Northern NY Agricultural Development Program
2017 Final Report

Optimizing Economic and Environmental Performance of Dairy Farms through Integration of Yield Assessments, Phosphorus Index Assessments, and Whole-Farm Nutrient Mass Balances

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- Participating farmers in Jefferson, St Lawrence and Clinton counties

Background:

In 2013-2015 we evaluated corn silage and grain yields for Northern NY farms as a Northern New York Agricultural Development Program (NNYADP)-funded project to evaluate the Cornell yield potential database for corn and associated nitrogen (N) recommendations and potential for phosphorus (P) removal through yields.

The average yield across those three years was 116 bu/acre versus an average listed yield potential of 118 bu/acre for the soil types in the study. However, 15 fields (33%) yielded less than 90% of what was listed as the yield potential for the soil type in the Cornell database, nineteen fields (41%) were within 10%, while twelve fields (26%) yielded more than 110% of the Cornell listed yield potential.

This assessment showed a clear need to evaluate all relevant soil types for yield potential across the Northern New York region (and the state). It also indicated the need to evaluate whole farms rather than selected fields, and to evaluate soil-type specific yield potentials across farms and over multiple years.

In the earlier dataset, the highest yielding fields had the lowest ratio of N applied to N removed (Figure 1) suggesting that corn in high yielding fields gets more N from the soil (a ratio of less than 0.5 means that more than 50% of the N removed with silage harvest was supplied by soil N; since N removed in high yielding fields is also higher, soil N supply for high yielding fields is substantial). It was clear from this assessment as well that crop response to N needed to be evaluated across yield-zones.

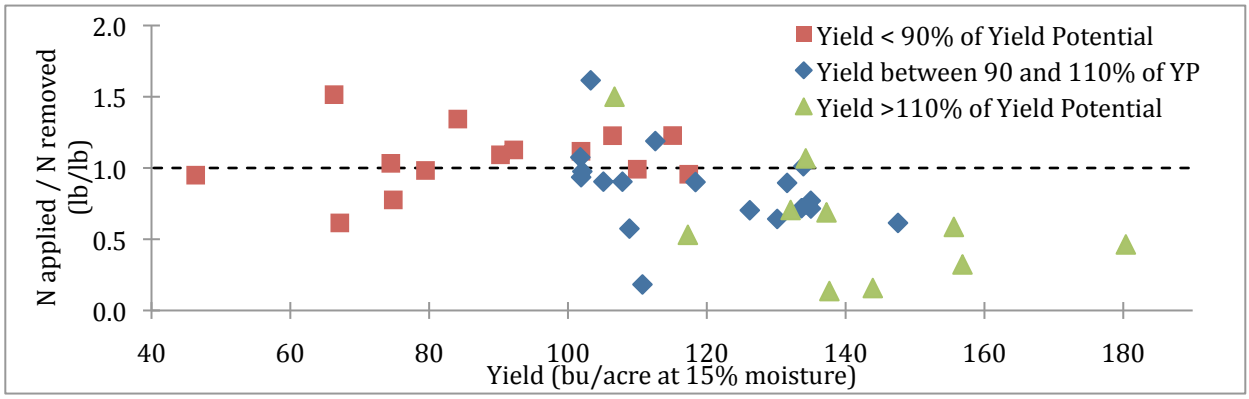


Figure 1: Ratio of nitrogen (N) applied (manure and fertilizer combined) to N removed with the actual harvest and the yield for each site.

In 2017, we were able to work with a number of Northern NY farms on assessment of whole-farm yield monitor-generated corn silage and grain data. Essential to the evaluation was the creation of a yield monitor data cleaning protocol. Calibration of yield monitors during the harvest season is essential for obtaining accurate yield data but even if calibrated properly, the data obtained from the yield monitors still need to be cleaned. A protocol needed to be developed and implemented across the region so that yield monitor data from individual farms and year could be combined.

At the same time, funded by a USDA-CIG grant these past four years, we evaluated the performance of the current NY Phosphorus Index (NY-PI) and worked with consultants to identify areas of improvement. This multistate activity included Northern NY farms and nutrient management planners and resulted in a newly proposed NY-PI that ranks fields based on transport risk and soil P status first, and then promotes best management practices (BMPs) for manure application for the fields with a higher risk of P losses.

This new approach has the potential for implementation across state boundaries and a collaborative evaluation is ongoing with Pennsylvania, Vermont, Massachusetts, and Connecticut with a new USDA-CIG. Initial coefficients were set, but those coefficients need to be evaluated and calibrated at the whole-farm level to ensure that targets for manure and field management and cutoffs from P application are set appropriately.

In parallel, working with many dairy farms in NY and many funding sources including NNYADP since 2006, we evaluated whole-farm N, P and K balances. We determined an "optimal operational zone [green box]" that sets benchmarks for evaluation and monitoring of improvements in whole-farm nutrient mass balances (NMBs) over time. This assessment now

allows farmers to identify balances against feasible benchmarks (within the green box), based on actual commercial dairy farms in NY.

The combination of information provided by NMBs, the new NY-PI assessment, yield maps, and yield potentials across soil types offers a unique opportunity to evaluate farm production and environmental sustainability. This can help steer targets for N and P management that allow for increases in yield over time while reducing the environmental footprint of dairy farming.

For 2017 we proposed:

1. to work with Northern NY dairy farms to evaluate yield records over time,
2. to include an assessment of N needs and P removal,
3. to conduct a comparison of the current NY-PI and the newly proposed structure and coefficients (and identify areas of improvement), and
4. to ensure that guidance based on whole-farm N and P balances are in line with yield records and NY-PI driven best management practices for manure allocation.

In short, we proposed to work with farmers and their advisors to evaluate production and environmental footprints so that Northern NY farms are well represented in the development of the NY-PI as well as the setting of new yield potentials for relevant soils for the NNY region.

Methods:

Yield data were obtained from farms that use yield monitor for silage and/or grain harvest, with each farm contributing multiple years of data. From these datasets, the data from three farms with corn silage data and three farms with corn grain data were used to evaluate the importance of raw yield monitor data cleaning (post processing), and to develop a standardized data cleaning protocol.

In addition, whole-farm NMB and P index information were obtained from three dairy farms. A fourth farm supplied P index information, but has not yet completed the NMB. Protocols for determination of whole-farm NMBs are available at the NMSP website: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html.

Information about corn yield monitor data sharing can be obtained from the yield potential website: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/YieldDatabase.html.

The website for the NY-PI is:
http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/PI_Eval_NE.html.

Results:

Initial datasets showed that calibration of yield monitors during the harvest season is essential for obtaining accurate yield data but that, even if calibrated properly, the data obtained from the yield monitors still need to be cleaned/processed for better yield estimation.

Errors that impact the accuracy of the yield data occur in multiple ways. For example, if a combine or chopper is not equipped with a harvest swath width sensor, the default will be the

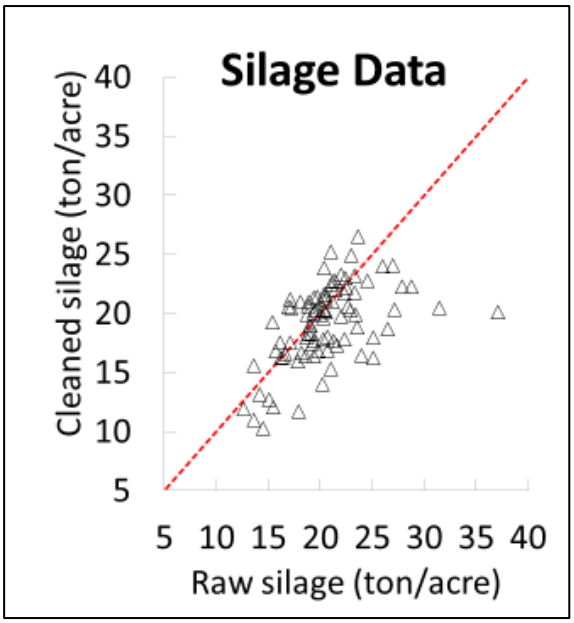
chopper or combine width and that can cause errors when fewer rows are harvested than the width of the chopper or combine.

Another source of error is the delay time of grain or silage moving from the chopper or combine head to the flow rate sensor. Flow rate sensors, moisture sensors, and Global Positioning System (GPS) units are located in different places on harvest equipment and because it takes some time for harvested silage or grain to travel to the sensors, adjustments need to be made (delay time correction). Each harvest pass will be affected by this delay correction, independent of whether a new pass starts from one end of the field or from somewhere within the field (in situations where the harvester is paused during harvest). The delay time itself is related to the speed of the combine or chopper as well, which may introduce another source of errors.

In addition, combines and forage choppers are calibrated for a certain velocity range. If the velocities that are recorded fall outside the calibrated range, flow rate and yield values associated with those points are no longer trustworthy and should be removed from the database. Similarly, abrupt changes in velocity affect the flow rate, resulting in erroneous yield calculations for logged data points.

Other easily trackable errors are logged data points with zero grain or silage moisture value; this may occur as the chopper or combine enters the field or pauses mid-field while the silage or grain flow has not yet reached the moisture sensor.

Last but not least, if the operator does not raise the combine/chopper head after completion of a pass, the pass number will not be updated in the logged dataset. Cleaning of data that are obtained this way will take additional effort, so lifting of the combine/chopper head while turning in the field is recommended.



Especially for corn silage yield data, use of raw data without proper cleaning can lead to substantial over- and under-prediction of actual yield, depending on the field and harvest conditions. Figure 2 shows this in more detail for a number of fields. As an example, Figure 2 shows that a 20 ton/acre corn silage yield (cleaned yield) for the fields in this figure can correspond to 15 to 37 tons/acre reported for raw data! The raw data for many of the fields in this figure overpredicted yield, while for quite some fields it actually underpredicted. Thus, data cleaning is absolutely necessary.

Figure 2: Not cleaning yield monitor data can result in larger over or under predictions of actual corn silage yield.

Implementation of the data cleaning protocol for the farms that submitted data allowed for generation of farm-specific yield reports for every year for which data were submitted (yield per

field, with and without headlands, yield per soil type within a field, and yields for each soil type represented in various fields on a farm).

Farm data for multiple years and multiple farms were combined and data were presented in frequency histograms (Figures 3 and 4) that show per soil type the frequency in which a specific yield level is obtained (each count is one field with the specific soil type listed).

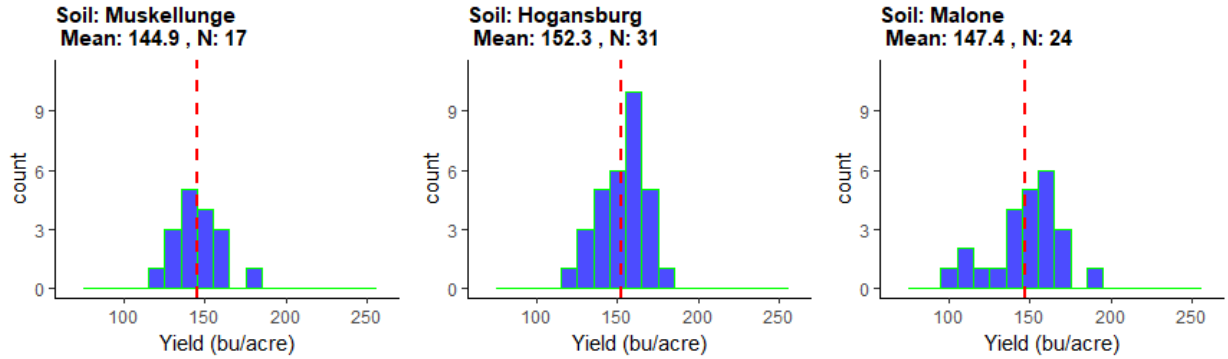


Figure 3: Yield histograms for corn grain for three Northern NY soil types with at least 15 fields with data. Listed are means across the fields for each of the soil types, as well as number of fields included. The histograms show average yields, most common yield, low and high yields, etc. Average yields based on these histograms are 26, 9, and 18% higher than currently listed in the yield potential database. This percentage might change as more farms contribute data to the database.

Work is ongoing to add more farms and more years of data to the dataset this winter (data already collected) and to expand with the 2018 growing season. The larger the number of fields represented per soil type, the more reliable the setting of new yield potentials and development of a corn silage database.

One of the observations from the existing database is that we have field variability that impacts yields beyond soil type. We can now use yield monitor data to try to understand variability better and to manage it better for increased yield and improved nutrient use efficiency. The best indicator around which to design zones is yield itself, and yield stability over time (consistency in yields from one year to another). Until recently we did not have a good way to identify such management zones due to lack of consistent yield data cleaning protocols and limited number of farmers with multi-year yield records.

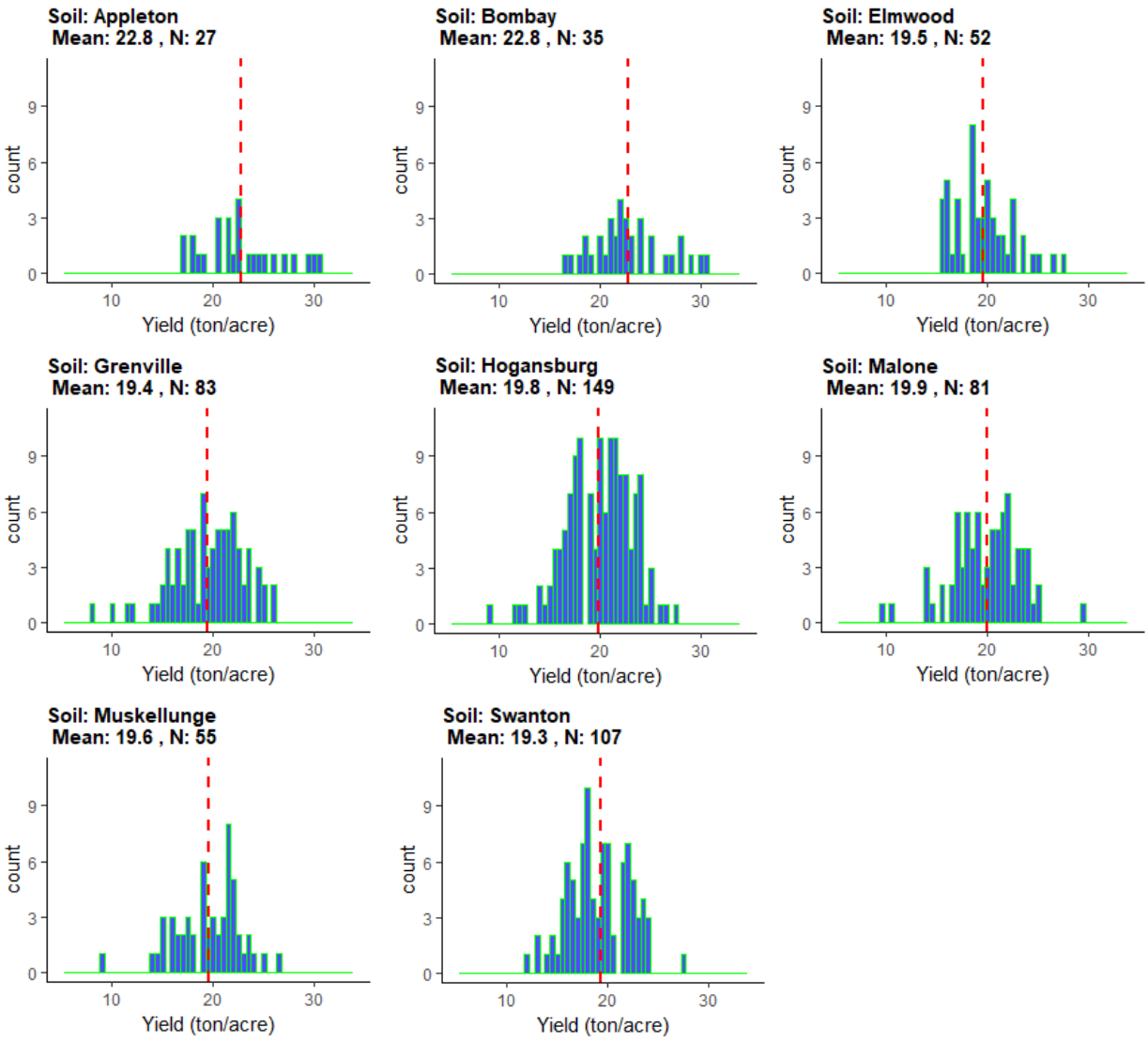


Figure 4: Yield histograms for corn silage for eight Northern NY soil types with at least 25 fields with data (to date). These histograms will contribute to the building of a new database of corn silage yield potentials.

In 2016 we introduced "yield stability zones." In this approach, three or more years of yield data for a field are combined into one yield stability map with four zones as shown in Figure 5. In this figure, the fields in quadrant 1 (Q1) yield above the farm average and do so consistency across years. The fields in Q4 are consistent as well over years but these are the low yielding fields. Fields in Q2 and Q3 are much more variable from year to year (standard deviation [SD] exceeding 5 tons/acre, the average SD for the farm). If a farmer can determine what keeps fields in Q3 and Q4 from being higher yielding, there could be options to increase the overall yield of the farm over time. Basically, yield stability zones can help identify and allocate resources better, including N and P.

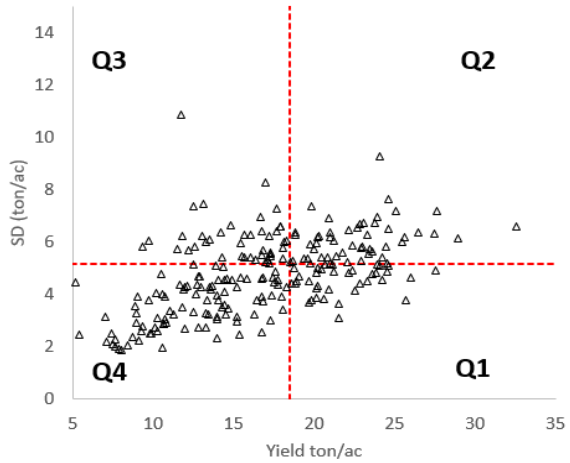
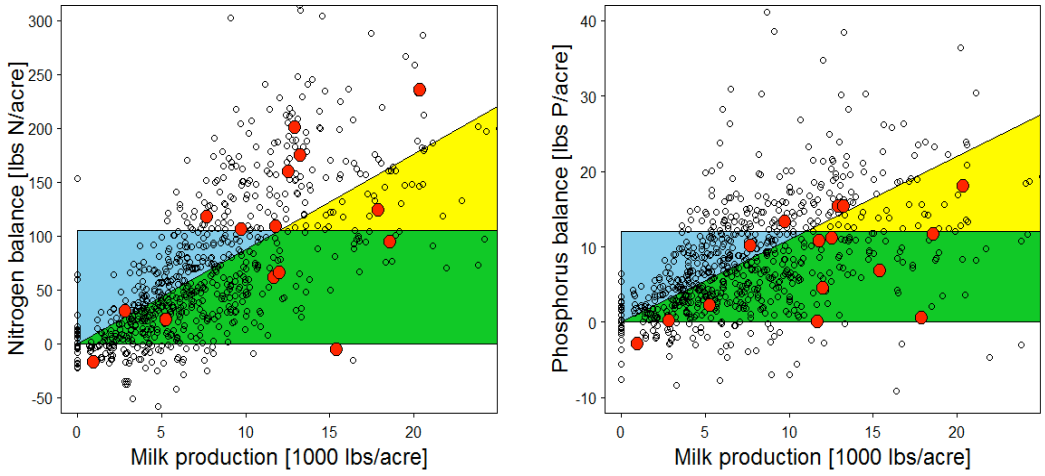


Figure 5: Average yield and standard deviation of a farm derived from 3 years of yield monitor data can be used to divide each field to four quadrant. The identical approach can be used to determine yield stability zones within fields.

In addition to progress with the yield database assessment and development of yield stability-based management zones, we also worked with three Northern NY farms to evaluate their NMB and NY-PI (current versus proposed). These three farms contribute to a statewide database of NY (now 15 farms) and a Northeast region database (with farms from Vermont, CT, MA, ME, and PA). This work is ongoing and will continue with a USDA-CIG grant. The N and P balances



of the statewide farms with both NMB and NY-PI information are shown in Figure 6 (red dots).

Figure 6: Nitrogen (left) and phosphorus (right) balances for 15 dairy farms in NY, including 3 Northern NY farms.

In 2018, an additional year of data will be added for each of the 15 farms, and other farms will be added. We are currently in the process of integrating the NMB data and the NY-PI. The goal is to make sure that farms with a feasible P balance (in the green box) are able to spread the produced manure on their land base without the need to export manure. This database can then be used to set the coefficients of the proposed NY-PI.

Conclusions/Outcomes/Impacts:

Data evaluation shows the importance of implementation of a standardized cleaning protocol for yield monitor data for silage and grain corn. Once cleaned from errors, such yield records can be used to determine field-based yields as well as yield per soil type within fields.

When data from multiple farms and years are combined, yield histograms can be generated and, once sufficient fields are included, we can set new yield potentials for those who do not have their own yield records or otherwise prefer to use book values for specific soil types. The database is growing with more farms and fields being included in the near future.

The initial NMB and NY-PI assessments showed high efficiency of P use on many of the farms in the 15-farm database (statewide), the need to adjust some of the parameters in the proposed NY-PI and develop a process by which farms that have their NMB in the optimal operational zone (the green box) are able to allocate manure on their land base without the need for export, as long as soil test P levels are not excessive. Work on this will be ongoing with Northern NY farms represented among the case study farms.

Outreach:

Protocols for determination of whole-farm NMBs were made available at the NMB website of the Nutrient Management Spear Program, and updated input sheets are downloadable here as well: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html.

Information about corn yield monitor data sharing can be obtained from the yield potential website: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/YieldDatabase.html. This website also shows the instruction for corn yield monitor data transfer: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/Protocols/YieldMonitorDataSharingInstructions.pdf.

The cleaning protocol is currently in final review and will be posted to this website once the final review is done. The website for the NY-PI is: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/PI_Eval_NE.html. A joint team meeting was held at the Miner Institute in Chazy, NY, on March 31, 2017, to discuss N and P management, NMBs, and yield data collection. In addition, an impact statement was written and made available: "Research Re-Evaluates Corn Yield Potential in Northern NY through Collaborative Partnership" (http://nmsp.cals.cornell.edu/publications/impactstatements/YieldPotential2017.pdf) and the Northern NY Cornell Cooperative Extension educators were updated on progress at the annual Ag Inservice at Cornell University. Training sessions were done on the yield monitor data cleaning process via webinar.

Next Steps:

We continue to work with farmers and farm advisors to expand on the current yield potential datasets, to develop yield-based management zones, and to implement N rich test strips to test crop response to N addition as a function of yield. Statistical approaches are being evaluated as part of a multi-state project, and those findings will aid in analysis of crop response to N with

zone-based management. We will collect NMBs and NY-PI data in 2018 as well to build on the currently existing database for the region, the state, and the Northeast.

Acknowledgments:

In addition to Northern New York Agricultural Development Program funding, we received a USDA-CIG grant (state and Northeast region P index grant), and a USDA-NIFA-AFRI grant (statistical approaches to analyzing of on-farm trials) as well as federal formula funds (statewide yield potential assessment).

Reports/articles in which results of this project have been published:

Project website (includes protocols):

- http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/MassBalances.html.
- http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/YieldDatabase.html.
- http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/Protocols/YieldMonitorDataSharingInstructions.pdf.
- http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/PI_Eval_NE.html.
- http://nmsp.cals.cornell.edu/publications/impactstatements/YieldPotential2017.pdf.

For More Information:

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