Journal of Extension
www.joe.org

October 2012
Volume 50 Number 5
Article Number:
5RIB10

Using Extension Phosphorus Uptake Research to Improve Idaho's Nutrient Management Planning Program

Steven Hines
Associate Professor of Extension
University of Idaho
Twin Falls, Idaho
shines@uidaho.edu

Amber Moore Assistant Professor-Extension Soil Specialist
University of Idaho
Twin Falls, Idaho
amberm@uidaho.edu

Brad Brown
Professor-Extension Soil and Crop Management Specialist
University of Idaho
Parma, Idaho
bradb@uidaho.edu

Mireille Chahine
Associate Professor-Extension Dairy Specialist
University of Idaho
Twin Falls, Idaho
mchahine@uidaho.edu

Rick Norell
Professor-Extension Dairy Specialist
University of Idaho
Idaho Falls, Idaho
rnorell@uidaho.edu

Mario E. de Haro Marti
Assistant Professor of Extension
University of Idaho

Gooding, Idaho

mdeharo@uidaho.edu

Christi Falen

Assistant Professor of Extension

University of Idaho

Shoshone, Idaho

cfalen@uidaho.edu

Tianna Fife

Assistant Professor of Extension

University of Idaho

Twin Falls, ID

tiannaf@uidaho.edu

Stuart Parkinson

Professor of Extension

University of Idaho

Preston, Idaho

stuartp@uidaho.edu

Jim Ippolito

Research Soil Scientist

Northwest Irrigation and Soils Research Lab

USDA-ARS

Kimberly, Idaho

jim.ippolito@ars.usda.gov

Abstract: *Irrigated silage corn is the main crop used for P removal in southern Idaho; however, little is known about the actual amounts of P removed under southern Idaho growing conditions. The study surveyed P removal by irrigated silage corn in primarily manured southern Idaho fields and wide-ranging soil test P. Whole plant corn tissue P concentrations ranged from 0.116 to 0.307% total P and averaged 0.208%—lower than Natural Resources Conservation Service (NRCS) estimates used prior to 2007 (0.26%P) but higher than estimates used since 2007 (0.185%). The study was used to update the OnePlan.org© Nutrient Management planning online program.*

Introduction

The Snake River is a 1,078 mile-long river stretching from Wyoming through southern Idaho and Washington, where it empties into the Columbia River. The Snake River is the largest tributary to the Columbia River, draining parts of six states. The Snake River is a working river used for irrigation, recreation, hydropower, and aquaculture. Agricultural activities are

primary non-point source pollution contributors to the Snake River (Said, 2008). The growing dairy industry in southern Idaho during the 1990's and the associated increased manure applications are a major concern as they potentially contribute phosphorus (P) to surface water through soil erosion and surface runoff (Sheffield, Brown, Chahine, de Haro Marti, & Falen, 2008). The P contributes to eutrophication in surface waters, which increases algae growth, clogs waterways and irrigation systems, reduces oxygen in the water, and can cause fish die offs (Oldham, 2007).

In the early 1990's, a local working group was formed to address water quality problems within the Middle Snake River reach in south central Idaho. The working group contributed to the design of Idaho's Nutrient Management planning process (Robison, Allen, & Merkle, 2002) which requires an approved Nutrient Management Plan (NMP) for each licensed confined animal feeding operation, or CAFO (Idaho Administrative Procedures Act, 2008).

Nutrient management is managing the amount, source, placement, form, and timing of nutrient and soil amendment applications to ensure adequate soil fertility for plant production while minimizing detrimental environmental impacts. Nutrient Management Plans document the management decisions and serve as an operational action plan (Oldham, 2007). All licensed dairies and beef cattle feedlots in Idaho are required to have a Nutrient Management Plan (Idaho Administrative Procedures Act, 2008). Manure application rates in the plans are subject to the USDA Natural Resources Conservation Service (NRCS), Conservation Practice Standard Code 590. If Olsen soil test P (0.05M sodium bicarbonate extractable) is above 40 ppm in the first foot, manure P applications are limited to the crop P uptake and removal with harvest. For planning purposes, estimates for crop specific P uptake are taken from the NRCS CP 590 Standard.

Because P uptake estimates frequently dictate manure application rates in southern Idaho, growers need to be confident that the estimates for specific crops are accurate. Silage corn is of particular interest, because it is produced by many dairies for feed and likely receives more dairy manure than other crops in Idaho. Nutrient Management planners and NRCS staff in Idaho have questioned established P recovery rate recommendations, especially since silage corn whole plant P concentration estimates were lowered in 2007 by the NRCS from 0.26% to the national database value of 0.185% (United States Department of Agriculture, 2011). The value was lowered because the NRCS was required in 2007 to use national database values unless credible local data was available (D. Johnson, personal communication, September 14, 2011). Because most P recovery estimates are based on data from crops grown in the Midwestern and Eastern regions of the United States, it is not known how appropriate the values are for irrigated production in arid regions and specifically the calcareous soils in southern Idaho that in some cases have been highly enriched with manure P.

The objectives of the study reported here were to survey 1) irrigated silage corn P concentrations and P removal in southern Idaho manured soils with variable soil test P concentrations and 2) Natural Resources Conservation Service adoption of Idaho-specific P

removal rates for silage corn, based on the survey findings.

Methods

Soil samples, whole plant tissues, and yield measures were collected from 21southern Idaho irrigated silage cornfields in 2008 and 21 fields in 2009. Fields were selected to represent predominate corn growing areas in southern Idaho (Table 1). The fields, located in eight counties across 360 miles of the Snake River Plain, ranged from approximately 2,350 to 4,715 feet in elevation. Fields sampled in 2008 were not resampled in 2009. Fields were selected to provide wide-ranging soil test P levels by asking growers and dairymen about their manure application histories. A small percentage (9-19%) of the fields did not have a history of manure applications, allowing the inclusion of lower and possibly limiting P soil test levels in the study.

Soil samples, whole plants, and yield data were collected within a week of harvest to approximate as close as possible actual harvest conditions. For consistency, fields were sampled once the kernels had reached the 1/2 - 2/3 milk line stage (approximately 65% whole plant moisture), the optimal dryness for southern Idaho silage storage systems. Each field was sampled at three random plot locations throughout the field, summing to a total of 63 samples for each year of the study. Each plot was 10 ft. long by 2 corn rows wide (corn rows varied in width from 22 to 30 inches). Soils were sampled by compositing ten 12 inch-deep soil cores from each plot. Soils were air dried and analyzed for extractable P using the Olsen (0.05Msodium bicarbonate) method. All stalks in each plot were cut at a 4-inch stubble height, counted, and weighed fresh in the field. The total fresh weight was used to estimate harvested tonnage. Three individual stalks were sub-sampled, weighed fresh, and put in the dryer the day they were cut. The plants were dried to 100% dry matter, re-weighed, ground, and analyzed for nutrient content using nitric acid digestion and Inductively Coupled Plasma analysis (Ippolito & Barbarick, 2000).

Table 1.

Sampling Locations of Corn Silage Fields in Southern Idaho

	Number of Fields Sampled	
County	**2008**	**2009**
Jerome	3	4
Twin Falls	4	4
Lincoln	3	2
Canyon	3	2
Cassia	3	2

Franklin	2	2
Gooding	2	5
Payette	1	0
Total	**21**	**21**

The data analysis was generated using SAS software, Version 9.2 of the SAS System for Windows, Copyright © 2002-2008 SAS Institute Inc. (SAS Institute, 2008). Using the SAS software, the PROC Surveymeans procedure was used to determine mean, standard error, and 95% confidence interval for yield, soil test P, dry matter content, P tissue concentration, and P uptake. Using the SAS software, the PROC Surveyreg procedure was used to perform a linear regression analysis between soil test P and corn plant tissue P concentration. Corn plant and soils were sampled over a two-year period as a method for increasing sample size and not to determine correlations between years. The effect between years is irrelevant to the study.

Results and Discussion

Average P concentration in the whole plant dry tissue at harvest was 0.208 % (Table 2), with 39 of the 42 fields (93%) sampled between 0.15 and 0.25 % (Figure 1). It appears that the NRCS default value for corn tissue P of 0.185% in the OnePlan.org© planning program (Idaho Association of Soil Conservation Districts, 2010) underestimates silage corn P removal and unnecessarily limits manure applications in all plans written since June 2007. The NRCS staff has agreed to change the values based on the survey findings. With more accurate silage corn P uptake estimates, higher and more realistic manure application rates can be planned and used by producers with more recent plans. However, producers with a NMP written before June 2007 have been grandfathered in with P uptake based on a tissue P of 0.26 %. As tissues from only three of the 42 fields measured at or above 0.26 % P, most producers using this estimate for P removal are likely overestimating P uptake by silage corn, over-applying manure, increasing soil test P, and the risk of higher runoff P. Producers with an older NMP should consider using 0.208 % as the value for tissue P when estimating P removal by silage corn. For the most accurate estimates of silage corn P uptake and removal, producers should analyze chopped corn samples from each harvest for nutrient content, and adjust manure applications accordingly.

Table 2.

Whole Plant Tissue Analysis, Yield, Dry Matter, P Uptake, and Soil Test Results

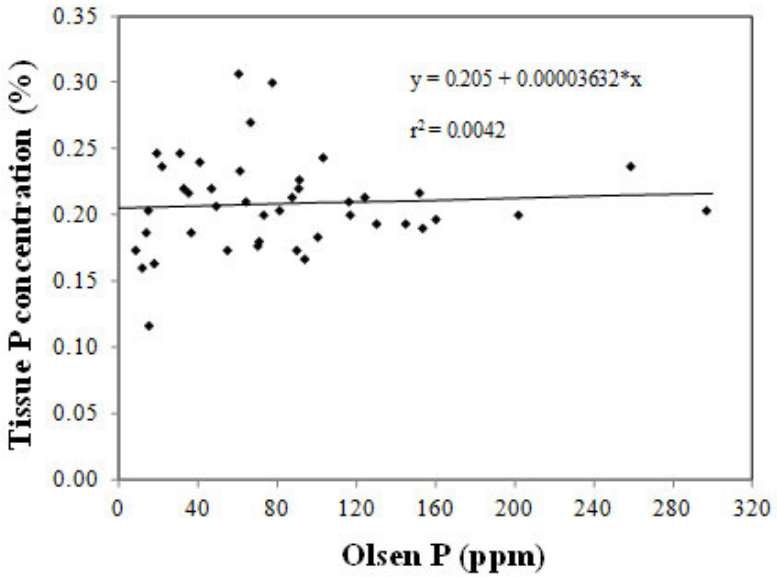
Variable	Mean	Standard Error	95% Confidence Interval	Observed Minimum	Observed Maximum

Yield (wet ton/acre)	31.6	1.05	29.4	33.7	15.7	43.6
Yield (dry ton/acre)	10.6	0.38	9.8	11.3	5.8	18.2
% dry matter	33.8	0.98	31.9	35.8	23.8	54.5
Tissue Concentration % P	0.208	0.0054	0.197	0.219	0.116	0.307
Soil Test ppm	83	9.7	63.6	102.9	8	297
P uptake (lb/acre)	43.6	1.77	40.0	47.2	24.1	76.3

The data in Figure 1 shows tissue P concentrations were not significantly correlated (R2=0.0042) to Olsen P soil tests ranging from 8 to 297 ppm (Figure 1). While there was some variability in tissue P for reasons that are not clear, there is little if any corn luxury consumption of P. Corn uses the amount of P necessary for growth and production but corn doesn't accumulate excess P simply because it is in the soil.

Figure 1.

Whole Plant Corn Tissue Total P Concentration as Related to End of Season Olsen Soil Test P in Southern Idaho



Impacts

The impact for Extension clientele can be shown in the following example. Using the survey's average corn silage yield of 11.2 dry tons /A, 58 pounds of P/A are removed using the pre

2007 P concentration value of 0.26%, only 41 pounds of P/A are removed using the post-2007 changed value of 0.185%, and 47 pounds are removed using the survey's 0.208% P average. Changing the default P concentration for silage corn in the OnePlan.org© program from 0.185% to 0.208% enables livestock producers to apply 0.9 tons/A more manure to fields limited to P based manure application, assuming lot scraped dairy manure contains approximately 6 pounds of P/ton (Zublena, Barker, & Wesen, 1994). An additional 90,000 tons of manure could be applied in a given year for 100,000 silage corn acres. Assuming each lactating dairy cow produces 20.4 tons of manure a year (United States Department of Agriculture, 1994) the increased application equates to an additional 4,400 cows.

For Idaho dairymen operating under a NMP written before June 2007, using the original plan default of 0.26% P has enabled over application of 1.9 tons/A, which equates to 190,000 excess tons of manure, applied each year for 100,000 acres, or that equal to about 9,300 additional dairy cows. The higher manure rates and imbalance of P removed with that higher rate has likely caused soil test P to continue to increase with the increased potential for P runoff. Idaho dairy producers already are permitted for far more dairy cows than are in production, and producers as an aggregate could expand by several thousand head without going through any additional permitting or planning requirements. If manure application is increased, there is a greater potential for P runoff because fields are not a closed system and the P recovery efficiency by corn is not 100%. Conversely, reduced manure application will reduce the potential for P runoff.

The aggregate impact on potential P runoff of using improved estimates of P removal is difficult to determine. The percentage of NMPs written before or after June 2007, the acreage involved, and the allowed manure application rates on that acreage are not known. Idaho privacy laws protect NMP information from public scrutiny. Clearly, using more accurate P removal estimates, 11 lb P/A less (47 vs 58 lb/A) than that estimated in older plans (pre 2007) could make a substantial difference in P runoff potential from those acres without affecting corn P removal. Increasing corn P removal estimates by 6 lb P/A (47 vs 41lb/A) from estimates in the post 2007 plans would increase the risk of P runoff, but this would be mitigated somewhat by increased corn P uptake and removal. If nothing else, the survey results indicate where educational efforts should be focused for reducing the greatest risk of higher P in runoff to water resources. Furthermore, applying less P than removed is not sustainable in the long term for maintaining or increasing yield and would require purchased P fertilizer.

A positive impact of enabling higher manure application rates for a post-2007 NMP is the reduction in the mineral nitrogen (N) producer's purchase to supplement manure applications. The manure N from P removal based applications typically falls short of meeting the N requirements for optimal corn production.

A final positive impact of the study has been the relationship building with the NRCS staff and the reinforced credibility of Idaho Cooperative Extension Nutrient Management professionals,

as indicated by NRCS willingness to alter the Idaho OnePlan.org© program.

Summary

Based on soil and whole plant samples collected from 42 fertilized and manured silage corn fields in Southern Idaho over a two-year period, University of Idaho Extension recommended that NRCS change the default tissue P concentration values used in the OnePlan.org© program from 0.185% to 0.208%. Producers with plans written before June 2007 are encouraged to reduce the amount of manure applied to their fields while those with plans written since June 2007 will be able to apply additional manure to their fields. More balanced manure P applied and crop P removal should decrease the P runoff potential from the 11,000,000 tons of Idaho dairy manure generated each year.

References

Idaho Administrative Procedures Act, Rules governing nutrient management, IDAPA 02 .04.30.000-990. (2008). Retrieved from: http://adm.idaho.gov/adminrules/rules/idapa02/0430.pdf

Ippolito, J. A., & Barbarick, K. A, (2000). Modified nitric acid plant tissue digest method. *Communications in Soil Science and Plant Analysis*, 31, 2473-2482. doi:10.1080/00103620009370602

Oldham, J. L, (2007). Understanding the different phosphorus indices in nutrient management planning. *Journal of Extension* [On-line], 45(1), Article 1TOT6. Available at: http://www.joe.org/joe/2007february/tt6.php

OnePlan.org© (2010) [Online planning program]. Boise, ID: Idaho Association of Soil Conservation Districts.

Robison, C. W., Allen, R. G., & Merkle, R., (2002). Water quality of surface irrigation returns in southern Idaho. In C.M. Burt & S.S. Anderson (Eds.), *Proceedings of 2002 US Committee on Irrigation and Drainage Environmental and Water Resources Institute* (pp.243-252). Retrieved from: http://www.kimberly.uidaho.edu/midsnake/docs/uscidewri/paper.pdf

Said, A, (2008). Estimating limiting nutrient loading in an interacting surface and groundwater basin. *Journal of Spatial Hydrology*, 6(2), 23-37. Retrieved from: http://www.spatialhydrology.com/journal/paper/fall2006/Nutrient.pdf

SAS Institute (2008) (Version 9.2) [computer software]. Cary, NC

Sheffield, R, Brown, B., Chahine, M., de Haro Marti, M., & Falen, C., (2008) *Mitigating high phosphorus soils* (Bulletin 851). Retrieved from: http://www.cals.uidaho.edu/edcomm/pdf/BUL/BUL0851.pdf

United States Department of Agriculture, Natural Resources Conservation Service. (1994).

Agricultural waste management field handbook (NEH Part 651, Ch. 4). Retrieved from: http://policy.nrcs.usda.gov/viewerFS.aspx?hid=21430

United States Department of Agriculture, National Agricultural Statistics Service, Idaho Field Office & Idaho State Department of Agriculture (2010). *2010 Idaho agricultural statistics*. Retrieved from: http://www.nass.usda.gov/Statistics_by_State/Idaho/Publications/Annual_Statistical_Bulletin/index.asp

United States Department of Agriculture, Natural Resources Conservation Service (2011). *Nutrient content of crops* [web link]. Crop nutrient calculator available online. Retrieved from: http://plants.usda.gov/npk/DisplayCrops?sflag=common&source=html&croptype=Forage&searchstring=&submit_crop_type=View+Crop+List

Zublena, J. P., Barker, J. C., & and Wesen, D. P., (1994). SoilFacts: Dairy manure as a fertilizer source (NCCES AG-439-28). Retrieved from: http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-28/AG-439-28.pdf

---