PROGRESS REPORT

Utilization of Enhanced Efficiency Nitrogen Fertilizer and Managed Drainage to Reduce Nitrate-N Loss

Investigators:
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Objective and Relevance:

Enhanced efficiency fertilizers such as polymer-coated urea have been shown to reduce nitrate concentrations in lysimeters in claypan soils (Nelson et al., 2009). These fertilizers may further reduce NO_3-N loss through subsurface drainage systems that utilize managed drainage for corn production, but no research has been conducted to evaluate both best management practices. Agricultural drainage is not a new concept; however, utilizing managed drainage as part of an integrated water management system (IWMS) is a relatively new concept that has been shown to improve water quality by reducing NO_3-N load up to 75% (Drury et al., 1996; Frankenberger et al., 2006; Drury et al., 2009) and sustain agricultural viability (Belcher and D'Itri 1995). Groundwater quality is affected by nitrate (NO_3^-) pollution that may result from excessive N fertilizer applications and other practices (Knox and Moody, 1991). Since NO_3-N is soluble in water and is not retained by soil particles, it is susceptible to be leached to groundwater prior to crop growth or following harvest. In the United States, N losses in crop production are a concern due to relatively high N fertilizer application rates and considerable amounts of NO_3-N released in drainage waters from agricultural soils (Cambardella et al., 1999). As a result, NO_3-N concentration is regulated to prevent negative health impacts and eutrophication (Shaviv and Mikkelsen, 1993; USEPA, 1995; Hunter, 2001).

Soil and water conservation systems for productivity and environmental protection are key components of this enhanced efficiency N fertilizer and managed drainage project. In order for rural communities to remain competitive in a rapidly changing agricultural environment, technology that integrates current best management practices must also maintain a highly productive, safe, and efficient food supply. Water conservation, reduced fertilizer loss, increased nutrient use efficiency, and reduced sediment loss while improving crop production combined with managed drainage that is based on solid research is a win-win situation for farmers, consumers, and the environment. It is expected that there will be a reduction in NO_3-N loading of up to 75% (Zucker and Brown, 1998; Frankenberger et al., 2006; Drury et al., 2009) and an additive effect of the enhanced efficiency fertilizer on reducing N loss in the crop production system and increasing corn grain yield. The hypothesis of this research is that managed drainage and enhanced efficiency fertilizer (polymer-coated urea) will synergistically increase corn yields and reduce NO_3-N loss.

The objective of this research is to determine the effects of managed drainage systems and enhanced efficiency nitrogen fertilizer (polymer-coated urea) on corn production, nitrogen use efficiency, and nitrogen loss through the subsurface drainage system.

Accomplishments for First Year:

Research was initiated in 2011 at two locations (Greenley and Bee Ridge sites) to determine the effects of managed drainage systems and enhanced efficiency N fertilizer (polymer-coated urea) on corn production, carbon sequestration, N use efficiency, and nitrogen, ortho-phosphate, and sediment loss with managed drainage systems. Corn production data including corn plant uptake of nitrogen, silage, and grain yields were collected at both field sites. Water samples and flow were collected from the drainage systems at both sites over the growing season using automated collection systems and samples analyzed for nitrate-N, orthophosphate-P, and sediment concentration. Water flowing out of subsurface drainage systems was restricted over the period of Oct. 2010 to Apr. 2011 with managed subsurface drainage systems, while conventional systems had unrestricted water flow.

Supplemental data including ammonia volatilization, nitrous oxide gas loss, and soil nitrogen concentration data was also collected at the Greenley site which will allow us to better understand how subsurface drainage systems and enhanced efficiency nitrogen fertilizer impacted corn production, nitrogen loss, and fertilizer use efficiency in 2011. However, this data is currently being analyzed.

Corn grain yields in 2011 at the Greenley site were generally low (<80 bu/acre) for all treatment combinations, which may have been a function of a wet spring followed by dry summer conditions (Fig. 1). Polymer-coated urea nearly doubled grain yields compared to non-coated urea in the non-drained system. The addition of subsurface tile drainage increased yields 20 bu/acre compared to non-coated urea. No grain yield differences were detected with managed subsurface drainage compared to conventional subsurface drainage. When averaging over drainage systems, polymer-coated urea fertilizer increased grain yield 15 bu/acre compared to non-coated urea (Fig. 2). Differences in grain yields among subsurface drainage systems and N fertilizer sources may have been a function of differences in soil moisture conditions, N loss, and plant uptake. Trends in silage yield based on dry weight at maturity due to the subsurface drainage systems and nitrogen fertilizer source followed similar trends to that previously discussed with grain yields (Fig. 3 and 4). The Bee Ridge site grain yields were approximately 6 to 8 bu/acre greater with PCU compared to non-coated urea, but no differences among drainage management systems were observed in 2011 (data not presented).

Nitrate-N, ortho phosphate-P, and sediment concentrations in the drainage water exiting the subsurface drainage systems were collected over a portion of the 2011 growing season at the Greenley and Bee Ridge sites (Fig. 5 and 6). Prior to the 2011 N application, polymer-coated urea treatment plots had minimal nitrate-N concentrations in the drainage water. At the Greenley site, nitrate-N concentration in subsurface drainage water was generally greater after non-coated urea was applied compared to polymer-coated urea (Fig. 5). Additional flow data was collected at both study sites and is currently being analyzed to calculate flow-weighted means and nutrient loading for each system. The addition of subsurface drainage flow data will allow us to determine if polymer-coated urea significantly reduced nitrate-N loss through subsurface drainage systems. No noticeable trends in ortho phosphate-P and total suspended solids concentrations due to subsurface drainage systems and nitrogen fertilizer sources were observed from Mar. to May (data not presented).

Procedures for Second Study Year:

- The second year of a three-year corn trial will continue to be conducted on claypan (Greenley) and silty clay (Bee Ridge) soil types.
    - Greenley site (Putnam silt loam). Two subsurface drain tiles were installed on 20 ft centers with a water level control structure in four of the six plots. Treatments include drainage only, managed drainage, and a non-drained control in a factorial arrangement with an enhanced efficiency fertilizer (polymer-coated urea) or non-coated urea. A plastic barrier was installed between the non-drained controls, drainage only, and managed drainage treatments. A levee plow used to construct rice levees was used to separate plots and prevent surface water movement between treatments.
    - Bee Ridge site (Wabash silty clay). Subsurface drain tiles were installed on 20 ft centers with four water level control structures installed per replication. There is a 40 ft spacing between treatments since the soil permeability is very slow. Fertilizer treatments are similar to the Greenley site.
- Plant Nutrient Uptake, Silage and Grain Yields. Plant samples will be harvested from a transect perpendicular to the tile lines to determine total N uptake. Whole-plant tissue samples will be collected from each treatment at physiological maturity, ground in a portable chopper, and a 1-kg subsample will be collected for determination of silage moisture content and total N. Silage yields will be determined on a dry weight basis. Grain yield will be determined using a yield monitor and plot weights at the Greenley site. Grain yield will be determined using a yield monitor from between the tiles at the Bee Ridge site. The combine will be able to quantify yield from a 20 ft harvest width in a single pass. Grain samples will be collected to determine N removal.
- Tile Flow Measurements. A pressure transducer, data logger, and minisat are being used to document water flow at each water level control structure to determine total N loading throughout the year. Calibrations for a V-weir installed in drainage systems have been determined (Norm Fausey, personal communication). Water level control structures were installed in the drainage only treatment with a V-notched weir as the bottom board in the control structure which is being used to determine tile water flow.
- Water and Soil Sampling for nitrate-N, orthophosphate-P, and total suspended solids. Flow proportional samples of subsurface drainage water for NO_3-N are being collected with individual auto samplers at each water level control structure. Auto samplers are being utilized to capture grab samples to determine concentrations during the winter periods. The minisat are being used to identify water flow events during the winter months and obtain grab samples. Deep soil samples (3 ft. depth; 2 in diameter) will be collected at both locations using a Giddings probe to determine soil N and organic C concentration in a transect perpendicular to the tile lines to determine residual N in the soil and indicate carbon sequestration differences among treatments.
- Nitrous Oxide and Ammonia Gas Efflux Measurements. The Greenley site is being utilized to monitor gaseous N fertilizer loss over the growing season Nitrous oxide and ammonia flux data will be collected multiple times a week over a four month period following nitrogen application.
- Nitrogen Use Efficiency. The collection of nitrogen loss, plant nitrogen uptake, and soil nitrogen concentration data at the Greenley site will be used to determine the impact of managed subsurface drainage and enhanced efficiency nitrogen fertilizer on nitrogen use efficiency.

Timetable:

2012

Jan.-Dec.	Monitor for water flows and nitrate-N concentration
April	Corn planting for the 2012 trials. Monitor for nitrous oxide and ammonia efflux.
September	Harvest tissue and grain samples for N uptake
Nov.-Dec.	Soil sample for nitrate and ammonium
December	Submission of annual report

2013 Repeat 2012 timetable

Proposed Budget:

CATEGORIES	Year 2012	Year 2013	Total
A. Salaries Ph.D. student	$16,890	$17,397	$34,287
B. Fringe Benefits Fringe for graduate student	$2,383	$2,454	$4,837
TOTAL SALARIES AND FRINGE BENEFITS	$19,273	$19,851	$39,124
C. Travel			
Travel to field site	$0	$0	$0
To present research findings at National Meetings	$0	$1,000	$1,000
TOTAL TRAVEL COSTS	$0	$1,000	$1,000
D. Equipment	$0	$0	$0
TOTAL EQUIPMENT use and maintenance COSTS	$0	$0	$0
E. Other Direct Costs			
Soil analysis	$840	$840	$1,680
Grain analysis	$900	$900	$1,800
Tissue analysis	$1,000	$1,000	$2,000
Water analysis	$5,600	$5,900	$11,500
Field supplies	$2,000	$2,000	$4,000
Publication cost	$250	$0	$250
TOTAL OTHER DIRECT COSTS	$10,590	$10,640	$21,230
TOTAL REQUEST	**$29,863**	**$31,491**	**$61,354**

Budget narrative:

Salaries and fringe benefits: Funds are requested for partial support of a Ph.D. student.

Presentations, publications, and documentation: This will help defray cost of publication and documentation of results and conclusions as well as assist travel and board for presentation of results

Other Direct Costs: Covers cost of analysis, sample containers, fertilizer, seed, plot preparation, planting, weed control harvesting, flags, and other field supplies and operations.

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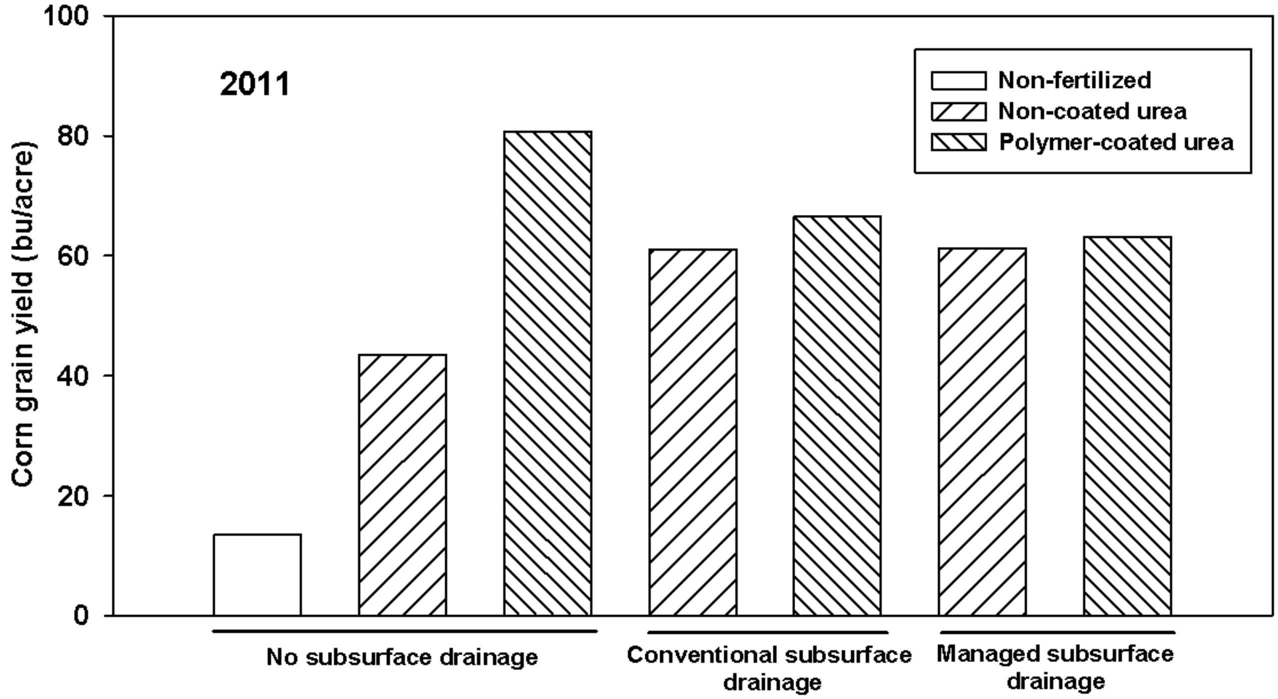

Figure 1. Corn grain yields from the 2011 growing season at the Greenley site due to the interaction of subsurface drainage type and nitrogen fertilizer source.

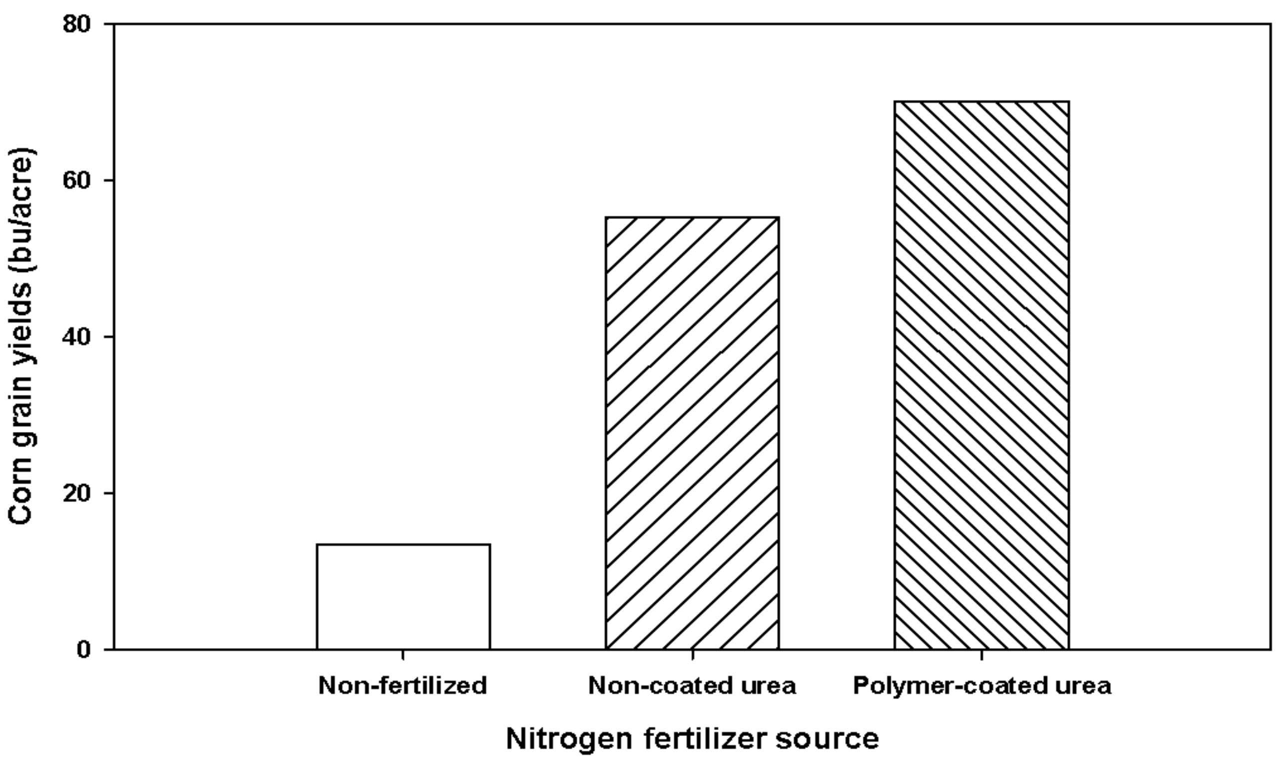

Figure 2. Corn grain yields from the 2011 growing season at the Greenley site due to the main effect of nitrogen fertilizer source.

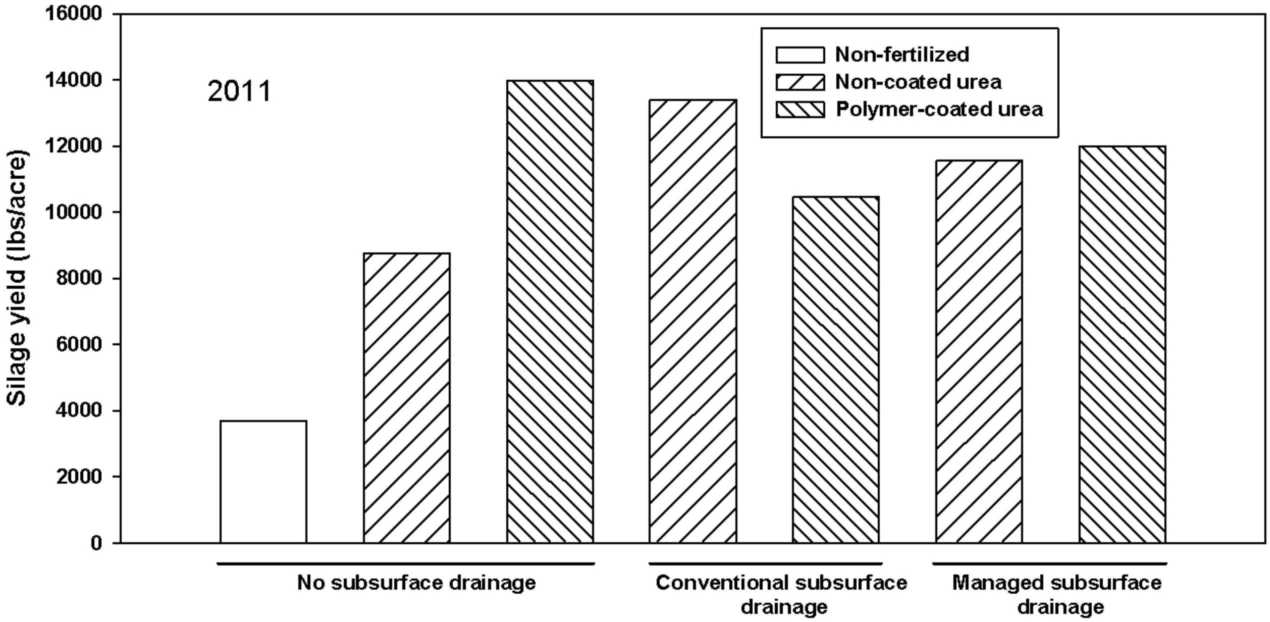

Figure 3. Silage yields at the Greenley site from the 2011 growing season due to subsurface drainage type and nitrogen fertilizer source.

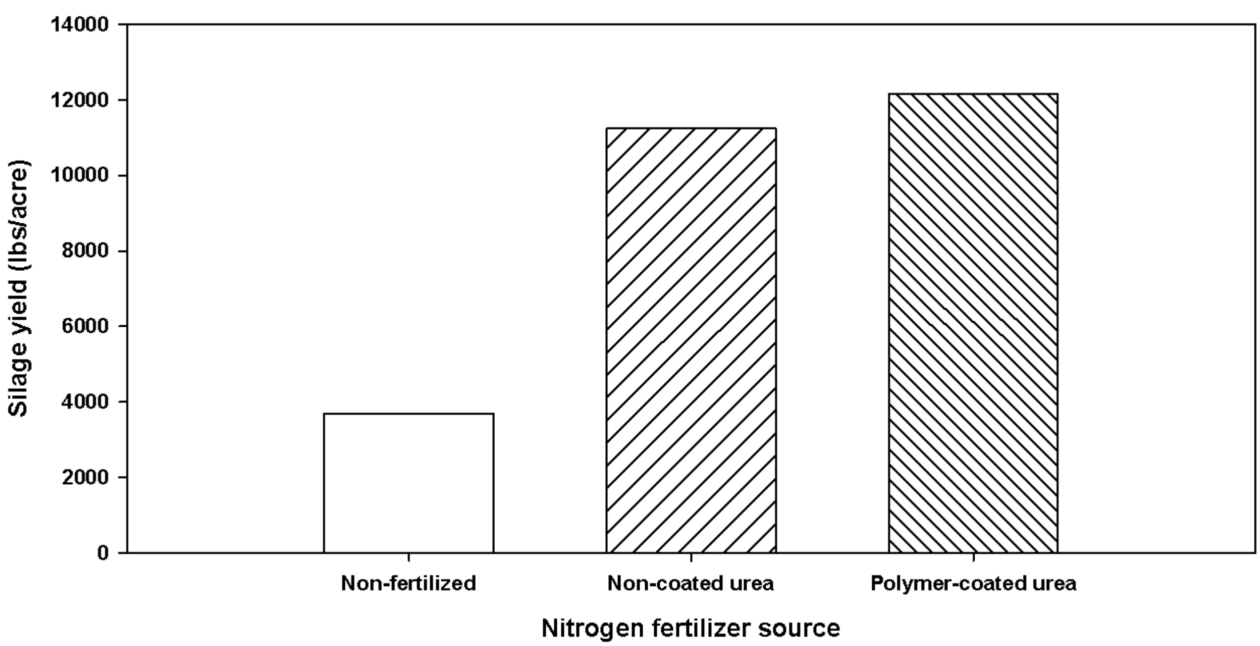

Figure 4. Silage yield at the Greenley site from the 2011 growing season due to the main effect of nitrogen fertilizer source.

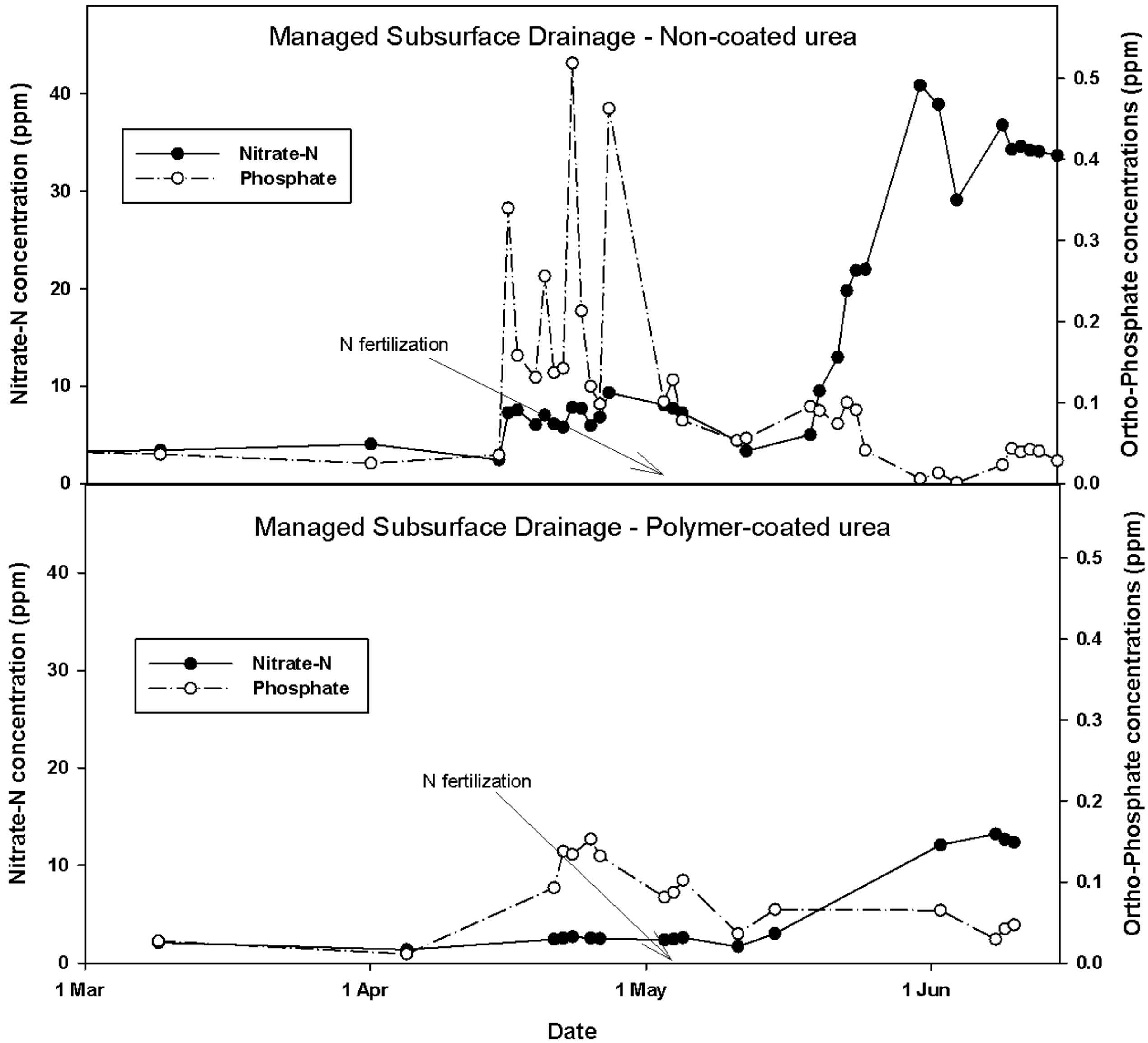

Figure 5. Nitrate-N and orthophosphate P concentrations in the drainage water exiting the subsurface tile drainage systems over the period of Mar. through June, 2011 at the Greenley site.

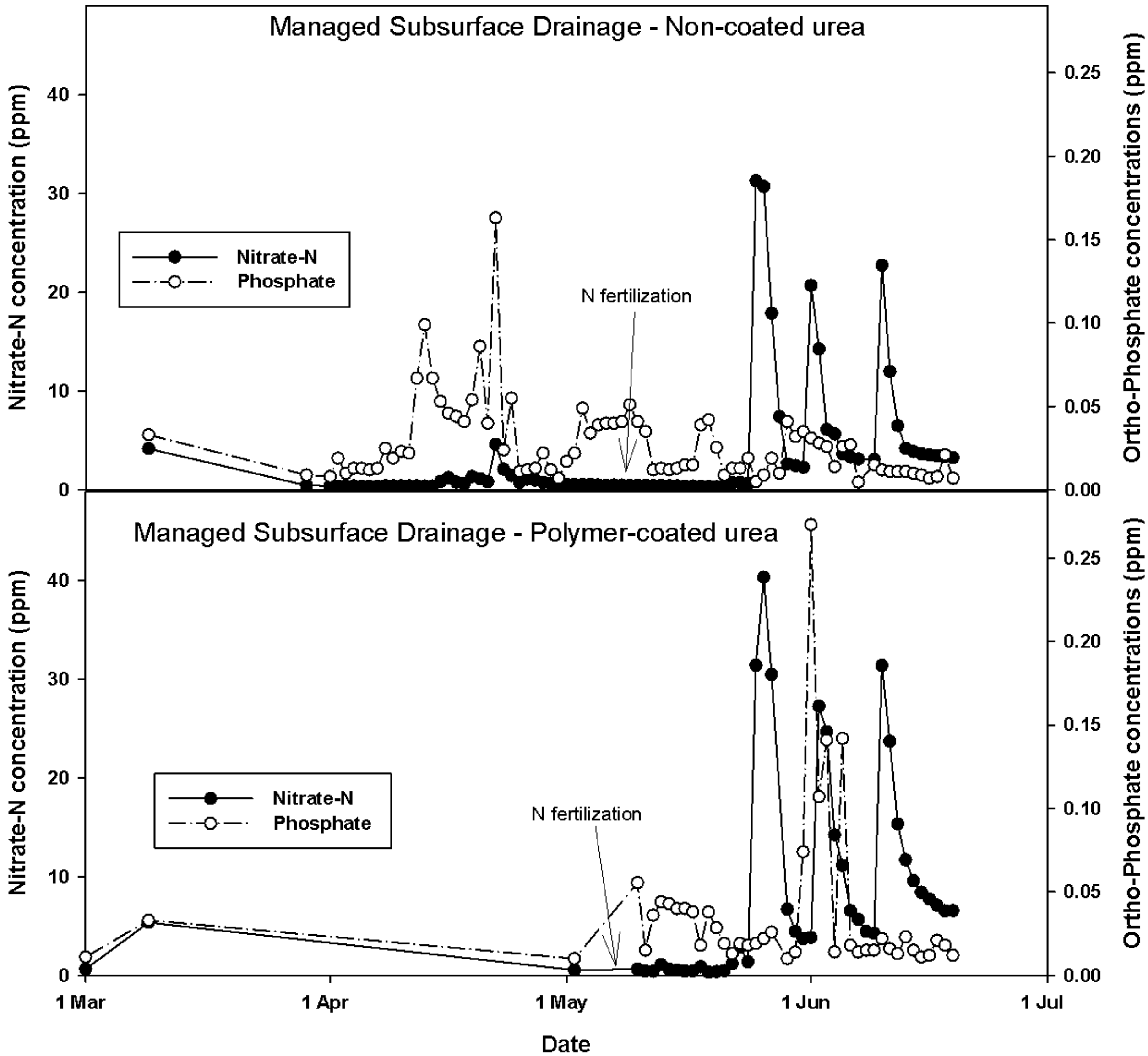

Figure 6. Nitrate-N and orthophosphate P concentrations in the water exiting the subsurface tile drainage systems over the period of Mar. through June, 2011 at the Bee Ridge site.