# What's Cropping Up?

A NEWSLETTER FOR NEW YORK FIELD CROPS & SOILS *VOLUME 27, NUMBER 1 Jan./Feb. 2017*


## Anatomy of a Rare Drought: Insights from New York Field Crop Farmers


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### Key Findings

- The record-breaking 2016 drought affected farmers across New York State (NYS) with more severe effects in Western and Central NY than Eastern NY.
- Crop loss estimates from a late summer survey of ~200 field crop farmers suggest that more than 70% of field crop and pasture acreage had losses greater than 30%, with some reporting nearly total crop failure.
- Common suggestions from farmers on help they could use in dealing with future drought included better long-range weather forecasts, financial assistance to expand irrigation capacity, and more information on drought resistant crops.

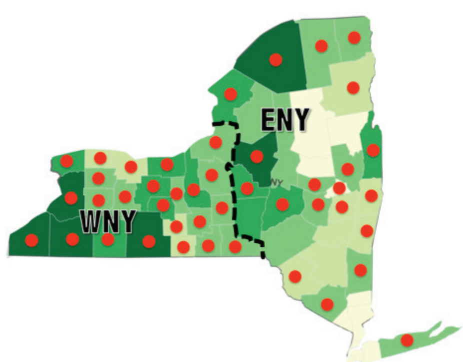


**Fig. 1. Drought survey responses by county.** New York State number of farms map (Source: 2012 USDA NASS, ESRI – 12-M249), where darker green colors indicate a greater number of farms. Red dots indicate counties where field crop farmers responded to the survey. The dotted line delineates two regions (WNY = Western NY and ENY = Eastern NY). Counties in WNY were those designated as "national disaster areas" due to the drought.

### Background

An unusually low winter snow pack, followed by lower than average rainfall and higher than average temperatures during the 2016 growing season (NRCC) led to continuously worsening drought conditions throughout New York State, and record-breaking low stream flows in Western and Central NY by late July and August (Drought Monitor). New York (NY) farmers have asked if they should expect more dry summers like the one we had in 2016 in the future with climate change. The answer to that is we don't entirely know. Climate scientists are fairly certain that the number of frost-free days will continue to increase and summers will be getting warmer, which will increase crop water demand (Horton et al. 2011; Walsh et al. 2014). Climate models are less reliable for predicting rainfall and snow, but most projections suggest that total annual precipitation will remain relatively stable in New York, with small decreases in summer months and possible increases in winter. Also, the recent trend of the rainfall we do get coming in heavy rainfall events (e.g. more than 2 inches in 48 hours) is likely to continue. This would suggest both flooding and drought will continue to challenge New York farmers, and it is possible that more severe short-term droughts in summer could increase in frequency. Given these projected impacts, we surveyed NY farmers throughout August and September (Drought Survey), so as to better understand how farmers were affected by the 2016 drought and if they are able to cope with drought risk. The survey was distributed online and in paper format with the help of Cornell Cooperative Extension and the Farm Bureau. Of the approximately 240 farmers that responded to the survey, 183 of those were field crop farmers from every county in Western NY, and several agricultural counties in Eastern NY (Fig. 1).

**Table 1.** The number of field crop farms in Western New York (WNY) and Eastern New York (ENY) that responded to the 2016 drought survey, and the total acres and mean estimated percent crop yield loss per farm within each region. Forages include hay, grasses, and alfalfa.

| CROP TYPE | NO. OF FARMS | | TOTAL ACRES | | MEAN % LOSS | |
|---|---|---|---|---|---|---|
| | WNY | ENY | WNY | ENY | WNY | ENY |
| All Field Crops | 137 | 91 | 24,047 | 13,413 | 41 | 25 |
| forages | 59 | 46 | 7,540 | 5,665 | 48 | 35 |
| pasture | 22 | 13 | 6,991 | 625 | 49 | 35 |
| soybeans | 13 | 8 | 1,787 | 1,519 | 45 | 20 |
| field corn | 38 | 17 | 7,095 | 4,719 | 40 | 21 |
| small grains | 5 | 7 | 635 | 885 | 21 | 13 |

## Drought Impact

Across the state, farmer-estimated crop losses for forages, pasture, soybeans, field corn, and small grains were 41%, 42%, 33%, 31%, and 17%, respectively. Figure 2 illustrates that estimated losses of more than 30% were reported for many field crops, and some forage and soybean farms reported losses above 90%. When asked what most limited field crop farmers' ability to maintain yields, 37% said limited water supply, 25% said inadequate irrigation equipment, and 16% said poor soil water holding capacity (data not shown). Of the 22% who reported that other factors most limited their ability to maintain yields, several mentioned: lack of time and labor, excessively hot temperatures and high solar radiation, and being completely unprepared for needing to irrigate. Additional comments from farmers related to the effect of the drought included statements about: extra costs associated with buying hay, and having to sell cattle due to an inability to keep them watered and fed. Several farmers indicated factors that helped them get through the drought, including: cover cropping, no-till farming, increased soil health, and improved grazing management. The drought impact was so severe in Western NY (WNY) that the USDA-Farm Service Agency (FSA) declared most counties in this region "natural disaster areas" in August of 2016, and eligible for some financial relief in the form of low-cost loans (FSA). The more severely drought stricken field crop farms in WNY reported higher crop loss compared to Eastern NY (ENY) (Table 1). A vast majority of field crop farmers in WNY estimated the overall economic impact to be "moderate" to "severe" and, though many farmers in ENY also felt a substantial economic blow, about half categorized the impacts as "minor" or a "nuisance" with almost no economic impact (Fig. 3).

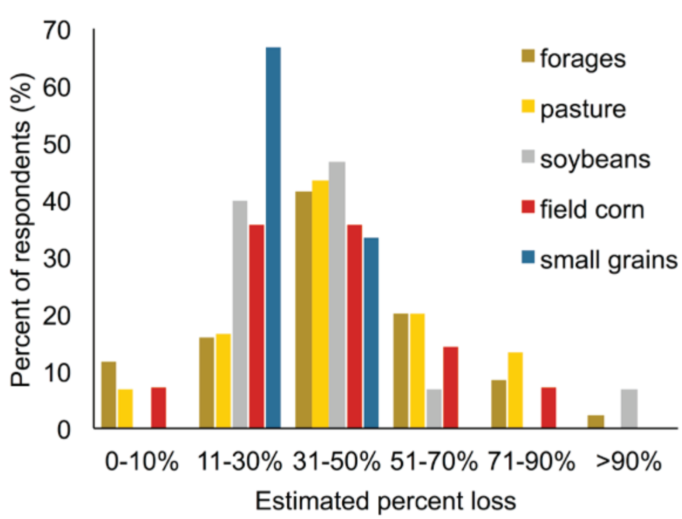


**Fig. 2.** Percent of respondents that estimated field crop yield losses within certain percent ranges. Forages include hay, grasses, and alfalfa. Data is averaged across NY.

## Adaptive Capacity

Field crop farmers' responses varied when asked what

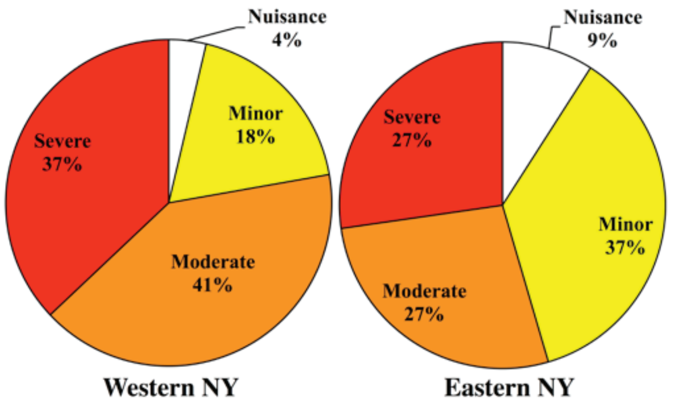


**Fig. 3.** Field crop farmer's rating of the economic impact of the drought.

they might have done differently if they had known in advance how dry this summer would be (Fig. 4). Many (37%) selected the "other" category and included suggested changes related to increasing soil organic matter and water holding capacity (e.g. cover crops and no-till), changing hay cutting regimes and increasing rotational grazing, investing in other water resources, selling or slaughtering livestock, and many others. A few farmers said they would not have done anything different if the drought could have been anticipated.

**Insights for extension educators, researchers and policy makers**

When asked how organizations such as Cornell Cooperative Extension, university researchers or government and non-government agencies could help them cope with future drought risk, farmers expressed interest in knowing more about:

- Drought resistant crop varieties
- Irrigation development and planning
- Improving soil quality and water retention, and water saving ideas
- Pasture rotation, silvopasture, rotational grazing, and stockpiling forage
- How to minimize the effect of drought
- What pests and diseases are more (or less) prevalent during a drought
- Dealing with mental stress related to drought and climate issues

In response to that same question, farmers said they wanted more:

- Development of online tools and better long-range forecasting
- On-farm courses and training, and educational materials about agriculture and drought
- Financial assistance to cover drought losses
- Inventory of vacant farmlands for potential use
- Financial assistance for irrigation equipment and ponds, and for soil improvement and water management
- Crop-specific crop insurance or discontinue crop insurance which encourages growing ill-suited crops
- Rentable and leasable irrigation equipment, and cheaper county water for agricultural use
- Cost sharing for: cover crops and no-till supplies, and for multi-purpose ponds

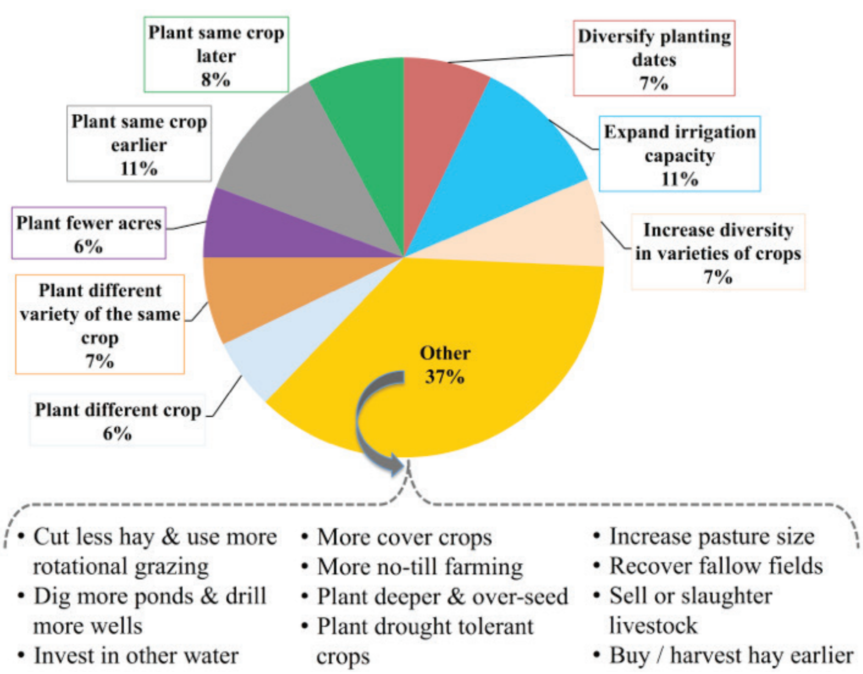


**Fig. 4.** Production changes field crop farmers would have made if the drought could have been anticipated.

Crop Production

This project was funded by Cornell University's Atkinson Center for a Sustainable Future and The Nature Conservancy. For more information contact Shannan Sweet: 126 Plant Science Bldg., Ithaca, NY 14853; 607 255 8641, sks289@cornell.edu.

**References and Hyperlinks**

Drought Monitor - http://droughtmonitor.unl.edu/

Drought Survey - https://dl.dropboxusercontent.com/u/27816/Survey_Drought_8-5-16%20(mail-in).pdf

FSA (Farm Service Agency) - http://www.fsa.usda.gov/news-room/emergency-designations/2016/ed_2016_0825_rel_0095

Horton R, Bader D, Tryhorn L et al. (2011). Ch. 1: Climate Risks. In: *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation*. New York Academy of Sciences. pp 217-254.

NRCC (Northeast Regional Climate Center) - http://www.nrcc.cornell.edu/regional/drought/drought.html

USDA (United States Department of Agriculture) - https://www.agcensus.usda.gov/Publications/2012/Online_Resources/Ag_Census_Web_Maps/

Walsh J, Wuebbles D, Hayhoe et al. (2014): Ch. 2: Our Changing Climate. In: *Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program, 19-67.

# Stalk Nitrate Test Results for New York Corn Fields from 2010 through 2016

Nutrient Management

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## Introduction

The corn stalk nitrate test (CSNT) is an end-of-season evaluation tool for nitrogen (N) management for 2nd or higher year corn fields. The greatest benefit of this test is that it allows for evaluation and fine-tuning of N management for individual fields over time. Corn stalk nitrate test results >2000 ppm indicate that more N was available during the growing season than the crop needed.

## Findings 2010-2016

The summary of CSNT results for the past seven years is shown in Table 1. For 2016, 51% of all tested fields had CSNTs greater than 2000 ppm, while 37% were over 3000 ppm and 19% exceeded 5000 ppm. In contrast, 13% of the 2016 samples tested low in CSNT.

Crop history, manure history, other N inputs, soil type, and growing conditions all impact CSNT results, and crop management records that include these pieces of information can be used to evaluate CSNT results and determine where changes can be made. Weed pressure, disease pressure, lack of moisture in the root zone in drought years, lack of oxygen in the root zone due to excessive rain (anaerobic soil conditions), and other stress factors can impact the N status of the crop as well, so in some circumstances, additional N might not have been able to overcome the real reason for the low CSNTs (e.g. no amount of N fertilizer can make up for a drought).

The 2016 data are consistent with 2012, another drought year with just 13.6 inches of rainfall between May and August. Large percentages of excessive CSNTs (36-40%) are also observed during very good growing seasons (2010, 2014) possibly due to a greater N supply by soils when growing conditions are good (moisture and heat).

These data point out the need to evaluate CSNT result in light of not just manure and fertilizer N management but also in light of the weather patterns that year. It does also show the need for multiple years of testing to gain experience with on-farm interpretation. In addition, within-field spatial variability can be considerable in New York, requiring (1) high density sampling (1 stalk per acre at a minimum) for accurate assessment of whole fields, or (2) targeted sampling based on yield zones, elevations, or soil management units. It is recommended to gather at least two years of data before making any management changes unless CSNT's exceed 5000 ppm (in which case one year of data is sufficient).

**Table 1.** Distribution of CSNT values (low, marginal, excess) for New York State (NYS) corn fields sampled in 2010-2016. Also presented are state average yield for corn (bu/acre at 85% dry matter and tons/acre at 35% dry matter). In grey are wet years. In orange are drought years.

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| NYS corn grain (bu/acre) | 149 | 133 | 134 | 137 | 148 | 142 | 133 |
| NYS corn silage (tons/acre) | 19 | 16 | 17 | 17 | 18 | 17 | . |
| May-August rainfall NYS (inches) | 15.9 | 20.0 | 13.6 | 20.0 | 18.3 | 16.7 | 12.4 |
| Low (<250 ppm) (%) | 24 | 21 | 20 | 35 | 29 | 37 | 13 |
| Marginal (250-750 ppm) (%) | 17 | 19 | 17 | 16 | 16 | 18 | 12 |
| Optimal (>750-2000 ppm) (%) | 19 | 24 | 22 | 20 | 19 | 21 | 24 |
| Excess (>2000 ppm) (%) | 40 | 36 | **41** | 29 | 36 | 24 | **51** |
| Excess (>3000 ppm) (%) | 28 | 24 | 29 | 20 | 27 | 16 | 37 |
| Excess (>5000 ppm) (%) | 14 | 12 | 14 | 9 | 14 | 6 | 19 |
| Total number of samples | 509 | 765 | 923 | 1473 | 1175 | 1039 | 859 |
| Maximum value (ppm) | 13966 | 16687 | 15671 | 13147 | 14659 | 13947 | 14959 |

Note: 2013 and 2014 data included results from NMSP and DairyOne; 2015 onwards includes samples from NMSP, DairyOne, and CNAL. Data prior to 2013 reflect submissions to the NMSP only.

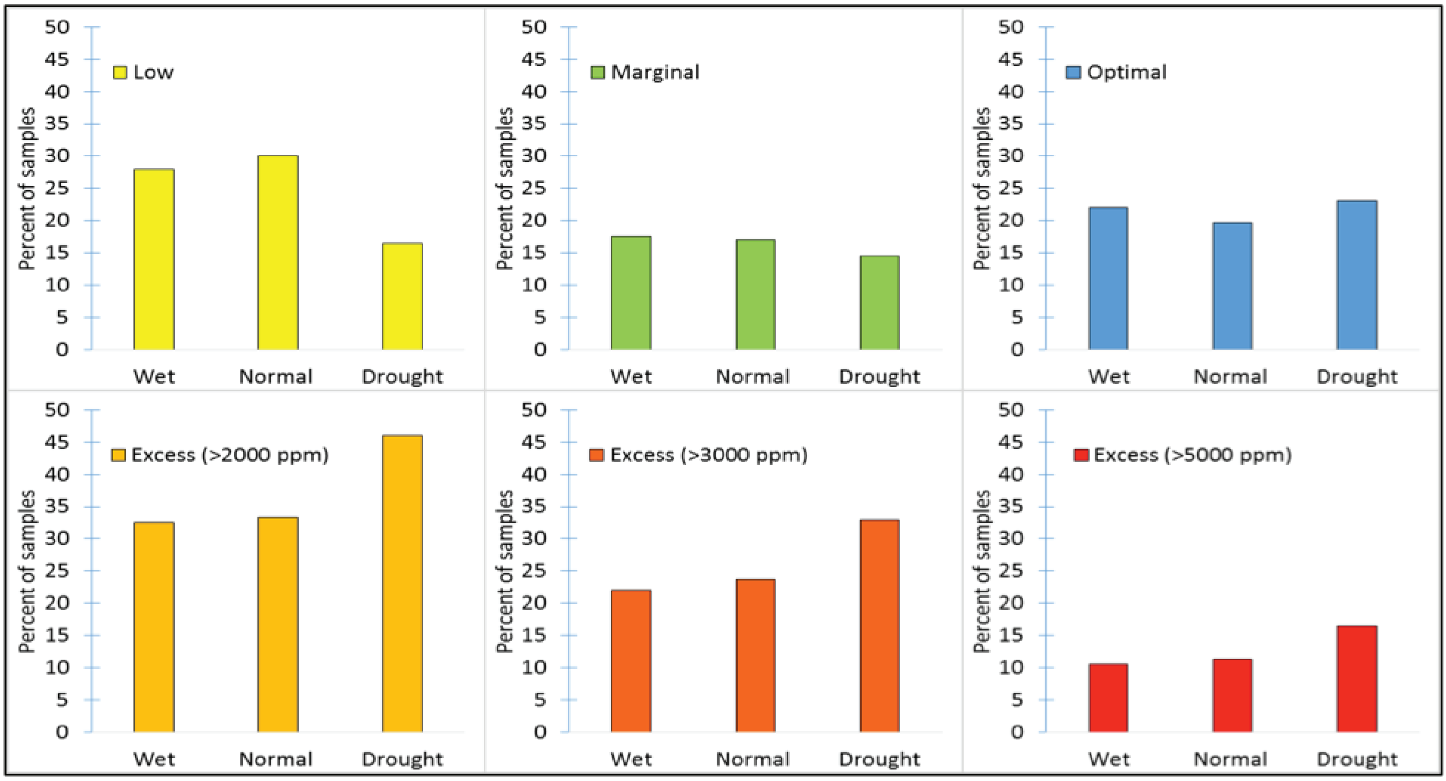


**Fig. 1**. In drought years like 2016, more samples test excessive in CSNT while fewer test low or marginal. This is consistent with the reduced yields in drought years.

### Relevant References


- Instructions for CSNT Sampling; Cornell Nutrient Management Spear Program: http://nmsp.cals.cornell.edu/projects/nitrogenforcorn/StalkNtest.pdf
- Agronomy Factsheet #31: Corn Stalk Nitrate Test (CSNT) (http://nmsp.cals.cornell.edu/publications/factsheets/factsheet31.pdf).
- Agronomy Factsheet 63: Fine-Tuning Nitrogen Management for Corn (http://nmsp.cals.cornell.edu/publications/factsheets/factsheet63.pdf)
- Agronomy Factsheet 72: Taking a Corn Stalk Nitrate Test Sample after Corn Silage Harvest. (http://nmsp.cals.cornell.edu/publications/factsheets/factsheet72.pdf)


### Acknowledgments

The thank the many farmers and farm consultants that sampled their fields for CSNT. For questions about these results contact Quirine M. Ketterings at 607-255-3061 or qmk2@cornell.edu, and/or visit the Cornell Nutrient Management Spear Program website at: http://nmsp.cals.cornell.edu/.

# Impact of Manure Injection on Alfalfa and Grass Hay Stands

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Nutrient Management

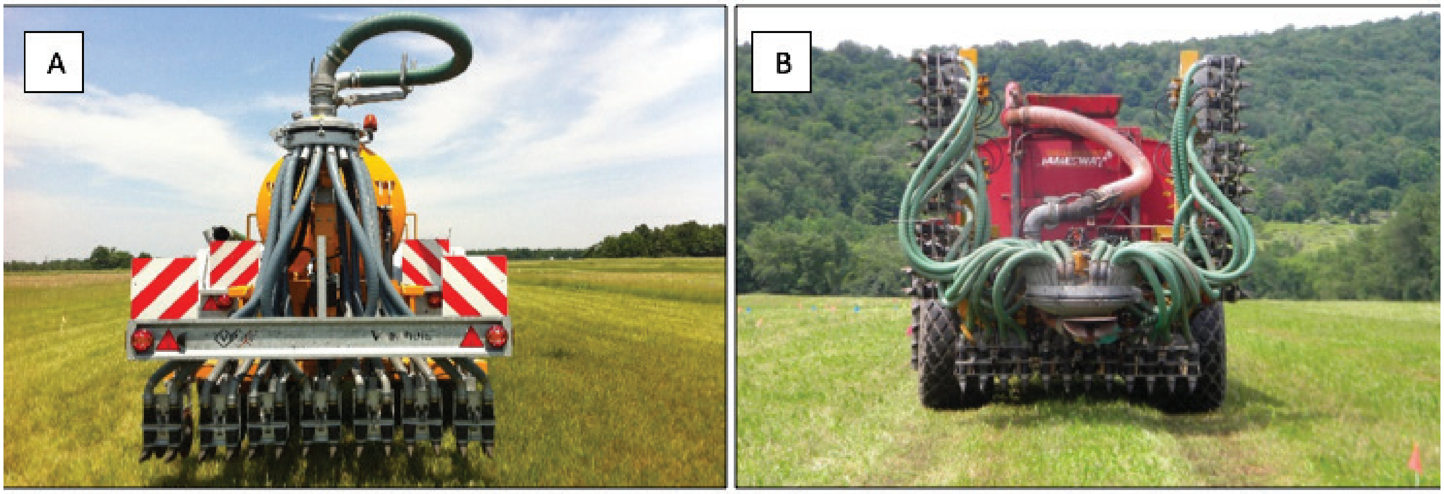


**Fig. 1.** A shallow disk injector designed for small scale research used in 2014 (A) and a shallow disk injector designed for large scale operation used in 2015 (B).

## Background

Producers in New York have shown interest in injecting manure into grass fields and alfalfa fields but have concerns about the potential for mechanical damage when injecting manure. In 2014 and 2015, six field trials were conducted to answer two questions: (1) will application of manure increase alfalfa and grass yields?, and (2) does injection reduce yields due to mechanical damage of the root system? In 2014, trials were conducted using a 4th year, low producing, tall fescue site and a thin 4th year alfalfa stand at the Musgrave Research Farm, in Aurora, NY. These two trials were continued in 2015. In 2015, we also added two trials using two higher-producing 2nd year alfalfa fields at the Cornell University Ruminant Center (CURC), in Harford, NY. Treatments included: (1) "disk down no manure" (slicing the soil, no manure) (2) injection of liquid dairy manure (slicing the soil, with manure); (3) no manure addition (no slicing, no manure); and (4) surface application of manure (no slicing, with manure). In the alfalfa trial at Aurora, manure was applied after 1st cutting in both years (4000 gallons/acre in 2014 and 8000 gallons in 2015). In the tall fescue trial, manure was applied after 1st and 3rd cutting in 2014 (4000 gallons/acre) and in 2015 (8000 gallons/acre for

**Table 1.** Forage yields at the Musgrave research farm, Aurora, NY, and the Cornell University Ruminant Center (CURC), Harford NY, as influenced by manure application.

| | | | Dry matter (DM) yield | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cut 1 | | Cut 2 | | Cut 3 | | Cut 4 | | Total | |
| | | | tons DM/acre | | | | | | | | | |
| Aurora 2014 | Tall fescue | No manure | ⱡNA | - | 0.15 | b | 0.08 | b | NA | - | 0.23 | b |
| | | Manure | NA | - | 0.33 | a | 0.29 | a | NA | - | 0.62 | a |
| Aurora 2015 | Tall fescue | No manure | 0.33 | b | 0.20 | b | 0.23 | b | 0.14 | b | 0.90 | b |
| | | Manure | 0.74 | a | 0.80 | a | 0.48 | a | 0.48 | a | 2.39 | a |
| Aurora 2014 | Alfalfa | No manure | NA | - | 0.57 | b | 0.49 | b | 0.19 | b | 1.25 | b |
| | | Manure | NA | - | 0.78 | a | 0.62 | a | 0.25 | a | 1.65 | a |
| Aurora 2015 | Alfalfa | No manure | 0.93 | a | 0.40 | a | 0.37 | b | 0.27 | a | 1.97 | b |
| | | Manure | 1.06 | a | 0.46 | a | 0.46 | a | 0.30 | a | 2.29 | a |
| CURC 2015 | Alfalfa | No manure | 1.61 | a | 1.28 | a | 0.97 | a | 0.52 | a | 4.38 | a |
| | | Manure | 1.56 | a | 1.37 | a | 0.80 | a | 0.40 | a | 4.13 | a |
| CURC 2015 | Alfalfa | No manure | 1.68 | a | 1.29 | a | 1.27 | a | 0.51 | a | 4.75 | a |
| | | Manure | 1.91 | a | 1.38 | a | 1.19 | a | 0.48 | a | 4.94 | a |

ⱡ not available; trial started with manure addition after 1st cutting. Each treatment includes plots with and without soil disturbance by injector disks.

each application). The 1st manure application to the CURC sites (4000 gallons/acre) took place in the fall of 2014, after 4th cutting. At CURC, a second manure application (8000 gallons/acre) took place after 1st cutting in the spring of 2015. Manure was injected using a Veenhuis shallow disk injector in 2014 and a modified, larger scale, unit in 2015 (Figure 1).

**Table 2.** Forage yields at the Cornell University Ruminant Center, Harford NY, and Musgrave research farm, Aurora, NY as influenced by injection ("disks down").

| | | | Dry matter (DM) yield | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cut 1 | | Cut 2 | | Cut 3 | | Cut 4 | | Total | |
| | | | tons DM/acre | | | | | | | | | |
| Aurora 2014 | Tall fescue | Disks up | †NA | - | 0.23 | a | 0.20 | a | NA | - | 0.43 | a |
| | | Disks down | NA | - | 0.25 | a | 0.16 | a | NA | - | 0.41 | a |
| Aurora 2015 | Tall fescue | Disks up | 0.57 | a | 0.52 | a | 0.38 | a | 0.30 | a | 1.67 | a |
| | | Disks down | 0.53 | a | 0.46 | a | 0.32 | a | 0.36 | a | 1.75 | a |
| Aurora 2014 | Alfalfa | Disks up | NA | - | 0.70 | a | 0.55 | a | 0.25 | a | 1.50 | a |
| | | Disks down | NA | - | 0.65 | a | 0.56 | a | 0.19 | b | 1.40 | a |
| Aurora 2015 | Alfalfa | Disks up | 1.00 | a | 0.45 | a | 0.40 | a | 0.27 | a | 2.13 | a |
| | | Disks down | 1.01 | a | 0.41 | a | 0.43 | a | 0.31 | a | 2.15 | a |
| CURC 2015 | Alfalfa | Disks up | 1.59 | a | 1.32 | a | 0.88 | a | 0.47 | a | 4.25 | a |
| | | Disks down | 1.59 | a | 1.33 | a | 0.89 | a | 0.45 | a | 4.26 | a |
| CURC 2015 | Alfalfa | Disks up | 1.83 | a | 1.33 | a | 1.29 | a | 0.49 | a | 4.94 | a |
| | | Disks down | 1.76 | a | 1.34 | a | 1.17 | a | 0.49 | a | 4.76 | a |

†NA; not available. Disks up consisted of no-manure and surface application of manure and disks down included disk down no manure and injection of manure combined.

### Does hay benefit from manure?

In Aurora, manure application to the older alfalfa stand resulted in a 0.40 (2-4th cutting, 2014) and 0.32 ton/acre (1-4th cutting, 2015) increase in yield, for both injected and surface-applied manure. The tall fescue stand at Aurora also responded with 0.39 (2nd+3rd cutting, 2014) and 1.49 ton/acre (1-4th cutting, 2015) higher yield with manure application (Table 1). In contrast to the findings for these old stands at Aurora, the 2nd year alfalfa at the CURC site did not respond to manure addition (Table 1). Alfalfa yields in 2015 were more than 2-fold higher at the Harford site compared to Aurora, most likely reflecting the age of the stand and manure history of the fields.

### Does injecting manure decrease hay yield?

In Aurora, alfalfa and tall fescue yields were comparable between "disks down" (injected) and "disks up" (surface applied) treatments (Table 2) and also for the younger and higher producing alfalfa trials at CURC injection did not help or hurt yields.

### Conclusions

Though more research (additional locations and year) is needed before drawing broad conclusions, in the test conditions here, manure application benefited old hay stands, both alfalfa and tall fescue, while neither benefitting nor harming higher producing 2nd year alfalfa. These results suggest that grass benefits most from manure addition but that yields of old alfalfa stands can be increased with manure as well. These results suggest as well that manure injection does not harm the stand. Further research is needed to better understand what drives the yield response.

### Acknowledgments

This material is based upon work that is supported in part by USDA-CIG (NFWF), Federal Formula Funds, Atkinson Center for Sustainable Future at Cornell, and the National Institute of Food and Agriculture, USDA, under Award no. 2013-68002-20525. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the USDA. We thank Aurora Ridge Dairy Farm for providing the liquid manure, Peter Kleinman of USDA-ARS for loaning us the Veenhuis unit in 2014, and Scott Potter for working with us on the applications in 2015. For questions about these results contact Quirine M. Ketterings at 607-255-3061 or qmk2@cornell.edu, and/or visit the Cornell Nutrient Management Spear Program website at: http://nmsp.cals.cornell.edu/.

# Organic Sunflowers for Seed Butter

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**Crop Production**

**Fig. 1.** Bob Gelser and Gael Orr of Once Again Nut Butter, and Dr. Matthew Ryan at organic sunflower trial on August 31, 2016.

Early in 2016, the Cornell Sustainable Cropping Systems Lab met with Bob Gelser, CEO of the Once Again Nut Butter Collective, Inc. (OANB) about the feasibility of growing organic confectionary sunflowers in New York State. OANB is an employee-owned business in Nunda, NY that produces several types of nut and seed butters and other products. The company makes organic sunflower butter, but imports organic sunflower seed kernels from Eastern Europe since local, organic supply sources are currently unable to meet OANB demand. Sunflower butter currently is a popular alternative to peanut and tree nut butters that have greater allergenic potential. Mr. Gelser proposed that our lab trial organic sunflowers, to gather experience and data under NYS conditions.

In general, there are two types of sunflower markets: oilseed and confectionary. Oilseed has greater oil content and is used in the production of vegetable oil, biodiesel, birdseed, and livestock feed. Confectionary has larger-sized seeds that are eaten as snacks or dehulled for food-grade kernel markets, including sunflower butter production. Smaller-sized confectionary seeds that do not make food-grade standards are often used for birdseed. Varieties suitable for both the oilseed and confectionary markets are called “conoil”.

While most US sunflower production is in the Western Plains and Northern Great Plains, sunflowers have the potential to broaden and diversify crop rotations in NYS. In the most recent census, USDA-NASS reports that in 2012 NYS produced 640,000 lb of sunflowers and 50,000 lb were confectionary sunflowers. Diversified rotations may help with weed management, break pest cycles, and increase farm viability.

With shared interests of increasing available crop markets and diversifying crop rotations for NYS organic farmers, we started an OANB-funded research project. Since we had no experience with the crop, we designed a simple experiment (Fig. 1). We acquired two varieties, Badger DMR (downy mildew-resistant) and N5LM307, an advanced new selection, donated by the major sunflower breeder Nuseed. They are both conoil types, suitable for dehulling. The trial was relatively large, about 2 acres, and our goal was to produce at least 700 lb of kernels of each variety. This is the amount OANB needed for roasting to evaluate the quality of the seeds for sunflower butter.

Growing sunflowers is very compatible with equipment that farmers use to grow corn grain. The seedbed was prepared by moldboard plowing and disking. Kreher’s 5-4-3 pelletized composted poultry manure was spread at 2000 lb/A and incorporated with a roller harrow. We used a 4-row JD 7200 MaxEmerge planter with finger pickup corn seed meters with 30 inch row spacing. The Kreher’s product was also applied through the corn planter at a rate of 220 lb/A, to give a total preplant plus starter nitrogen application of 111 lb N/A. We estimate that about half of that was available to the sunflower crop. Seeds of the two varieties were planted on June 10, 2016 at Musgrave Research Farm in Aurora, NY, at two target rates, 25,000 and 35,000/A, in a randomized complete block design.

The planting was done in the midst of a severe dry spell. Only 2.00 inches of rain had fallen in the month of May at Musgrave Farm, and 0.74 inches fell in June. The first significant rainfall after planting was 0.69 inches on July 19. Nonetheless, the sunflowers emerged well, though a bit slowly. By July 1, they were big enough to cultivate, which we did with a 2-row belly-mounted cultivator that we typically use for research plots. Sunflowers are an ideal crop to mechanically cultivate because they quickly reach a height of 4-5 inches. Soil can be lightly hilled around the base of the plants to smother weeds. Because of the dry conditions, weed emergence was also low. The rows were cultivated a second and last time with a JD 4-row row crop cultivator

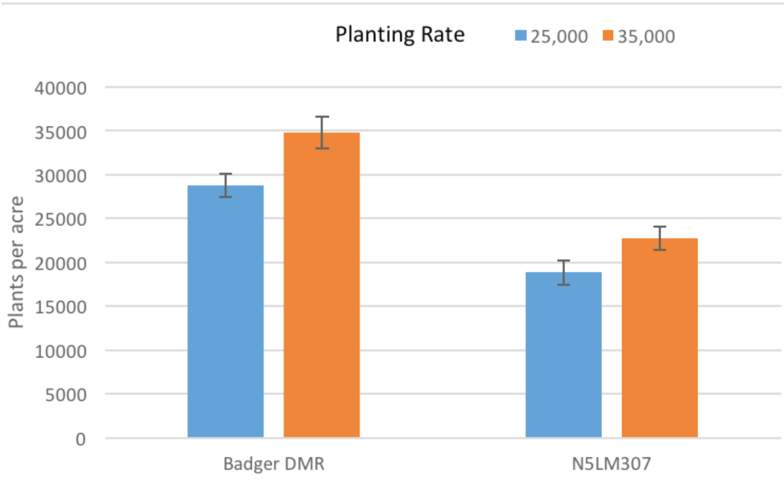


**Fig. 2.** Average organic sunflower stands in 2016. Bars represent the standard error of the mean.

on July 11.

Sunflowers are quite drought-tolerant. They grew well through the drought and started flowering around August 15 at a height of 4-5 feet (Fig. 1).

On October 7, sunflowers were deemed physiologically mature evidenced by the banana-yellow color of the back of the sunflower disc. On this date, we hand-harvested sunflower heads for moisture content and yields. Plant population data and weed biomass samples were also collected. The Badger DMR seeds had a moisture content of 13.4% and the N5LM307, 15.7% at that time. However, the discs of the heads were still quite moist, around 80%. We did the hand harvest to measure the maximum potential yield of the crop. It is likely that a fair amount of moist material would have been mixed with the seed if we harvested with the combine on that day, presenting the danger of molding during storage. Given the high moisture of the disc, we decided to delay machine harvest. We also anticipated significant losses to bird predation over the next few weeks.

Plant stands were different, both by seeding rate and variety. Badger DMR established at significantly higher rates than the N5LM307 (Fig. 2).

Weed biomass was relatively low, though there were a few large plants that went to seed. This caused variability in the weed biomass data. Weed biomass was significantly different by variety but not by seeding rate. The Badger DMR variety had 48 lb/A of weed biomass, while N5LM307 had 202 lb/A. These low amounts of weed biomass likely did not significantly reduce yields.

Hand harvest yields were high. The low seeding rate of Badger DMR yielded the most at 4260 lb/A (10% moisture). The high seeding rate of Badger and both rates of N5LM307 yielded the same at 3100-3450 lb/A (Fig. 3). The low rate of Badger DMR may have performed better due to lower within-crop competition during the dry conditions. These yields are considerably higher than the 1000-1400 lb/A reported for dryland production in Texas. However, it should be kept in mind that this was the first year for sunflowers at the Musgrave Research Farm, and thus pest and disease populations have not built up.

When we harvested with the combine on November 1, our bulk measurements showed average yields of 3300 lb/A for Badger DMR and 3600 for N5LM307 (Fig. 4). Evidently, there was not much loss to birds. The combine handled the crop well, leaving little trash in

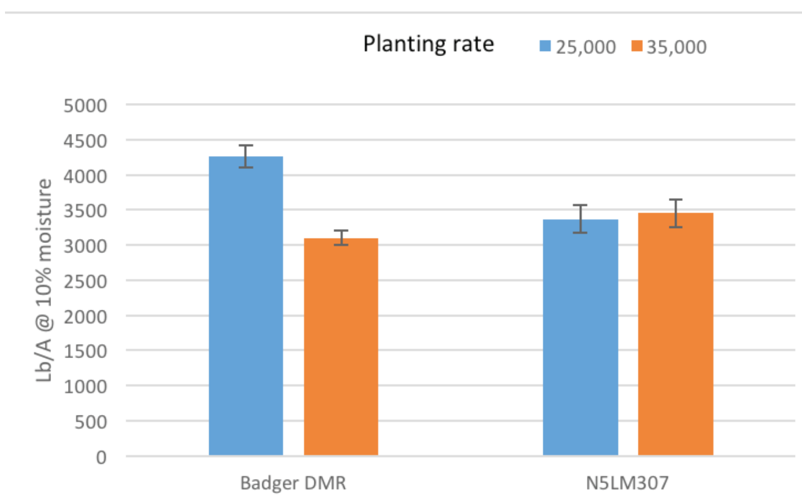


**Fig. 3.** Average sunflower hand harvest yields in 2016. Bars represent the standard error of the mean.

**Fig. 4.** Sunflowers at harvest on November 1, 2016.

**Fig. 5.** "Sunflower plates" bolted on to the corn head keep the sunflower heads from bouncing forward and out.

the harvested crop. The only modification we made to the standard corn head was to install Golden Plains sunflower plates, which direct the sunflower heads in and prevent seed loss out the front (Fig. 5). These cost $1142 used or $1693 new for our Case IH 1644 4-row combine and were easily installed. We immediately put the harvested seed into 1-ton bulk tote bags and installed a screw-in aerator in each (Fig. 6). This small-scale approach seemed to do a very good job of removing excess moisture and kept the seeds from heating up. Drying temperatures need to be held below 110 degrees F to maintain quality. After 4 days, they had dried down to the 8-9% range, which is considered ideal for storage, so we turned off the aerators.

**Fig. 6.** Harvested sunflower seed in tote bags with aerators. These were moved under cover. This accomplished rapid, low-temperature drying after experiment harvest.

Two more steps remain before they can be processed into sunflower butter. First, they will be cleaned of crop residue, and then dehulled. The seeds were delivered to OANB and they will be in charge of these steps, which we will document. Finally, OANB will process them into sunflower butter and evaluate the quality of the product.

Hulled organic sunflower seeds may typically receive a delivered price of $0.90-$1.10/lb. Estimates vary, but the seeds are reported to be about 60-80% kernel. Whole seed yields of 3000 lb/A would produce dehulled yields of about 1800+ lb/A, minus losses during dehulling. The gross returns from such a sunflower crop would be good, but we do not have data on the costs and losses from the dehulling operation. Drying after harvest is critical and may add to costs. Otherwise, growing and harvest costs appear similar to organic corn. More work will be needed in the future to determine yield variability and cost numbers.

The dry season of 2016 was perhaps ideal for sunflowers in some ways. First, they appear to have a good competitive advantage against weeds under dry conditions. Second, dry weather minimizes the occurrence of white mold, *Sclerotinia sclerotiorum*, which can affect all parts of the plant. It can also infect soybeans and reduce yields and quality of this valuable crop. We did not see white mold in 2016.

Sunflowers can perform well and mature even if planted in early- to mid-June, making them a valuable option when wet soil conditions delay planting outside of the optimum corn and soybean window. They also do not need high fertility levels and provide diversity within the rotation, with the important caveat of being a host for white mold. Our 2016 agronomic results were favorable. Later this winter, we will also find out processing results from OANB for these varieties. We need to determine the performance of sunflowers in wetter growing seasons. Other factors we hope to examine in the future are whether they will tend to increase white mold on soybeans within the rotation, and whether sunflower pests (including birds) and diseases will increase.

This project was undertaken with the generous support of the Once Again Nut Butter Collective, Inc., Nunda, NY. Seed was provided by Nuseed US, Alsip, IL.

# Within-Field Profitability Analysis Informs Agronomic Management Decisions

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## Background

Digital agriculture is a new concept that focuses on the employment of computational and information technologies to improve the profitability and sustainability of agriculture. A promising opportunity is the use of advanced analytical methods on data that are routinely collected on farms, which allow insight into ways to improve management. One example is the use of combine yield monitor data that are now customarily collected as part of harvest operations.

Crop fields have high variations in crop performance due to varying soil types and topography, which interact with climate and management. A major objective of most growers is to maximize profit. Understanding the underlying profitability potential in varying areas of agricultural fields allows managers to construct zone-specific strategies using information on yield potential and yield-constraining factors. One might consider two management interventions to optimize profitability: (i) take field areas that are known in advance to be unprofitable out of crop production, and (ii) make underperforming field areas more profitable through improved management implementation.

Therefore, our objectives were to (i) evaluate the variation in spatial patterns of within-field profitability as well as field-average expected profitability, and (ii) determine opportunities for site-specific management change to increase overall field profitability.

## Procedures

The study fields are located in Delaware, Maryland, Virginia, West Virginia, and southeastern Pennsylvania within three physiographic provinces: Coastal Plain, Piedmont, and Blue Ridge. All fields had similar crop rotations: corn, soybean, and wheat or barley. In some cases, double crop soybean was cultivated following the harvest of small grains. Soil nutrient, pest, weed, and irrigation water management on each field was based on individual farms' management schemes.

Yield data were collected for corn and soybean on 18 fields throughout the study region with well-calibrated yield monitors on combine harvesters. The fields ranged in size from 14.3 to 115.9 acres. For a particular field, the number of growing seasons for which digital yield data were available ranged from 3 to 12, with a range of 1 to 7 growing seasons for a single crop. Irrigation occurred on 6 of the 18 fields. Post-processing of yield data was done using the Yield Editor 2.0.7 software and data were then rasterized (15x15 ft) using the SAGA function within the QGIS environment.

We calculated site-specific profitability using:

$$Profitability = E[Yield] \times Price - Cost \qquad (1)$$

where E[*Yield*] is the expected value of yield estimated from the multi-year average yield, *Price* is the average price of the crop (corn or soybean), and *Cost* is the average cost of production. We utilized the 10 year average (2004-to-2013) price of corn and soybean for the profitability calculation, which were $4.73 and $411.45 per bushel, respectively (University of Illinois, 2015). The cost of production was determined using the Farm Resource Regions (USDA-ERS, 2000) for 2014, and ranged from $590.6 to $666.7 per acre for corn and $395.3 to $437.0 per acre for soybean.

We adopted different scenarios for profitability calculation for both rented and owned fields, where we subtracted the land rental rate from the total cost. We also estimated the cost of irrigation to be $138.0 per acre (Tyson and Curtis, 2008), which was added to the total annual cost of production when appropriate.

**Table 1.** Summary of average profit and the percentage of acreage in profit or loss for corn and soybean.

| | Site-years | Average Yield | Owned | | | Rented | | |
|---|---|---|---|---|---|---|---|---|
| | | | Profitable | Non Profitable | Ave Profit | Profitable | Non Profitable | Ave Profit |
| | | bu/ac | - - - % field area - - - | | $/ac | - - - % field area - - - | | $/ac |
| Corn | 72 | 160.2 | 76 | 24 | 114 | 57 | 43 | 15 |
| Soybean | 43 | 50.0 | 95 | 5 | 195 | 76 | 23 | 82 |

### Results and Discussion

*Field-Scale Profitability*

In the first analysis, the variation in spatial patterns of within-field profitability as well as field-average expected profitability was evaluated. Expectedly, profitability was affected by owned versus rented field status (Table 1) in both corn and soybean scenarios. In the owner-field scenario, 76% of the field area was on average profitable compared to 57% for the rented scenario. Profitability was higher overall in soybeans compared to corn for both owned and rented scenarios, partly due to the assumed lower cost of production by approximately $200 per acre (USDA-ERS, 2015), mostly related to the exclusion of N fertilizer cost.

Irrigation effectively improved profitability (not shown here), even under rented scenarios, indicating that soil moisture shortage is a major yield limiting factor in the Mid-Atlantic region and irrigation can achieve positive profits even after accounting for the added cost.

*Spatial Patterns of Profitability and Opportunities for Alternative Land Uses*

A second analysis focused on the identification of profitable vs. unprofitable zones within fields. I.e., based on multi-year yield data, can we consistently expect certain parts of the field to be money losers? We identified three general categories of within-field profitability patterns: "economically sensitive" (Fig. 1a and 1b), "distinct profitable-unprofitable zones" (Fig. 1c and 1d), and "all-profitable" (Fig. 1e and 1f).

The economically sensitive fields generally showed high temporal variation in yield pattern due to irregular precipitation, and due to most areas being on average, either slightly profitable (Fig. 1a and 1b; green zones) or slightly unprofitable (yellow zones). This indicates that profitability at a field location strongly depends on the growing season's environmental conditions and the relative prices of inputs and grains. The small margins in profitability suggest that modest changes in production efficiencies, grain prices, input costs, or localized yields can turn areas from unprofitable to profitable, or vice versa. For example, in fields 1a and b most profitable green zones would turn unprofitable with a $0.50 drop in grain prices. Conversely, reducing fertilizer costs through precision N management could change yellow zones from unprofitable to profitable.

In fields with distinct profitable-unprofitable zones, areas exist that are either consistently profitable or unprofitable (Fig. 1c and 1d). The profitable areas (light and dark blue) presumably have favorable growing conditions, while the consistently unprofitable areas of the fields (orange and red) experience yield-limiting conditions. In some fields, money-*losing* zones of $200 per acre (red) existed along with $200 per acre money-*making* zones (blue), resulting in a $400 per acre total profitability range. The very profitable areas in these fields have higher than field-average yield potential, which may warrant increased site-specific inputs like fertilizer and possibly seed.

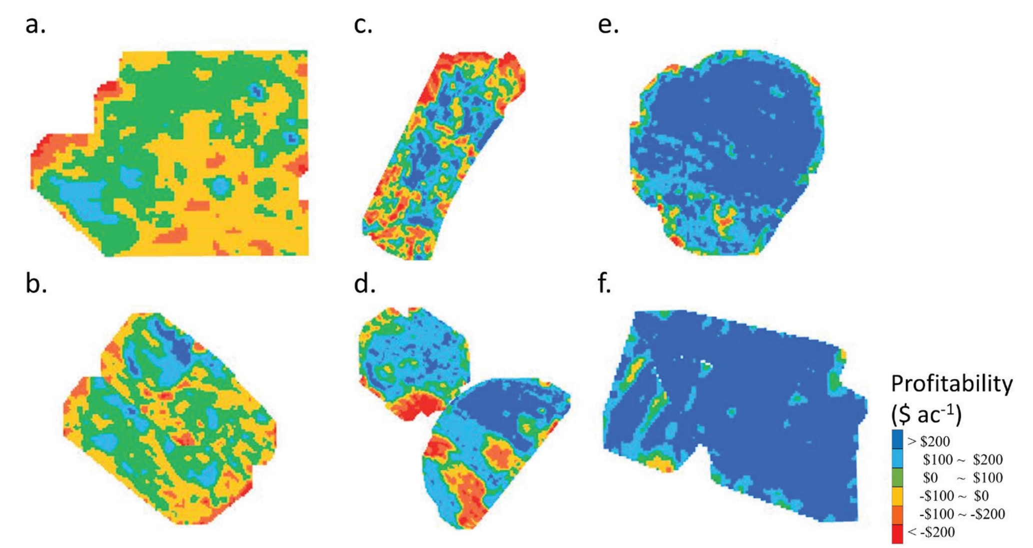


**Fig. 1.** Selected maps of within-field profitability for the owned-field scenario for corn representing three profitability categories; a and b) economically sensitive; c and d) distinct profitable-unprofitable zones; and e and f) all-profitable.

The consistently low-yielding zones are possibly compacted headlands, areas experiencing shading from adjacent woods, damaged by wildlife, erosive or poorly-drained. Since profitability for those field zones is predictably negative, overall field profitability would be enhanced by taking those field areas completely out of production. For example, herbaceous buffer strips on the field borders or in swales could be installed to enhance environmental benefits while still providing equipment turnaround space and minimal effects on yield in the rest of the field. We evaluated the removal of low profitability areas (< -$200 per acre) from the field in Figure 1c and found an increase in overall field profitability from $41 to $63 per acre.

Alternatively, potential areas of yield-constraining factors, like compaction, poor drainage or low organic matter, may be identified and managed to make those field areas profitable. For example, season-specific yield constraints were identified for the two fields in Figure 1d from excessive early-season precipitation combined with poorly-drained soil from concave field areas. Over time, improving the soil health status of these areas could make them profitable.

A third profitability pattern shows field areas being all profitable (Fig. 1e and 1f). These are the most preferred conditions where no additional considerations are warranted and fields can be managed uniformly.

**Conclusions**

Adoption of yield monitoring has accumulated large amounts of data. Based on our analysis of multi-year site-specific data, yields vary spatially and temporally at the field scale. We assessed within-field spatial patterns of profitability using grower collected yield data and input cost information for fields in the Mid-Atlantic USA. Three types of profitability pattern categories were identified: economically sensitive, clear profitable-unprofitable zones, and all-profitable. For fields with areas of permanent yield constraints, the removal of consistently unprofitable areas can increase overall field profitability. Conversely, high-yielding zones may justify more inputs, notably higher fertilizer and possibly seed rates. Other fields showed high sensitivity to prices and may benefit from improved management efficiencies. In conclusion, the combination of site-specific profitability and yield constraint information can inform future management optimization, including removing field areas from crop production entirely and improving management efficiencies.

This article is based on a paper titled Within-Field Profitability Analysis Informs Agronomic Management Decision in the Mid-Atlantic USA (Kinoshita et al., 2016).

**Acknowledgements**

We are grateful to the participating growers for providing the yield data. This work was supported by grants from Willard Agri-Service, Inc., the New York Farm Viability Institute and the USDA-NRCS.

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# The Soil Health Manual Series: Fact Sheets from the Comprehensive Assessment of Soil Health Training Manual

**Soil Health**

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The Comprehensive Assessment of Soil Health (CASH) provides a framework for measuring the physical, biological and chemical aspects of soil functioning. The assessment includes specific measurements, evaluated for their relevance to key soil processes, sensitivities to changes in management, and cost of analysis.

As a framework, CASH encompasses not only soil health testing, but also outlines field-specific planning strategies and management approaches. In 2016, the Cornell Soil Health Laboratory released the third edition of the Comprehensive Assessment of Soil Health Training Manual (bit.ly/SoilHealthTrainingManual). The manual contains information on introductory soil health concepts, a detailed discussion of individual soil health indicators, laboratory procedures, a step-by-step guide to our soil health management framework, and an extensive list of additional resources.

Out of this training manual, we have developed the Soil Health Manual Series of Fact Sheets (bit.ly/SoilHealthFactSheets) to further facilitate the guide's utility as an educational tool for growers, extension agents, and Ag Service Providers. The fact sheets are one page, two-sided handouts, designed to explain different soil health concepts and show how we measure soil health.

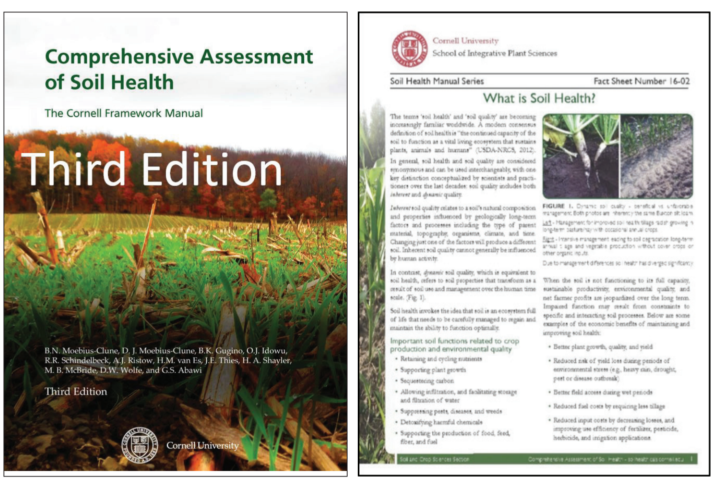


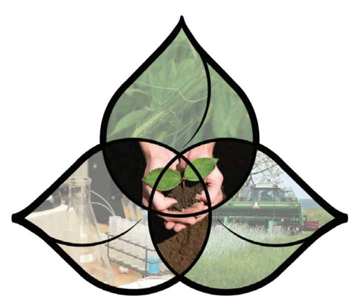

**Fig. 1.** The Soil Health Manual Series fact sheets are designed to explain different soil health concepts and show how we measure soil health in downloadable, one page, two sided, easy to read handouts.

Purveyors of soil health can easily download and print the sheets to be handed out at field days and other outreach events (Figure 1). They are available on the CASH website (http://soilhealth.cals.cornell.edu/).The entire collection is also available as a booklet or "mini-manual".

Below are links to the fact sheets that are currently available online. New handouts will be posted as they are added to the series.

- 16-01 – Soil Health Sampling Protocols
- 16-02 – What is Soil Health?
- 16-03 – Common Soil Constraints
- 16-04 – Soil Texture
- 16-05 - Available Water Capacity
- 16-06 – Surface and Subsurface Hardness
- 16-07 - Wet Aggregate Stability
- 16-08 - Soil Organic Matter
- 16-09 – Soil Protein
- 16-10 - Soil Respiration
- 16-11 - Active Carbon
- Comprehensive Assessment of Soil Health Laboratory Soil Health Manual Series mini-manual

For more information, please visit our website: soilhealth.cals.cornell.edu.



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## Calendar of Events

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| FEB 8 | Western NY Soybean Congress - Batavia, NY |
| FEB 9 | Western NY Soybean Congress - Waterloo, NY |
| FEB 10 | Hudson Valley Value-Added Grains School - Coxsackie, NY |
| FEB 14 | Corn Day - Cooperstown, NY |
| FEB 15 & 16 | Farm Transfer & Management Conference - Syracuse, NY |
| FEB 16 | CCE Oneida No-Till Workshop - Oriskany, NY |
| FEB 23-25 | NY Farm Show - Syracuse, NY |
| FEB 28 | Western NY Forage Congress - Mount Morris, NY |
| MAR 15 | Madison County Crop Congress - Cazenovia, NY |
| MAR 16 | NOFA-NY Organic Dairy & Field Crop Conference - Liverpool, NY |

***Have an event to share? Submit it to jnt3@cornell.edu!***

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