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REDUCING OVER-WINTER NITROGEN LOSS

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ABSTRACT

Nitrogen can be lost when the quantity of available nitrogen exceeds crop demand or nitrogen availability is not in synchrony with crop demand. Either situation results in accumulation of available nitrogen, primarily in the nitrate form, at the end of the growing season. Over-winter nitrogen loss occurs primarily as nitrate- N is leached below the root zone. The remedy to N loss is obvious; don't allow nitrate-N to remain in soil after harvest. Matching crop use to N supply so that little if any NO_3-N remains in the soil after harvest is difficult. One step toward low residual NO_3-N is synchrony of application and crop use. If crop use is known, application time can precede use. References are provided for seasonal and daily crop N uptake of 25 crops. The list of crops grown in the western United States is many times this number and a data for a crop of interest to advisors and consultants is logically not available. If crop N use is not available, methodology for collecting data and constructing uptake graphs is provided.

INTRODUCTION

Loss of nitrogen from agricultural systems is an economic detriment for producers and potentially damaging environmentally. If the crop does not use grower purchased N, the grower investment is lost. To the environment, nitrate in the groundwater is a health hazard.

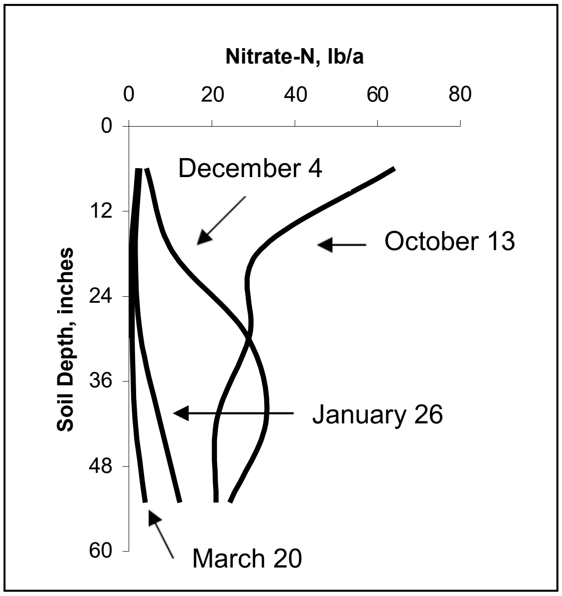
Nitrogen can be lost when the quantity of available nitrogen exceeds crop demand or nitrogen availability is not in synchrony with crop demand. Either situation results in accumulation of available nitrogen, primarily in the nitrate form, at the end of the growing season. Over-winter nitrogen loss occurs primarily as nitrate-N is leached below the root zone.

The soluble and mobile nitrate ion remains in the soil after crop production and readily moves through the soil profile with precipitation as shown in Figure 1. In western Oregon's Willamette Valley, November, December, and January are months in which the most rain falls. The movement of NO_3-N from the surface of a sandy loam soil is rapid, decreasing from approximately 65 lb N/a in the surface foot to less than 5 lb/a in two months.

The December sample date also shows the movement of NO_3-N to the subsurface soil. Only 25 lb NO_3-N/a remained in January and less than 10 lb NO_3-N/a was measured in March.

The remedy to N loss is obvious; don't allow nitrate-N to remain in soil after harvest. Matching crop use to N supply so that little if any NO_3-N remains in the soil after harvest is difficult. One step toward low residual NO_3-N is synchrony of application and crop use. If crop use is known, application time can precede use.

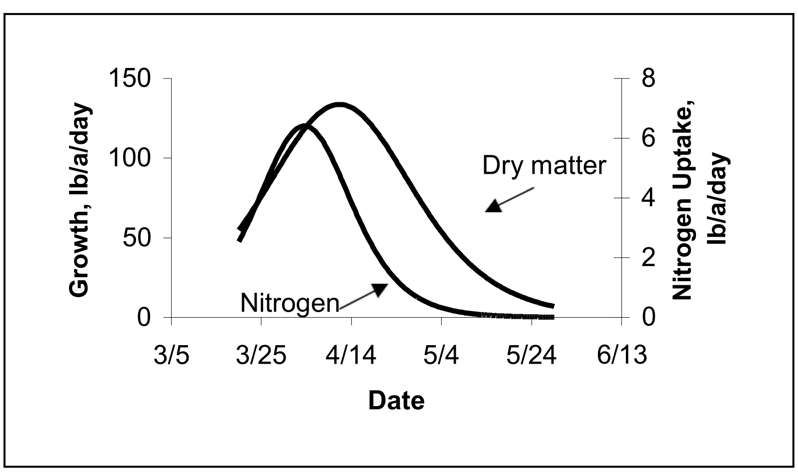
Figure 1. Soil Nitrate-N at four sampling dates in the upper 60 inches of a hop yard planted in Newberg fine sandy loam, Willamette Valley, Oregon.



Annual and herbaceous perennial crops typically begin growth and N uptake slowly, move to a steep linear growth and N accumulation, then both growth and N uptake decline as the crop matures. Residual N can be reduced if application is completed before the N uptake rate declines. N applied late in the season will not be used by the crop. It remains in the soil after harvest and is vulnerable to over-winter leaching loss.

Gauging or anticipating N application time from growth can lead to ill-timed N application since maximum N uptake precedes maximum growth, Figure 2. Conversely, little growth early in the season does not mean no nitrogen is needed. Some yield components, such as tiller formation in cereals, requires N early in the season. Where early-season N supplies are very low, applying all of the N just prior to the rapid uptake phase can limit yield.

Figure 2. Daily aboveground dry matter production and N accumulation for rhubarb grown in the northern Willamette Valley of Oregon in 2001.



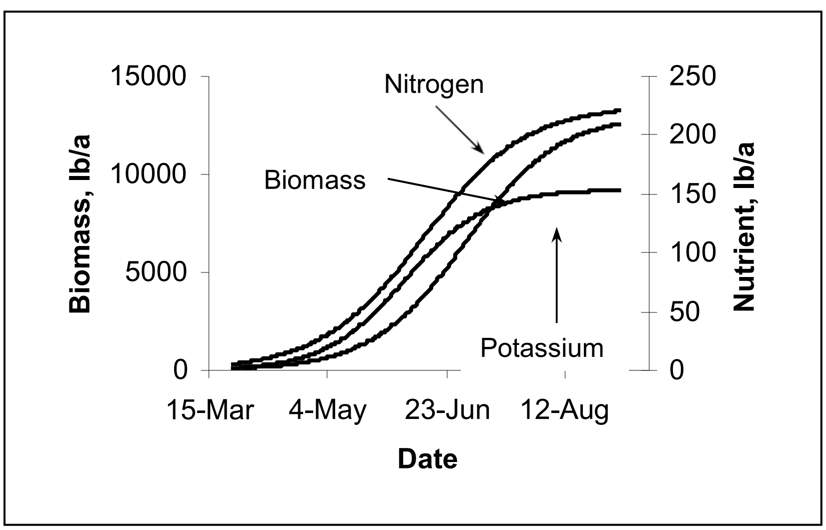
The management strategy is to apply N in synchrony with plant demand. To do so, N uptake and growth information needed. Table 1 contains a list of crops for which N uptake and growth information is available.

Table 1. Crops listed by reference for which N uptake and growth data is available.

Doerge et al.	PNW 513	Proposed OSU publication
Broccoli	Broccoli	Annual ryegrass for seed
Cabbage	Cauliflower	Carrots, hybrid for seed
Cantaloupe	Hops	Fine Fescue for seed
Cauliflower	Onions	Green beans
Corn, Field	Peppermint	Kentucky bluegrass for seed
Corn, Sweet	Perennial ryegrass for seed	Meadowfoam
Cotton	Potatoes	Orchardgrass for seed
Lettuce	Tall fescue for seed	Rhubarb
Potatoes	Wheat, soft white winter	Roughstalk bluegrass for seed
Grain Sorghum		
Watermelon		
Wheat, Durum		

Crop selection in the western United States is diverse. Oregon annually reports approximately 90 agricultural commodities with a gross farm gate value in excess of $1 million. Many of these crops are "high value" commodities grown on relatively few acres. High value crops are characterized by input cost for items such as fertilizer being small compared to gross income.

Figure 3. Seasonal biomass or dry matter, nitrogen, and potassium accumulation for Nantes hybrid seed carrots grown in central Oregon during 2002.



The potential for over application or mistimed N application and loss of N to groundwater is high for crops when no data for application timing exists and N is a small production cost. The rhubarb example in Figure 2 is fitting since it is a high value crop for which little research is performed, grown on approximately 1,000 acres of sandy soils adjacent to the Portland, OR-Vancouver, WA metropolitan area with more than 1 million population.

The likelihood is high that N uptake and growth data for at least one crop with which you work will not be available. If so, we encourage you to collect data and make your own graph. With the data collected, you will be able to produce graphs for growing season accumulation and daily accumulation for biomass and nitrogen. If you choose to analyze plant tissue for nutrients other than N, you will be able to create graphs for these nutrients as shown in Figure 3.

METHODS

To create nitrogen daily or rate of N uptake graphs, plant samples must be collected throughout the growing season, analyzed for nitrogen, and analyses manipulated mathematically. Plant growth and season long nutrient uptake can typically be characterized with a sigmoid or "S" shape curve as shown in Figure 3. To capture plant growth and nutrient uptake, early and late season samples are necessary. Take a soil sample from the area where plants are sampled to have background information about the site.

In addition to plant samples, collection of maximum and minimum temperatures is suggested. Temperature data is useful when data from more than one year is combined. Heat units or growth degree days are calculated and used on the X axis in place of date.

Contact the laboratory that will analyze samples as part of the planning for the project since a few steps in the process are not normally performed by a laboratory. You will need to discuss sample size submitted and obtaining dry sample weights.

Record keeping is important to the project. A common method for keeping data is recording all data and information in a bound notebook dedicated to the project. Record sampling dates, size of area sampled, plant development stages, time of fertilizer application, other significant cultural or management practices, soil series, crop variety, information about variety such as short stature, long season, or typically produces high protein, and data such as sample dry weight.

Sample collection

Select four areas in a field that are uniform and growing normally. Mark these areas so you can return to the vicinity for repeated samples. The first sample should be obtained early in the growing season, well before the crop begins its rapid biomass increase. Collect samples five to six times during the growing season. The last sample should be collected near or at harvest. Sample collection before harvest should be governed by plant growth rather than routine interval. Collect samples three to four times during the rapid growth of the crop.

The crop dictates selection of area to sample. Crops planted in rows, such as wheat, are easily sampled by harvesting 1 to 2 feet of 2 adjacent lineal rows at each of the four locations in the field.

For crops without rows, such as hay or peppermint, use a hoop or template to delineate the area. The area sampled should be 4 to 6 ft^2. For these crops, early season placement of hoops is advised. Use plastic drip irrigation tubing or other inexpensive material to construct hoops. Make enough hoops for sampling throughout the season. Place a flag in center of each hoop. The flag needs to project above the crop canopy at end of season so the hoops can be located.

Placing hoops in the field early in the season allows you to obtain uniform non-disturbed samples compared to fitting a template over tall or lodged plants.

A single plant or hill in four locations should be sampled for crops such as squash or rhubarb.

Record dimensions of sample area. This information is necessary for calculating amount of biomass or nutrients per acre.

Sample handling

The first measurement necessary is dry weight of the sample. Two approaches can be used for obtaining dry weight, (1) drying and weighing the entire sample or (2) drying and weighing a subsample. Drying the entire sample is easy for the first and second sampling. By the end of season, you will need a large drying capacity since four grocery or two burlap sacks from each replication are easily filled with plant material from each of the four locations in the field.

If you choose to dry a subsample, first weigh the entire moist sample, and then obtain a subsample. The subsample wet weight and dry weight are both needed to calculate the dry weight of the total sample.

If you dry the entire sample rather than subsampling, grind the entire sample in preparation for nutrient analyses. Subsampling dried plant material before grinding can easily lead to biased nutrient concentrations. Dry plant material easily shatters, especially leaves and some seeds. Leaves contain more nutrient than stems. Loss of leaves from a subsample submitted for analysis will produce a lower nutrient concentration than if leaves are included.

Data manipulation

Enter the dry matter and nutrient in the spreadsheet found in the new publication, *Synchronizing Nitrogen Supply and Crop Needs: a Quantitative Approach*. The publication will be available on the Oregon State University Extension and Experiment Station Publications Website, http://eesc.orst.edu/agcomwebfile/EdMat/, in December of 2005. Follow instructions in the publication to create the desired graphs.

DISCUSSION AND CONCLUSIONS

Aboveground biomass accumulation, daily N uptake rate and season long N uptake can be used to schedule N applications and to estimate the total amount of N needed by crop. For example, when an onion crop has accumulated 50% of its biomass, 80 to 90% of the nutrients needed to produce the entire crop are already in the plant and no more nutrients should be applied. Additional examples for Nantes Hybrid seed carrots follow.

Biomass or growth

Seed carrots grow slowly in the fall and spring, producing only 500 to 1000 lb biomass/a by late April or early May, Figure 3. From early to mid-June through mid to late-July, the growth is rapid and linear, accounting for two-thirds to three-fourths of the total biomass. Less than 20 percent of the biomass is produced after late-July. Peak biomass production of 150 to 200 lb/a/day occurs in the last week of June or first week in July. Growth of carrots for seed production slows after seed set.

Cumulative or season long nitrogen uptake

N uptake is rapid during May and June, essentially complete by early August, five to six weeks before harvest as shown in Figure 3.

Daily nitrogen uptake rate

Peak N uptake of 2.5 to 3.5 lb/a/day occurred in mid to late-June both years. The peak N uptake rate occurs as bloom is beginning and before bees are placed in the field. The peak N uptake rate occurs during the third week of June, when day length is longest, Figure 1. The maximum biomass production was estimated to occur one to two weeks after the maximum rate of N accumulation was achieved.

Management

Some N should be applied in mid- to late-April to support early growth. The bulk of the N is accumulated during June. Nitrogen should be supplied well in advance of need, early to mid- May at the latest. If sufficient nutrients are supplied during the early growing season, late season applications are not efficient or effective. Nitrogen uptake decreases rapidly after seed set in late June. After seed set occurs, the crop enters a phase of growth where redistribution of nutrients rather than accumulation predominates.

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