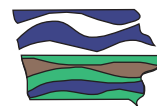


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2003 SUMMARY OF RESULTS

MAQUOKETA WATERSHED PROJECT

TABLE OF CONTENTS

Introduction	3
Corn following soybean - Phosphorus management	4
Corn following soybean - Nitrogen management	7
Manure management	11
Map of Maquoketa and Elk River watersheds	15
The end-of-season cornstalk nitrate N test	16
Online resources	18

INTRODUCTION

Since crop year 2000, 56 producers in the Maquoketa River, Elk River and Mud Creek watersheds of eastern Iowa hosted 73 on-farm nutrient management field demonstrations. The demonstrations evaluated the effectiveness of manure as a source of nitrogen and phosphorus, and compared several rates of nitrogen and phosphorus in corn-following-soybean rotation.

Field demonstrations were conducted to provide the cooperating farmers with information using their normal production practices and small nutrient rate alternatives to assist in refining crop nutrient inputs. Computer modeling scenarios suggest that watershed producers can save \$7 to \$9.50 per acre by refining manure and nitrogen use and up to \$18 per acre by eliminating phosphorus fertilizer applications on high or very high testing soils. The field demonstration results have shown that manure does have a high value for crop production and that commercial nitrogen and phosphorus applications can be reduced while maintaining corn yields and increasing net farm income.

Growing conditions resulting in exceptional corn yields the past three seasons have provided a unique opportunity to measure the effectiveness of refined nutrient management. Results from a wide area of eastern Iowa are presented in the following field demonstration summary.

CORN FOLLOWING SOYBEANS – PHOSPHORUS MANAGEMENT

Each of the past four growing seasons, producers in the Maquoketa watershed have questioned the need for crop removal application of phosphorus (P) fertilizer. Past practice on many farms called for annual or bi-annual applications of P and potassium before the next corn crop. These applications were often considered to be "putting money in the bank" if P wasn't really necessary in the year of application. However, as operating margins tighten and concerns about the impact of P on the environment escalate it is necessary to know for sure if additional P is needed. The best way to determine if P is needed is to conduct a soil test to measure the crop available P in the soil resource.

Twenty-two producers hosted P management demonstrations to study the impact of P applications on corn yield in a corn/soybean rotation. As part of each demonstration a baseline soil sample was collected to measure the available soil P. Through this process 77 percent of the demonstration sites were found to be testing high, 21 to 30 parts per million (ppm), or very high, greater than 30 ppm for P, with an average P test of 53 ppm. Five of the 22 locations tested 20 ppm or less for soil P.

Iowa State University recommends fertilizing with P when soil tests fall below the high range (less than 21 ppm P), with an option to use a low rate of P in starter fertilizer when P tests are in the high soil test range. Based on an average P soil test of 53 ppm, no yield increase would be expected. Cooperators sought to confirm this expectation by implementing replicated, multi-rate demonstrations across many field conditions and years.

The corn-following-soybean demonstrations were fertilized with a single, non-limiting N rate of 120 pounds per acre and received replicated applications of P₂O₅ at zero, 46 (crop removal rate) and 92 pounds per acre (two-year crop removal rate).

When yields from all sites were averaged, there was no yield response to the one and two-year crop removal rates of added P. Applications of 0, 46 and 92 pounds P per acre resulted in average yields of 195, 194 and 196 bushels per acre, respectively.

There was a yield increase when P was added to optimum and low P (less than 21 ppm) testing sites, as shown by the blue bars in the figure 1. Corn yield did not increase significantly when P was applied to high or very high P (21 ppm or greater) testing sites, especially when soil tests were at the highest end of the range, as shown by the brown bars.

When corn is valued at \$2.40 per bushel and P costs \$0.23 per pound, improved yield due to P application, regardless of soil test level, was not sufficient to pay for P fertilizer and application costs, as shown in the lower portion of the figure. When soil tests are in the very high range, net return to P was reduced significantly.

These results confirm economic modeling conducted by the Texas Institute for Applied Environmental Research, TIAER, for producers in the Maquoketa Headwaters, which showed that farm profits could be increased by more than \$18 per acre if crop removal applications of P to high and very high testing soils were eliminated.

Applying phosphorus fertilizers to high P testing soils adversely affects more than just profitability. Phosphorus, once considered a stable nutrient, can go into solution and run off in rainwater or move through the soil and drain from the field in tile water. A University of Illinois study showed that soil test levels as low as 20 ppm P with any commonly-used tillage system will result in P in runoff water that is two times greater than the benchmark limit of 0.035 ppm set for lakes in Environmental Protection Agency Region 7.

Measuring soil P levels and utilizing prior P investments by not making new applications should not be viewed as mining the soil but as good financial and environmental resource management. Table 1 on the next page provides P recommendations based on three different soil tests for corn and soybean production.

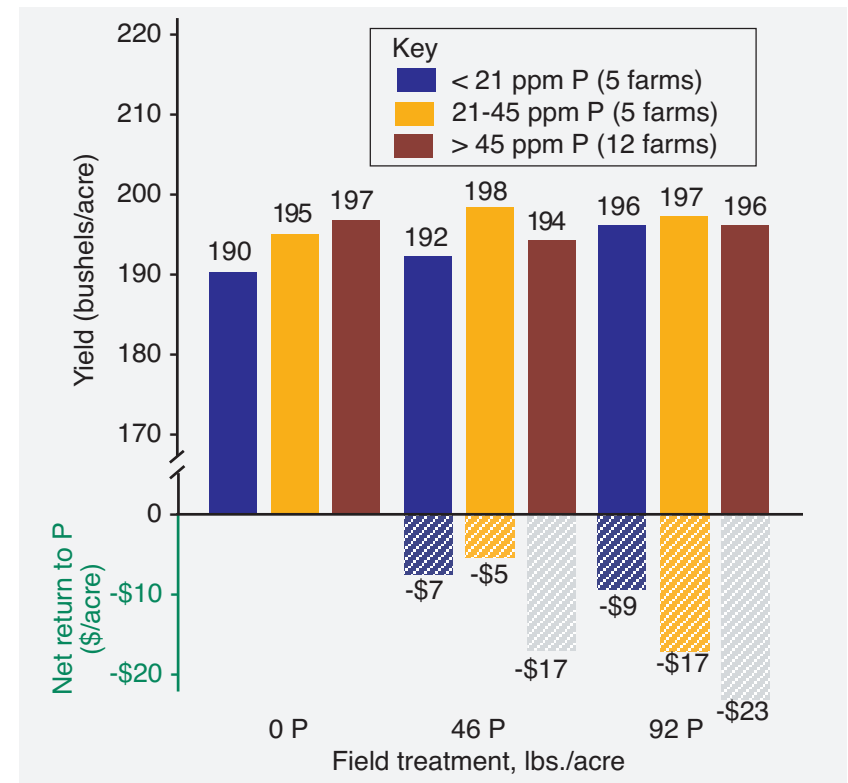


Figure 1. Yields and net return to P on 22 on-farm P management demonstrations, corn following soybeans, 2000-03.

PHOSPHORUS (P) RECOMMENDATIONS FOR CORN AND SOYBEAN GRAIN PRODUCTION.

Soil test category	P soil test (ppm) ^a				
	Very low	Low	Optimum	High	Very high
Bray P, and Mehlich-3 P					
Low subsoil P	0-8	9-15	16-20	21-30	31+
High subsoil P	0-5	6-10	11-15	16-20	21+
Olsen P					
Low subsoil P	0-5	6-10	11-14	15-20	21+
High subsoil P	0-3	4-7	8-11	12-15	16+
Crop	P₂O₅ to apply (lbs/acre)				
Corn	100	75	55	0	0
Soybean	80	60	40	0	0

^a The recommended amounts of P₂O₅ for the optimum test category are based on nutrient removal for the reported yield. The amounts shown in the table for the optimum soil test category are for 150 bu corn grain per acre or 55 bu soybean per acre which will be used if no yield goals are given on the information sheet.

Recommendations for soils with a corn suitability rating (CSR) of 30 or less will be based on expected crop yield and nutrient removal for soil test categories of optimum or lower.

SOIL SAMPLING TIPS

- Develop a sampling plan.
- Identify areas with different uses, then sample separately.
- Collect 15-20 cores per sample to increase confidence in the results.
- Sample at the same time of year following the same crop each time.
- Make visual observations during sampling.
- Use a certified lab for analysis, contact the Iowa Department of Agriculture and Land Stewardship for a current listing.
- Keep accurate records of past soil sample results.

CORN FOLLOWING SOYBEANS – NITROGEN MANAGEMENT

Between 1995 and 2000, the number of acres planted to soybeans in the eight counties that the Maquoketa River flows through increased from 389,000 acres to 668,000 acres.

Growers added soybeans to their rotation in response to the farm program and commodity prices, and some use the rotation to break weed, insect and disease cycles associated with continuous corn production. University of Wisconsin research conducted from 1987-2001 shows corn yields 17 percent higher, 169 bushels per acre, when rotated with soybean than a continuous corn system, 140 bushels per acre. In addition, the amount of nitrogen (N) needed for corn can be reduced following soybeans.

Iowa State University recommends applying 100-150 pounds N per acre for corn following soybeans versus applying 150-200 pounds N per acre for continuous corn. During the past four crop seasons, producers in the Maquoketa watershed have studied N management in an attempt to further refine ISU recommendations, increase farm profitability and reduce N loss to the environment.

Cooperating producers have used both small-plot demonstrations and larger, field-scale demonstrations to compare several different N rates. Two years of field-scale N demonstrations hosted by thirteen eastern Iowa producers produced remarkably similar results to small-plot N demonstrations conducted by 19 producers in the Maquoketa and Mud Creek watersheds. These corn-following-soybean demonstrations show that N use is optimized when applied at rates between 90 and 120 pounds N per acre.

FIELD-SCALE N DEMONSTRATIONS

To initiate each N demonstration, cooperating producers applied N treatments pre-plant, at planting or side-dress either as anhydrous ammonia, 28 percent urea ammonium nitrate (UAN) solution or 32 percent UAN solution in large field-width blocks at five N application rates (zero, 60, 90, 120 and 150 pounds N per acre). Treatments were from two to 10 acres in size. Each demonstration field was machine harvested using a combine equipped with a global positioning system-enabled yield monitor.

Figure 2 shows corn yield, residual nitrate-N and return to N from 13 field-scale N demonstrations. Average yield for each of the five N treatments, ranging from 155 to 195 bushels per acre, shown as the white bars.

Residual nitrate-N in the cornstalks following corn maturity was measured for all N treatments, shown as the brown bars in the graph.

To measure the residual nitrate-N in the cornstalks, fifteen 8-inch segments of the lower stalk are collected from each N treatment and sent to a certified laboratory. To learn more about the end of season stalk test please turn to page 16.

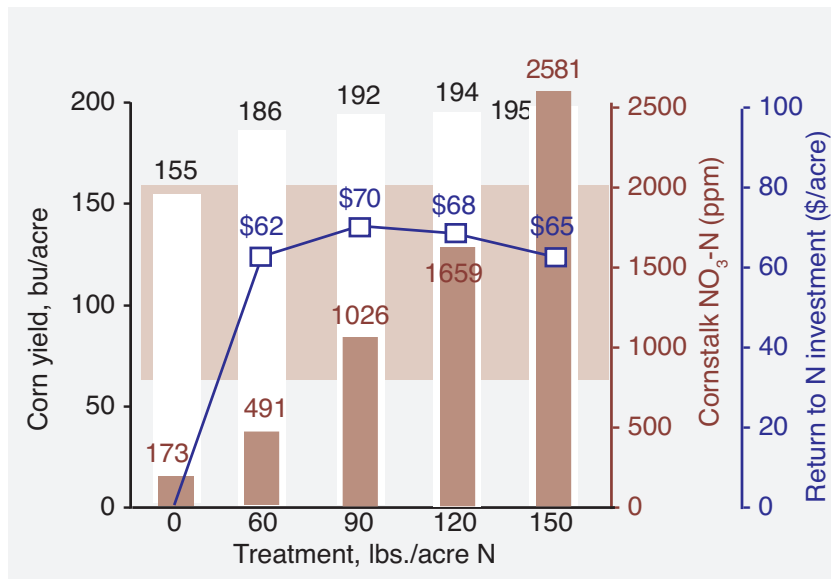


Figure 2. Corn yield, end-of-season cornstalk nitrate-N results and return to N investment from 13 field-scale N rate demonstrations, 2002-2003. The return to N investment is based on corn at \$2.40/bushel and N at \$0.20/lb.

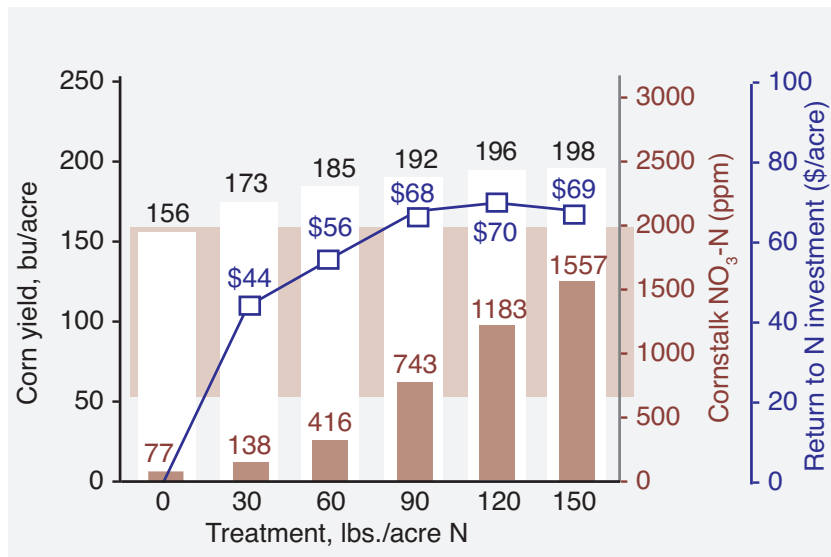


Figure 3. Corn yield, end-of-season cornstalk nitrate-N results and return to N investment from 19 small-plot N rate demonstrations on corn-following-soybeans, 2000-03. (Corn at \$2.40/bushel and N at \$0.20/lb.)

The check and 60 pounds N per acre treatments did not have enough N available to optimize corn production. Both the 90 and 120 pounds N per acre rates were within the optimum range of 700 to 2,000 parts per million (ppm), while the 150 pounds N per acre rate showed excessive N remaining in the corn plant after maturity.

The optimum range for cornstalk nitrate-N of 700-2,000 ppm, marked by medium-green rectangles in the background, indicates a high probability that the appropriate N rate was applied to the crop to provide the most profitable return on the N investment.

The average return to dollars spent for N fertilizer, priced at 20 cents per pound and corn at \$2.40 per bushel, is shown as the blue line on the graph. The best return to N fertilizer, \$70 per acre, was the 90 pounds N per acre rate. Application of N at rates higher than 90 pounds N per acre showed a reduction in net return to the N investment.

SMALL-PLOT N DEMONSTRATIONS

To implement the smaller N demonstrations, six rates (zero, 30, 60, 90, 120 and 150 pounds N per acre) of N were applied at planting to replicated plots in one-half acre, uniform soil type demonstration sites. Each treatment covers a 15- by 40-foot area and is repeated three times at each location. Ammonium nitrate was used as the N source because of its non-volatile nature.

Figure 3 details corn yield, residual nitrate-N and return to N from 19 N management demonstrations. Average yield for the 90, 120 and 150 pounds per acre rates all exceed 190 bushels per acre, shown by white bars.

As with the field-scale N demonstrations, end-of-season cornstalk nitrate-N was measured at harvest for all N treatments. The residual nitrate-N is lower at all N rates than in the field-scale study due mostly to the N source being surface-applied rather than incorporated mechanically. However, the resulting trend of higher residual nitrate-N when more N is applied is the same both large and small-plot demonstrations.

A second series of small-plot N demonstrations were conducted by three northeast Iowa producers during 2003 using six rates of N (zero, 40, 40, 120, 160 and 200 pounds N per acre) on corn-following-soybeans.

In these demonstrations, the application of 120 pounds N per acre resulted in the highest yield, 207 bushels per acre, the highest return to N, \$97 per acre, and was the only treatment with residual stalk nitrate-N in the optimum range, 1378 ppm NO₃-N (figure 4, page 10).

Field demonstrations cooperators found that comparing N rates in small demonstrations can be an effective way to study N refinement strategies. Figure 5 (page 10) shows a comparison of yields from the field-scale and small-plot demonstrations. Notice that yield by treatment does not vary by more than three bushels per acre between the small-plot and field-scale demonstrations.

MANURE, N AND P MANAGEMENT USING THE MANURE AT ITS USUAL APPLICATION RATE ON COOPERATING FARMS

Twenty Maquoketa Watershed farmers hosted on-farm manure management demonstrations during crop years 2000-03 to study manure as a crop nutrient resource. Manure from beef, dairy, poultry and swine operations was previously regarded as a waste product, but these producers found that by accounting for nitrogen (N) and phosphorus (P) in the manure and by reducing commercial N and P applications on fields receiving manure they could significantly increase net return to their cropping operations.

Each manure management demonstration involved a manure spreader calibration to accurately determine the amount of manure applied, in addition to the collection of a representative manure sample for laboratory analysis to quantify the amount of nutrients applied with the manure. Crop available N, P and potassium were calculated for each demonstration using manure application rate, manure nutrient analysis results and nutrient availability factors obtained from ISU Extension publication PM 1811, Managing Manure Nutrients for Crop Production.

MANURE N MANAGEMENT

Average corn income increased \$64 per acre when manure was the only N fertilizer source compared to the zero check, when corn was valued at \$2.40 a bushel, shown by the black line in figure 6, page 12. Return to an application of 100 pounds N per acre was \$45 per acre, \$19 per acre less than when manure was the sole N source. The cost of manure hauling was not calculated because the cost varies greatly between operations and manure spreading is usually associated with livestock production accounting.

To initiate each demonstration the producers applied solid or liquid livestock manure at their historic application rate as a baseline for the demonstrations. Solid manure was applied in a range from 9 to 26 tons per acre and liquid swine manure was applied at rates between 2,500 and 5,000 gallons per acre. Two rates of N, 50 and 100 pounds per acre, were randomly applied as replicated treatments in addition to manure. The solid manure was surface applied, usually in the fall, and not incorporated until immediately prior to planting, while liquid manure was incorporated at application. Other field treatments were a check (no manure and no N) and a single application of 100 pounds N per acre to corn following soybean or 150 pounds N per acre to second-year corn (the 100N* column in the figure).

Average first-year crop-available N credits from manure averaged 133 pounds per acre (M) for the 20 demonstrations, while the manure contribution ranged from 29 to 286 pounds N per acre. The manure N contribution

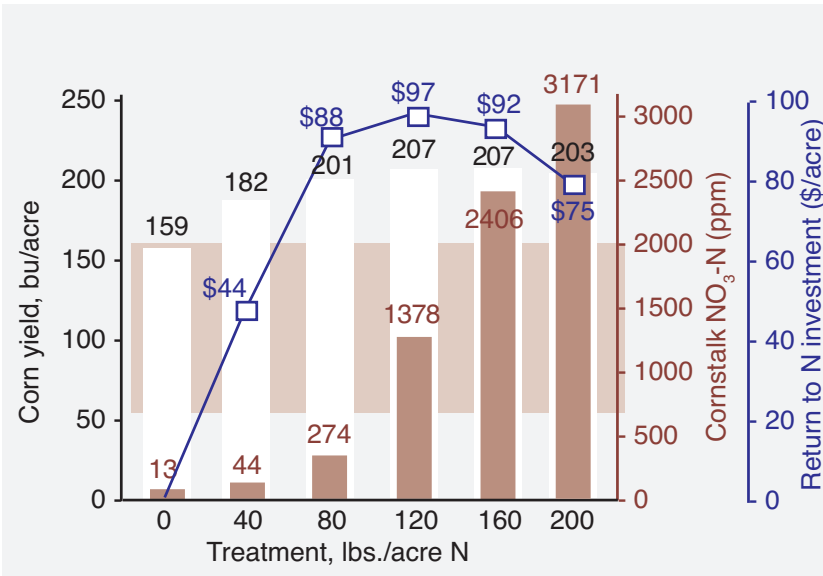


Figure 3. Corn yield, end-of-season cornstalk nitrate-N results and return to N investment from three small-plot N rate demonstrations on corn-following-soybeans, 2003. (Corn at \$2.40/bushel and N at \$0.20/lb.)

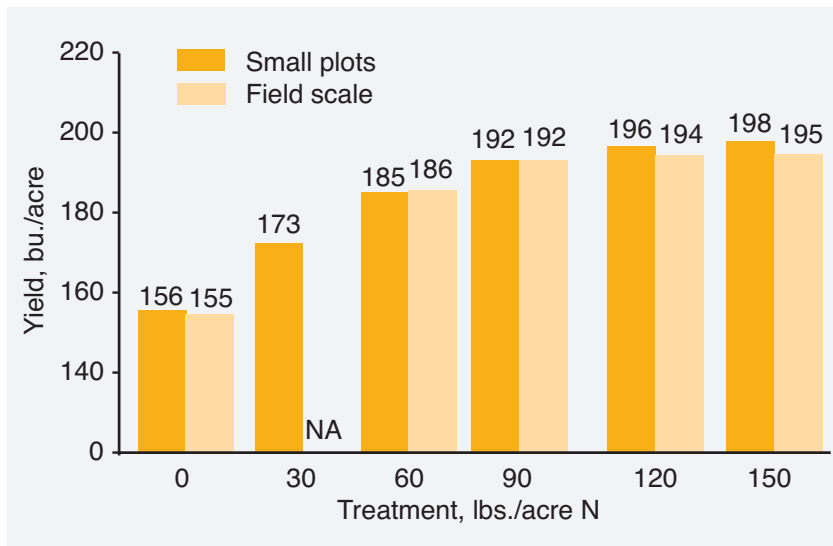


Figure 5. Comparison of yields at 19 sites of small-plot field demonstrations (2000-2003) and 13 sites in the field-scale nitrogen study (2002-2003).

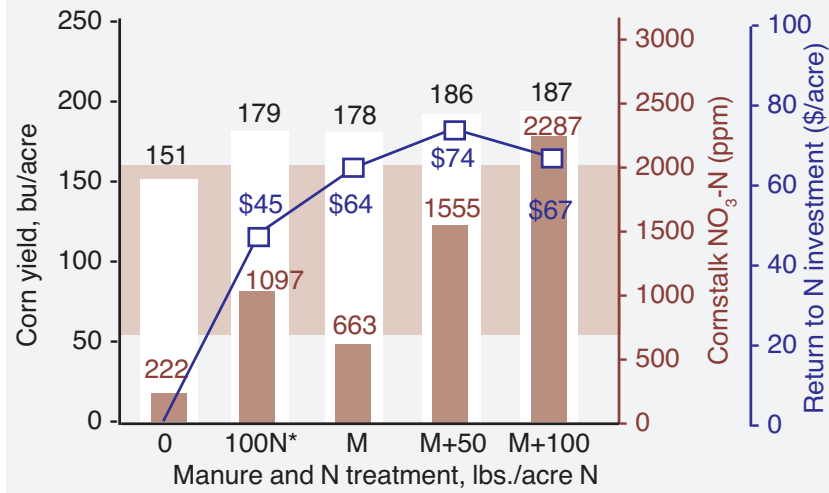


Figure 6. Corn yield, end-of-season cornstalk nitrate-N results and return to N investment from 20 manure demonstrations (corn at \$2.40 per bushel and N at \$0.20 per pound), 2000-03. Manure N contribution equals 133 pounds N per acre. *See text: either 100 or 150 lbs. N per acre.

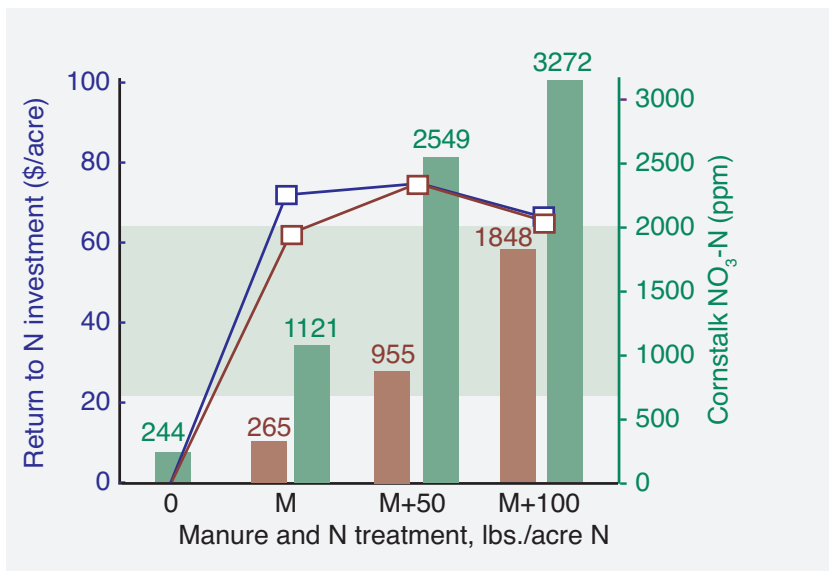


Figure 7. Return to N investment and end-of-season cornstalk nitrate-N results from 5 liquid swine manure (169 pounds N per acre) and 15 solid dairy, beef, poultry and swine manure (97 pounds N per acre) demonstrations, 2000-03. (Corn at \$2.40/bushel and N at \$0.20/lb.)

bution was calculated using adjustment factors of field manure history, N loss from surface application versus manure incorporation and first-year nutrient availability based on the type of manure applied.

When a minimal amount of N, 50 pounds per acre, was applied in addition to manure, corn yield increased from 178 bushels per acre to 186 bushels per acre, as shown by the white bars in figure 6. In addition, net return to added N increased \$10 per acre to \$74 per acre for manure plus 50 pounds N per acre shown with the blue line. Applying at the 100-pound N rate did not increase corn yield sufficiently to pay for the extra N.

The end-of-season cornstalk nitrate N (residual N in the corn plant at maturity) was in the optimum range, 1,555 parts per million (ppm), when 50 pounds N per acre supplemented the manure application, as shown by the dark bars in figure 6.

When manure was the only N source residual nitrate-N after maturity was slightly less than optimum at 663 ppm.

The optimum range for cornstalk NO₃-N is 700 to 2,000 ppm, indicating a high probability that the appropriate N rate was applied to the crop to provide the most profitable return on the N investment. Analyses higher than 2,000 ppm indicate that the N application rate most likely exceeded the N requirement of the crop.

Five of the 20 demonstrations involved the application of liquid swine finishing manure. Average first-year available N applied with the manure was 169 pounds per acre. At these sites no significant economic benefit resulted from the addition of commercial N, shown in figure 7. Adding 50 pounds N per acre to swine manure also resulted in excess residual cornstalk nitrate-N, 2,549 ppm, versus when 50 pounds N per acre was applied in addition to solid manure, 955 ppm NO₃-N. Calculated first-year available N in the solid manure was 97 pounds per acre.

The results show that manure is a significant source of crop available N but additional N from commercial fertilizer may be needed to supplement manure applications when insufficient amounts of manure are applied or the manure application is not uniform. However, when manure is applied uniformly at sufficient rates to supply crop needs added commercial N will not be used efficiently and net income will be reduced.

MANURE P MANAGEMENT

Manure applied to high or very high P soil test fields (more than 20 ppm P) rapidly increased soil P levels but did not increase corn yield when compared to a commercial application of N at 100 pounds per acre receiving no additional P, as shown in figure 8, next page.

Prior to each demonstration a single baseline soil sample was collected from the demonstration site. Average soil P from the 20 demonstration sites was 56 ppm P, shown in figure 8 as the horizontal orange line. Replicated treatments of manure (M), manure plus 46 P, and 100 pounds N per acre plus zero P, 46 P or the manure P (MP) contribution (139 pounds P per acre) applied as commercial P were usually fall-applied at

each location. Following corn maturity, post-season soil samples were collected for each treatment. Fifteen soil cores were collected for each sample.

Average yield varied only three bushels per acre between the five field treatments, not enough to pay for a single crop removal P application.

While yield did not vary, soil test values increased from their already very high level for each treatment receiving either commercial or manure P. Manure alone increased soil P, from 56 ppm to 80 ppm, with a single application, shown by the yellow bars. The P contribution in the liquid swine manure and solid beef, dairy and swine manure were similar on average and increased soil P equally.

When P is valued at \$0.23 per pound, the lost value by applying 139 pounds per acre manure P to high or very high P testing fields was nearly \$32 per acre because there was no yield benefit from the P application.

To get the most benefit from manure P, target manure applications to low or optimum testing fields further away from livestock operations. After seeing initial demonstration results some Maquoketa Headwaters watershed producers started hauling manure two to three miles, one way, in order to get the most economic benefit from the manure and to reduce the impact excess soil P levels may have on the environment.

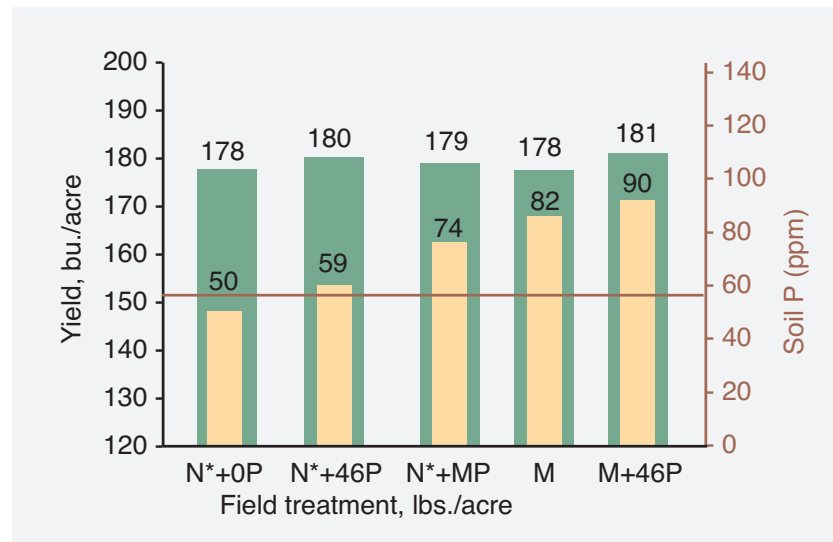
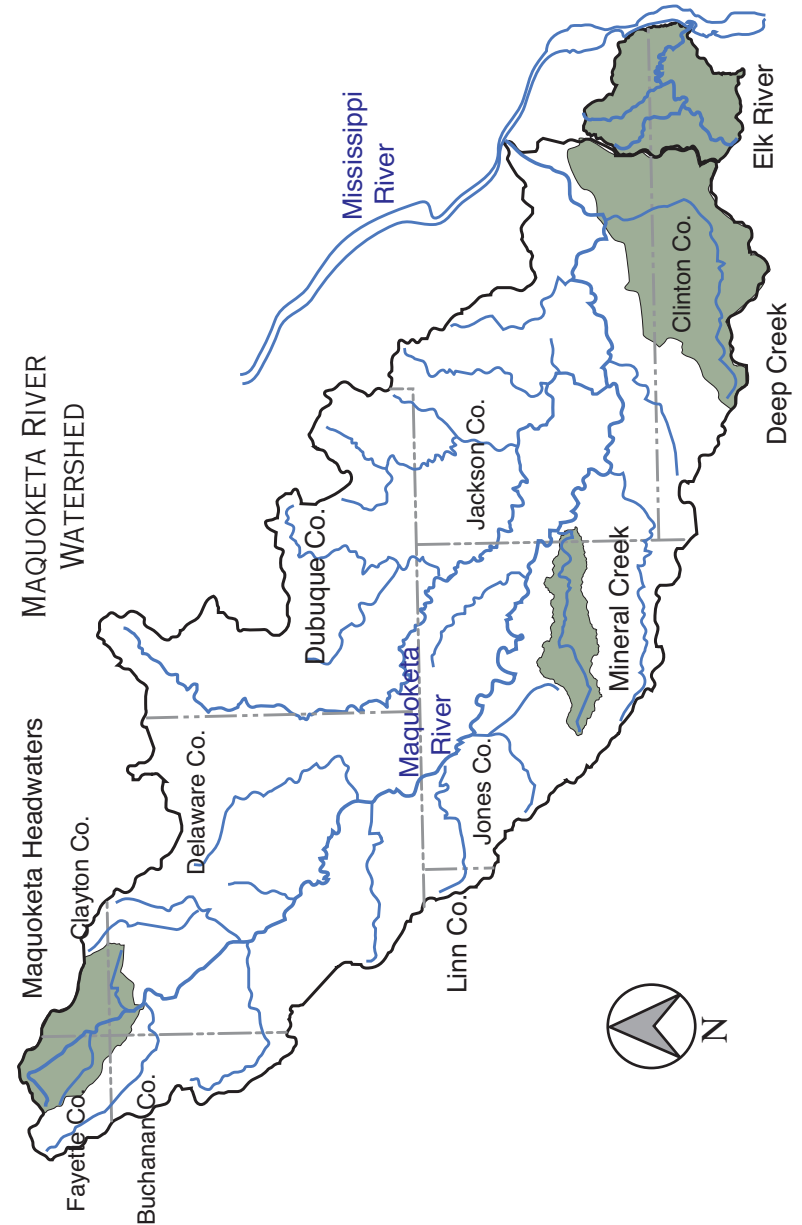


Figure 8. Corn yield and soil phosphorus levels. Pre-demonstration average soil P was 56 ppm indicated by the brown line in the middle of the graph.



Maquoketa River and adjacent Elk River watersheds. Mud Creek (not shown) is in Cedar, Muscatine and Scott counties.

THE END-OF-SEASON CORNSTALK NITRATE N TEST

Cornstalk residual nitrate levels are an indicator of whether or not the nitrogen supply is adequate for corn development. The test measures nitrate concentration in the lower portion of the cornstalk at the end of the growing season.

The basis of the test is that a corn plant suffering from inadequate nitrogen availability removes nitrogen from the lower cornstalk and leaves during grain filling. If the plant has more nitrogen than needed for maximum yields, nitrate accumulates in the lower stalks at the end of the season.



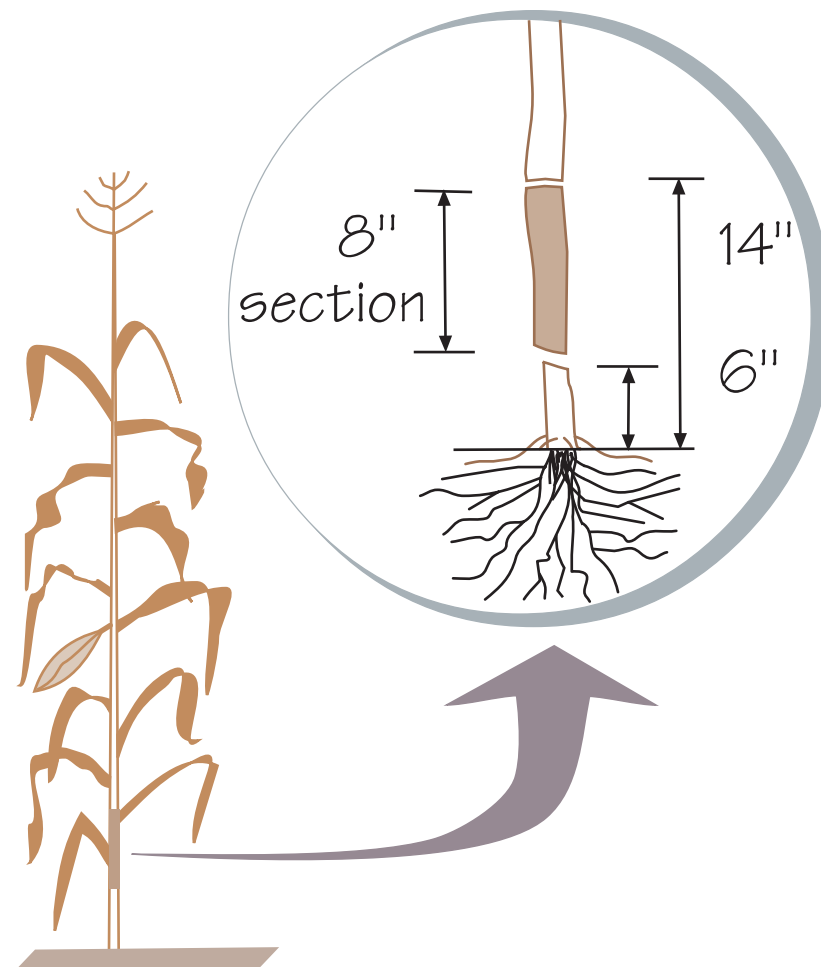
Producers can use this information to determine whether or not their corn crop had adequate nitrogen late in the growing season.

Low stalk nitrate nitrogen levels (less than 250 parts per million, or ppm) indicate that additional nitrogen would have been likely to increase yields. The marginal range (250-700 ppm) indicates a level very close to the minimal amount needed by the crop, but grain yield may not be reduced. The optimum rate (700-2,000 ppm) indicates that nitrogen availability was close to the rate needed by the plant, while levels in excess of 2,000 ppm indicate a high probability that there was more nitrogen than needed.

The cornstalk nitrate N test is a valuable tool for nitrogen management, however drastic changes in nitrogen management should not be made with just one year's results. Annual sampling can provide trends of residual nitrate levels over time, accounting for seasonal variability, ultimately increasing the confidence in refining nitrogen management.

Try using the end-of-season stalk nitrate test to compare two nitrogen management practices, such as two nitrogen rates or manure versus manure plus some rate of commercial nitrogen.

Contact the Maquoketa Watershed Project staff or your local ISU Extension staff for a list of labs doing the end-of-season cornstalk nitrate nitrogen test.



HERE'S HOW TO COLLECT SAMPLES:

Cut an 8-inch segment of stalk beginning 6 inches above the soil. Optimum time for sampling is when the corn is between one to three weeks after black layer formation. Remove the leaf sheaves.

Do not sample stalks severely damaged by disease or insects.

Fifteen 8-inch segments make up a single sample. Areas of a field differing in soil types or management history should be sampled separately.

Place the samples in paper (NOT PLASTIC) bags and send to the lab as soon as possible. If it's not possible to send the samples to the lab within one day of removing them from the stalk, place them in the refrigerator — but don't let them freeze.

ONLINE RESOURCES FOR MANURE, PHOSPHORUS AND NITROGEN MANAGEMENT

Iowa Manure Management Action Group (IMMAG)

<http://extension.agron.iastate.edu/immag>

ISU Extension Maquoketa River Watershed Project

<http://extension.agron.iastate.edu/waterquality/projects/maquoketa.html>

Nitrogen and Phosphorus Knowledge

<http://extension.agron.iastate.edu/NPKnowledge>

Iowa State University Extension Publications

<http://www.extension.iastate.edu/pubs>

Natural Resources Conservation Service

<http://www.ia.nrcs.usda.gov>

Iowa Department of Natural Resources, Environmental Protection
Division

<http://www.state.ia.us/epd>

Iowa Department of Agriculture and Land Stewardship

<http://www.agriculture.state.ia.us>

ISU Odor and Nutrient Management Newsletter

<http://www.exnet.iastate.edu/Pages/communications/EPC>

Midwest Plan Service

<http://www.mwpshq.org>

Iowa Corn Growers Association

<http://www.iowacorn.org>

Iowa Pork Producers Association

<http://www.iowapork.org>

This Summary of Results was created by Chad Ingels, nutrient and manure management specialist, and Charles Wittman, communication specialist, Maquoketa Watershed Project.

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