled plasma atomic emission spectroscopy (ICP-AES) versus turbidimetric (TS) determination of S in the extraction solution. Adapted from Ketterings et al. (2011).

## Nutrient Management

Table 1: Alfalfa yield as impacted by S addition. The 2008 yields are for 2nd and 3rd cutting only. In 2009, no additional S was applied and yields represent season yields.

Site	Treatment	2008	2009
		(sulfur added)	(no additional sulfur)
----- Tons DM/acre -----			
1 Essex County	Control	1.37 b	3.15 a
	Plus S	1.72 a	3.54 a
2 St. Lawrence County # 1	Control	2.07 b	2.97 a
	Plus S	2.41 a	3.04 a
3 Lewis County	Control	2.72 a	3.95 a
	Plus S	2.63 a	4.00 a
4 St. Lawrence County # 2	Control	2.50 a	3.21 a
	Plus S	2.55 a	3.49 a
5 Cayuga County	Control	3.79 b	5.68 b
	Plus S	4.44 a	7.08 a
6 Columbia County	Control	3.02 a	4.44 a
	Plus S	2.86 a	4.44 a
7 Steuben County	Control	2.29 a	1.80 a
	Plus S	2.44 a	1.76 a
8 Wayne County	Control	2.67 b	2.26 a
	Plus S	2.97 a	2.14 a

outside the actual harvest area. Forage subsamples were taken at each cutting to determine moisture content and forage quality parameters. All forage analyses were done at Cumberland Valley Analytical Services, Inc. in Hagerstown, MD. Plant tissue analyses were performed at Brookside Laboratories Inc. in New Knoxville, OH.

### Results and Discussion

#### Part 1: soil testing methodologies

Although each of the extraction and detection methods resulted in an increase in extractable S with S addition, the 0.01 M CaCl<sub>2</sub> extraction with ICP-AES detection of S in solution showed the most promise as a soil test for S: this method was best correlated with S added across all four soils and showed the greatest increase in soil test S per lb of S applied (Fig. 1), and it was the only test that showed good consistency between the two detection methods (Fig. 2).

#### Part 2: Alfalfa response to S addition

Of the eight sites, four (sites 1, 2, 5, and 8) had a relative yield less than 95% and a significant yield response to S fertilization during the 2008 growing season (Table 1). Averaged across these four locations, S fertilization increased yield by 17%. The highest yield and the greatest response to S were measured in central NY (site 5). This was also the only location where residual S resulted in

a significant yield increase (a 25% increase) in 2009. Excluding sites 6 and 7, two locations with a suboptimal pH and high field variability, yield and tissue data from 2008 indicate a critical tissue S level of 0.27% S is needed to produce a 95% relative yield (Fig. 3A), similar to the 0.25% S critical value commonly reported.

Initial soil test S concentrations at the 8 test sites ranged from 3 to 26 ppm S (Fig. 3B). Sulfur fertilization increased the average soil test S

(all locations) from 8 to 27 ppm S measured at 3rd cutting. Excluding the two locations with suboptimal pH (sites 6 and 7), the critical soil test S level needed to produce 95% relative yield without S fertilization was 8 ppm CaCl<sub>2</sub> extractable S (Fig. 3B).

An accidental manure application at site 3 resulted in elevated soil test S suggesting manure addition is an effective way to increase S levels. For plots that had been fertilized with S, soil S in the spring of 2009 was 38-85% lower than levels measured at 3rd cutting in 2008, supporting the hypothesis that there is limited carryover of fertilizer S into the following year.

### Conclusions

Given the drastic decrease in S deposition since the 1980's, it is not surprising that four of the eight locations in the current study showed a significant yield increase to S fertilization. Most likely candidates for S deficiency are coarse-textured, low organic matter sites with no manure applied in recent years. Both tissue and soil testing for S were effective in predicting an alfalfa yield increase from S fertilization for the sites in this study. The data support a critical tissue S level of 0.27% S for samples taken at the 3rd cutting (top 6 inches of the plant). The soil test data suggest a critical level of 8 ppm S (with 0.01 mol/L CaCl<sub>2</sub>

## Nutrient Management

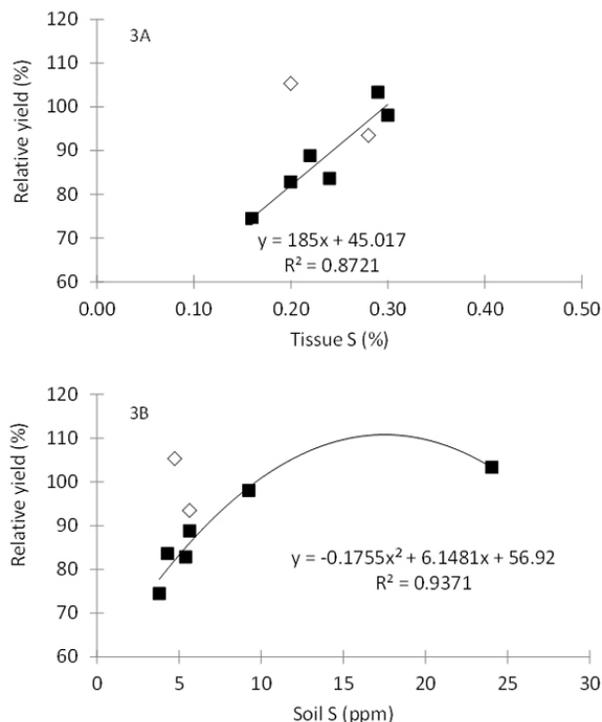


Figure 3: Tissue S content (A) and 0.01 mol L<sup>-1</sup> CaCl<sub>2</sub> extractable soil S (B) as predictors for relative yield of alfalfa (the ratio of yield without and yield with the addition of 150 lbs S/acre). The open diamonds indicate two locations with suboptimal pH (6.2 or lower). Adapted from Ketterings et al. (2012).

extractable S, 0-8 inch soil samples) with samples taken at 1st cutting. Manured fields are not likely to be S responsive in the year of manure application. Deficiencies could occur if no manure has been applied in the past couple of years. More site-years of S response studies, covering a wider diversity of soils, field histories, and climatic conditions, are needed to fully test the utility of soil and tissue testing for S management of alfalfa.

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# Trial Results for Manure Injection at Table Rock Farm

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## Nutrient Management

### Introduction

Due to increasing nitrogen (N) fertilizer costs as well as high energy costs there has been greater interest in finding more economic and environmentally sound ways to incorporate spring-applied manure. At Table Rock Farm in Castle, NY, manure injection studies were conducted to determine the impact of injection versus aerator incorporation and to compare different spring injection rates on corn production. Previous work indicated that shallow mixing of manure and soil (with an aerator) in reduced till systems has the potential to reduce fertilizer use, fuel cost and equipment costs, as compared to more aggressive chisel incorporation, while conserving the same amount of nitrogen (N) as chisel plowing (Lawrence et al., 2007; Place et al., 2010). At Table Rock Farm we compared (1) direct injection with aerator incorporation (shallow mixing) and surface application of manure (2008-2009), and (2) three manure incorporation rates (2010-2011).

### How was the research conducted?

Baseline soil fertility samples were taken for each plot (15 cores per plot) in early spring, prior to manure application. Soil samples were analyzed for pH, organic matter, and Morgan extractable P, K, Ca, Mg, Zn, Mn, and Al at the Cornell Nutrient Analysis Laboratory.

For the trials in 2008 and 2009 (repeated on the same field), manure was applied at a rate of 9,000 gallons per acre using (1) injection (8 inches), (2) aerator incorporation directly after manure application (implement set at maximum angle), and (3) surface application without incorporation. Manure sampling was done on the field directly from the manure spreader at the time of application. Samples were analyzed for total N, ammonia N, and total P and K, solids and density (Table 1). Per standard procedure, organic N was determined as the difference between total N and ammonia N. For the years 2008-2011, spring injection of 9,000 gallons/acre gives estimated available N rates of 123, 100, 112, and 79 lbs N/acre, respectively (Table 1).

At planting, the plots were soil-sampled again for general soil fertility (Table 2). No starter fertilizer was used at planting based on earlier research that showed manure could replace the need for starter N. Planting took place within a day after zone building (30 inch spacing, 14 inches deep) and aerator plus rolling basket land preparation. There was typically a week between manure injection and zone building to allow fields to dry prior to zone building and planting. Each plot was soil sampled at sidedress time and again at harvest. At sidedress time soil samples

Table 1: Manure composition in each of the four years of trials at Table Rock Farm.

	Total nitrogen	Ammonia nitrogen	Organic nitrogen	Phosphate equivalent	Potash equivalent	Total Solids	Density	Available with 9,000 gallons/acre		
	N	N	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O			N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	----- lbs/1000 gallons -----					%	lbs/gallon	----- lbs/acre -----		
2008	26.6	14.5	12.1	6.5	25.1	9.1	8.4	123	59	226
2009	20.2	13.6	6.6	8.3	21.8	9.1	8.4	100	75	196
2010	24.7	12.9	11.7	8.7	22.3	9.4	8.4	112	78	201
2011	15.9	10.8	5.1	6.5	18.3	5.6	8.4	79	59	165

Table 2. Initial soil fertility status (0-8 inch depth).

Field		pH	OM	ISNT-N	P	K	Mg	Ca	Al	Mn	Zn				
			%	ppm	----- lbs/acre -----										
500	2008	7.1	7.1	449	O	52	VH	255	VH	708	VH	5197	20	27	3.4
500	2009	6.8	6.8	477	O	55	VH	359	VH	761	VH	5911	22	26	4.3
A JAK 9	2010	7.1	4.9	382	O	78	VH	451	VH	440	VH	4966	18	21	3.0
B JAK10	2010	7.1	4.6	334	M	66	VH	432	VH	439	VH	4519	20	32	3.2
C Weiss1	2011	6.5	3.5	260	D	25	H	340	VH	269	VH	3060	26	39	1.5

Soils were analyzed for pH, organic matter (OM) by loss-on-ignition, Morgan extractable P, K, Mg, Ca, Al, Mn, and Zn. The soils were Mardin and Volusia channery silt loams (2008-2009), Bath channery silt loam (67%) with the remainder Mardin channery silt loam (2010), and Bath channery silt loam (2011). For ISNT interpretations: O = Optimal (no response to extra N fertilizer), M = marginal, D is deficient (i.e. soil organic N supply is insufficient).

## Nutrient Management

Table 3: Stand density, corn yield and moisture as impacted by manure application method.

Year	Treatment	Stand density at sidedress time	Corn silage yield (35% DM)	Moisture content at harvest
		plant/acre	tons/acre	%
2008	Surface	30,574 a	22.4 b	68.2 a
	Aerway incorporation	28,428 a	22.9 b	68.3 a
	Direct injection	30,538 a	27.0 a	67.9 a
2009	Surface	33,019 a	13.7 b	64.1 a
	Aerway incorporation	33,219 a	14.1 b	64.4 a
	Direct injection	32,612 a	18.2 a	63.7 a

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

Table 4: Forage quality at harvest as impacted by manure application method.

Treatment	Milk per acre	Milk per ton	Crude Protein	Soluble Protein	NDF	dNDF	Lignin	Starch
	lbs/acre	lbs/ton	-----% of DM -----					
2008								
Surface	29,126 b	3,722 a	6.3 a	1.7 a	38.4 a	71.1 a	2.7 a	36.9 a
Aerator incorporation	29,774 b	3,660 a	6.3 a	1.7 a	39.1 a	71.5 a	2.7 a	35.9 a
Direct injection	34,515 a	3,651 a	6.5 a	1.8 a	38.2 a	67.7 b	2.8 a	36.8 a
2009								
Surface	17,809 b	3,721 a	6.3 a	1.6 a	38.2 a	73.3 a	2.1 a	42.3 a
Aerator incorporation	18,327 b	3,716 a	6.1 ab	1.6 a	38.0 a	72.6 a	2.1 a	42.5 a
Direct injection	23,388 a	3,684 a	5.8 b	1.5 a	39.0 a	69.8 a	2.2 a	42.6 a

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

Table 5: Illinois Soil Nitrogen Test (ISNT) (0-8 inch), Pre-Sidedress Nitrogen Test (PSNT) (0-12 inch), and Corn Stalk Nitrate Test (CSNT) as impacted by manure application method.

Year	Treatment	Sidedress time			Harvest time		
		ISNT-N	PSNT-N	CSNT	ISNT-N	PSNT-N	CSNT
-----ppm -----							
2008	Surface	469 a	O	56 b	S	292 a	M
	Aerway incorporation	428 b	O	67 ab	S	333 a	M
	Direct injection	450 ab	O	84 a	S	1464 a	O
2009	Surface	505 a	O	33 b	S	143 a	L
	Aerway incorporation	447 a	O	44 b	S	156 a	L
	Direct injection	480 a	O	84 a	S	113 a	L

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

were also analyzed for the Illinois Soil Nitrogen Test (ISNT; 8 inch samples) and the Pre-sidedress Nitrate Test (PSNT; 12 inch samples). Mid-season stand counts were taken in two representative 40 ft sections per plot along with row length measurements to determine the stand density. At harvest, we took Corn Stalk Nitrate Test (CSNT) samples, forage samples, and determined corn silage plot yield weights for each treatment. A forage subsample was taken from each plot and

dried to determine moisture content and forage quality.

In 2010 and 2011, three identical trials (three different fields) were conducted to evaluate the impact of manure application rate (spring injection) on corn silage yield, quality, and environmental indicators (soil nitrate, ISNT, P, and K) and CSNT results. The objective of this second study was to determine if 9,000 gallons/acre spring incorporation was sufficient or if a higher rate (12,000 or 15,000 gallons/acre) was needed to support optimum corn silage yield. Field operations were identical to those in the 2008-2009 application method studies (zone building, aerator plus rolling basket, and planting within a day of zone building).

### Results

#### Manure Application Method

In 2008 and 2009, there was a significant yield response of about 4 tons/acre to injection of 9,000 gallons/acre manure as compared to surface application or aerator incorporation (Table 3) while stand density and moisture content at harvest were not impacted by application method.

Forage NDF, lignin and starch were not impacted by manure

Table 6: Nitrogen balances and indicators (Pre-Sidedress Nitrogen Test (PSNT) (0-12 inch), and Corn Stalk Nitrate Test (CSNT)) as impacted by manure application method.

Year	Treatment	Yield	N uptake	N supply	N difference	PSNT	CSNT
		ton/acre	lbs/acre	lbs/acre	lbs/acre	ppm	ppm
2008	Surface	22.4 b	158	38	-120	56 b	292 a
	Aerator incorporation	22.9 b	162	123	-39	67 ab	333 a
	Direct injection	27.0 a	197	123	-74	84 a	1464 a
2009	Surface	13.7 b	97	34	-63	33 b	143 a
	Aerator incorporation	14.1 b	96	100	4	44 b	156 a
	Direct injection	18.2 a	118	100	-18	84 a	113 a

## Nutrient Management

Table 7. Stand density at sidedress time, percent moisture content and yield as influenced by rate of spring injected manure. A P-value >0.05 indicates that there is no significant difference among the treatments (manure rates).

Field	Manure rate	Stand density	Moisture at harvest	Corn yield (at 35% DM)
	gallons/acre	plants/acre	%	tons/acre
A (JAK9)	9,000	31,172 a	57.6 a	29.0 a
	12,000	30,873 a	57.9 a	27.8 a
	15,000	31,514 a	57.8 a	29.4 a
B (JAK10)	9,000	31,001 a	55.9 a	27.2 a
	12,000	31,113 a	55.6 a	28.4 a
	15,000	30,883 a	57.3 a	28.4 a
C (Weiss1)	9,000	32,344 a	65.4 a	26.0 a
	12,000	31,581 a	65.2 a	28.6 a
	15,000	32,670 a	65.7 a	28.5 a
Average all fields	9,000	31,505 a	59.6 a	27.4 a
	12,000	31,189 a	59.6 a	28.3 a
	15,000	31,689 a	60.2 a	28.8 a

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

Table 8. Cornell Morgan soil test nitrate (NO<sub>3</sub>-) (0-8 and 0-12 inch depth and PSNT) and CSNT as influenced by rate of spring injected manure. A PSNT > 21 ppm indicates no additional N is needed. A CSNT is optimum if between 750 and 2000 ppm, marginal if 250-750 ppm.

Field	Rate	--Pre-Application--	--PSNT--	---At Harvest---	CSNT
	gallons/acre	0-12 inches	0-12 inches	0-12 inches	
		ppm	ppm	ppm	ppm
A (JAK9)	9,000	11.0 a	58.3 a	17.4 a	599 b M
	12,000	11.5 a	66.9 a	18.9 a	1,821 ab O
	15,000	12.2 a	73.5 a	23.7 a	3,952 a E
B (JAK10)	9,000	10.2 a	40.4 b	16.0 a	1,569 a O
	12,000	7.6 a	54.1 b	19.1 a	1,713 a O
	15,000	9.6 a	86.4 a	20.9 a	2,724 a E
C (Weiss1)	9,000	3.9 a	54.3 a	19.9 b	878 b O
	12,000	3.6 a	57.6 a	32.1 a	3,802 a E
	15,000	4.0 a	51.2 a	26.1 ab	4,430 a E
Average all fields	9,000	8.4 a	52.1 b	17.8 b	1,016 b O
	12,000	7.6 a	59.5 ab	23.4 a	2,445 a E
	15,000	8.6 a	70.4 a	23.6 a	3,702 a E

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

application method (Table 4). However, injection led to a decrease in crude protein in 2009. Overall estimated milk yield per ton of silage was not impacted and the difference in milk per acre was a result of yield differences for both the 2008 and 2009 seasons (Table 4).

The ISNT results, together with organic matter estimates, indicated that no additional N was needed beyond what the soil was expected to supply in a good growing season (Table 2 and 5). The PSNT results reflect high N

availability as well especially in the injection treatment (84 ppm nitrate N). This could mean higher N conservation with injection of manure and/or be a reflection of sampling within the injection zone as at sidedress time it is not possible to determine where injection took place, raising questions about sampling protocols for PSNT in reduced till and manure injection systems.

Despite high PSNTs and ISNTs, 2009 yields were low and CSNTs were low too. The combination of low yield and high PSNT (in addition to high ISNT) indicates

## Nutrient Management

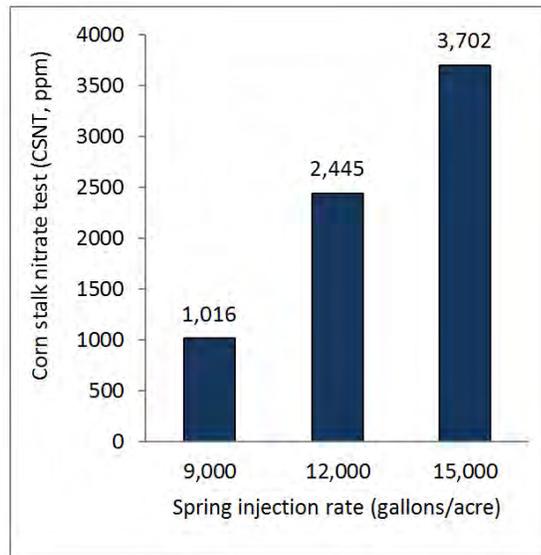


Figure 1: Corn stalk nitrate test as impacted by manure injection rate (3-site average).

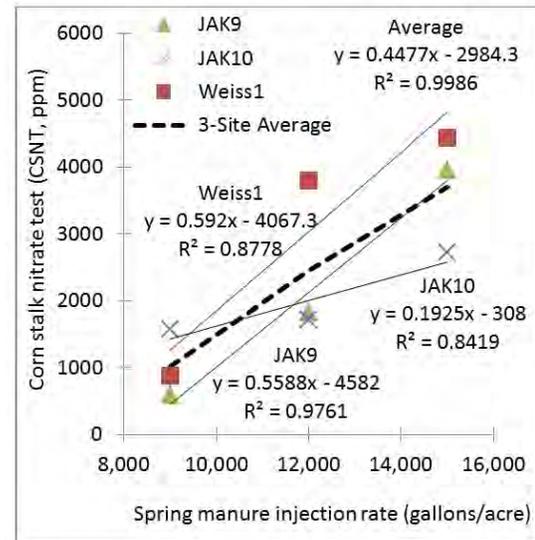


Figure 2: Corn stalk nitrate test results for all three sites (2010 and 2011 growing season).

Table 9: Corn silage crude protein, NDF, NDF digestibility, and estimated milk production potential expressed in milk/ton and milk/acre as influenced by rate of spring injected manure.

Field	Manure rate gallons/acre	CP %	NDF %	dNDF % of NDF	Milk/ton lbs/ton	Milk/acre lbs/acre
A (JAK9)	9,000	7.0 a	35.6 a	63.5 a	3,672 a	37,228 a
	12,000	7.2 a	39.7 a	67.4 a	3,591 a	35,022 a
	15,000	7.6 a	39.6 a	68.2 a	3,612 a	37,217 a
B (JAK10)	9,000	6.6 a	37.4 a	66.6 a	3,676 a	34,971 a
	12,000	6.7 a	40.4 a	66.8 a	3,564 a	35,393 a
	15,000	7.7 a	38.7 a	64.3 a	3,571 a	35,631 a
C (Weiss1)	9,000	7.0 b	36.9 a	69.5 a	3,670 a	33,450 a
	12,000	7.7 a	37.4 a	69.5 a	3,622 a	36,316 a
	15,000	7.7 a	37.9 a	69.7 a	3,603 a	36,029 a
Average all fields	9,000	6.9 b	36.6 b	66.5 a	3,673 a	35,216 a
	12,000	7.2 b	39.2 a	67.9 a	3,592 a	35,577 a
	15,000	7.7 a	38.7 ab	67.4 a	3,595 a	36,292 a

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

non-N crop growth limitations. This is consistent with the lack of a yield difference between surface application of manure and aerator incorporation of manure, despite an 80 lbs N/acre difference in available N from the manure between these two treatments in 2008 and an almost 70 lbs N/acre supply difference in 2009 (Table 6). The low CSNTs and considerably reduced soil nitrate levels at harvest (results not shown) compared to very high nitrate

levels at PSNT time suggest large N losses after PSNT time, consistent with the saturated soil conditions for a larger portion of 2009 and very variable crop height at PSNT time (taller over tile drains, much shorter where drainage was restricted), a pattern that persisted through harvest. The injection treatment may have resulted in better soil structure/root growth conditions but additional measurements are needed to evaluate these hypotheses.

Table 10. Cornell Morgan soil test P (0-8 inch depth) as influenced by rate of spring injected manure. A soil is optimal in P when the Morgan soil test P value is between 9 and 40 lbs/acre.

Field	Rate gallons/acre	Initial Planting Sidedress Harvest ----- lbs/acre -----							
		A (JAK9)	9,000	75.3	a	88.0	a	89.8	a
	12,000	83.5	a	91.0	a	105.8	a	92.3	a
	15,000	76.5	a	90.8	a	101.3	a	92.3	a
B (JAK10)	9,000	66.3	a	80.8	a	66.5	b	71.3	b
	12,000	66.5	a	79.0	a	84.3	a	78.5	ab
	15,000	65.0	a	87.8	a	90.5	a	82.8	a
C (Weiss1)	9,000	23.8	a	26.5	a	30.3	a	26.0	a
	12,000	24.5	a	27.5	a	28.3	a	26.5	a
	15,000	25.5	a	28.8	a	29.0	a	26.8	a
Average all fields	9,000	55.1	a	65.1	a	62.2	b	59.6	a
	12,000	58.2	a	65.8	a	72.8	a	67.3	a
	15,000	55.7	a	69.1	a	73.6	a	65.8	a

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

While N shortage is often implicated in excess-water conditions, N did not seem to be the limiting factor for the crop in either of the project years on these soils (high ISNT and high PSNT), but due to wet soils post PSNT time, N losses were large (deficient CSNT). The fact that the injection plots showed 4 ton/acre higher yield and there was no difference in yield between surface application and aerator incorporated manure, especially in 2009, a very wet year, is consistent with the observations that N availability was not the limiting factor in yield in either of the two years, as all plots would be expected to experience similar loss of N and the yields in plots with surface applied manure would have been lower than for the other treatments.

### Manure Application Rate

The 2010 and 2011 yield results indicate no benefit of an increase in manure rate beyond the 9,000 gallons/acre (Table 7), although in 2011, the higher rates averaged 28.5 tons/acre versus 26.0 ton/acre with the 9,000 gallon/acre application rate. This was also the year in which the manure N content was considerably lower (Table 1) and in which soil ISNT indicated additional N was needed for optimum yield (Table 2). Increasing the application rate did not impact stand density or moisture content of the corn silage at harvest and did not result in a DM increase. Yields were good: 28.7 and 28.0 tons/acre for fields JAK9 and JAK10, respectively, in 2010, and 27.7 tons/acre for Weiss1 in 2011.

The higher application rates resulted in an increase in

PSNT-N (significant increase in JAK10; similar trends for JAK9 and Weiss1) and CSNT-N (JAK9 and Weiss1; similar trend for JAK10) (Table 8). Across all sites, PSNT and CSNT increased with manure application rate but also the 9,000 gallon/acre application resulted in PSNTs and CSNTs that exceeded critical values, illustrating N was not limiting production, even at the 9,000 gallon/acre application rate.

The 3-year average suggest CNST increases of about 450 ppm per 1000 gallon of manure applied beyond the 9,000 gallon/acre rate (Figure 1) although actual increases for individual sites varied from a little less than 200 ppm (JAK10) to almost 600 ppm (Weiss1) per 1000 gallons of manure (Figure 2). This reflects field and growing season differences among sites and years.

Crude protein did increase with manure rate from 6.9% when 9,000 gallons/acre was applied to 7.7% with injection of 15,000 gallons/acre. Although not significant at individual sites, across all three locations, injection of 12,000 gallons/acre resulted in significantly higher NDF than the lower rate (Table 9). However, estimated milk production was not impacted when forage quality was expressed as estimated milk production per ton of silage or milk production per acre (Table 9) suggesting applications exceeding 9,000 gallons/acre do not increase milk produced from this forage.

The soil test P data showed seasonal variability (compare four sampling times) and a significant increase in soil test P application rate for one of the three trials only (JAK10). At the 9,000 gallon/acre rate, across all locations, soil test

## Nutrient Management

P values were maintained while higher application rates resulted in an increase in soil test P levels (Table 10).

### Conclusions

The results of the manure application method showed a 4 ton/acre silage yield increase (at 35% DM) with injection. Soil test indicators suggest that N was not a limiting factor at the manure application method trials, suggesting benefits of injection that are independent of N supply. End of season CSNTs in 2009 suggested considerable N loss post PSNT time when using surface application or aerator incorporation of manure in 2008 (a good growing season), and under all application methods in 2009 (a very wet growing season with sub-optimal yields). The yield rate studies confirmed that the 9,000 gallon/acre application rate employed at the farm is sufficient and higher rates lower the nutrient use efficiency of the application and result in buildup of soil P. Similar trials need to be done at other farms under different growing conditions (soil types, soil fertility levels, weather differences, etc.) before we can draw conclusions for manure injection for New York State.

### Trials in 2012-2013

New York Farm Viability Institute (NYFVI) has selected expansion of this project to a larger number of farms for funding in 2012-2014, as part of our New York On-Farm Research Partnership (<http://nmisp.cals.cornell.edu/NYOnFarmResearchPartnership/index.html>). If you are interested in implementing a manure injection rate study or a comparison of injection versus aerator incorporation of spring-applied manure, as described in this article, contact Quirine M. Ketterings at 607 255 3061 or [gmk2@cornell.edu](mailto:gmk2@cornell.edu). Trial protocols for both types of trials can be downloaded from: <http://nmisp.cals.cornell.edu/NYOnFarmResearchPartnership/ManureRateMethod.html>.

Remember: "A single trial has value, particularly to the grower on whose farm it was conducted. However, there is much more value in looking at data from many trials, whether they are collected from farmers in a local group or pooled from across the state and across time." Iowa Soybean Association.

### References

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This work was supported by the New York Farm Viability Institute and in-kind contributions by Table Rock Farm. For questions about these results contact Quirine M. Ketterings at 607-255-3061 or [gmk2@cornell.edu](mailto:gmk2@cornell.edu), and/or visit the Cornell Nutrient Management Spear Program website at: <http://nmisp.cals.cornell.edu/>.



## Newsletter Update



### Cornell University Cooperative Extension

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Dear *What's Cropping Up?* Subscribers,

As we move into the spring of 2012, I wanted to give you an update on the future of the *What's Cropping Up?* bimonthly newsletter produced by the Cornell University Department of Crop and Soil Sciences.

Currently subscribers have several ways that they can access articles in *What's Cropping Up?*

These include:

- the printed hard copy version that you currently receive
- the online version of the newsletter which can be accessed at <http://css.cals.cornell.edu/cals/css/extension/cropping-up/index.cfm>
- the new *What's Cropping Up Preview* which can be accessed at <http://blogs.cornell.edu/whatscroppingup/>. *What's Cropping Up Preview* showcases online the same articles that you can find in the *What's Cropping Up?* newsletter as soon as they are written. You no longer have to wait every two months for the information to be printed.

**With the rising costs of printing and shipping, we will unfortunately discontinue the printed version of the *What's Cropping Up?* newsletter by the end of 2012.**

The newsletter will still be available **free of charge online** as outlined above. We appreciate your interest and support as we move forward with this publication.

Please feel free to contact me if you have any questions or comments.

Sincerely,

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*Helping You  
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### Calendar of Events

June 7, 2012	Small Grains Management Field Day, Musgrave Farm, Aurora, NY
July 17, 2012	Weed Science Field Day, Freeville and Aurora, NY
Aug. 14, 2012	New York Summer Crop Tour, Dumond Farm, Union Springs, NY

***What's Cropping Up?*** is a bimonthly newsletter distributed by the Crop and Soil Sciences Department at Cornell University. The purpose of the newsletter is to provide timely information on field crop production and environmental issues as it relates to New York agriculture. Articles are regularly contributed by the following Departments at Cornell University: Crop and Soil Sciences, Plant Breeding, Plant Pathology, and Entomology. **To get on the mailing list, send your name and address to Mary McKellar, 237 Emerson Hall, Cornell University, Ithaca, NY 14853 or [mem40@cornell.edu](mailto:mem40@cornell.edu).**