# Predicting Phosphorus and Nitrogen Needs in Sweet Corn
2012

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## Executive Summary

Overall
This year we evaluated P fertilizer needs and continued previous research that is evaluating ways to better forecast corn N fertilizer needs. Our research has identified opportunities for reduced cost of production without sacrificing corn yield. Specifically:

- For Nitrogen: We demonstrated that N mineralized from soil organic matter supplies about half of the N utilized by a corn crop, and we worked on fine-tuning several approaches to better forecast crop N fertilizer needs.
- For Phosphorus: We showed that P fertilization rates currently used in western Oregon sweet corn production can be reduced on soils that have high soil test P without compromising ear yield.

Nitrogen
This is the second year of field and laboratory measurements of soil N mineralization rate. **We measured soil N mineralization rate in order to understand how to better forecast N fertilizer needs**.

**Nitrogen mineralization in the field**. Corn was grown on small plots within 7 cooperator fields that did not receive current season N fertilizer application. At 1200 GDD after planting (silking) plants were harvested to determine plant N uptake with zero N fertilizer applied. Plants were also harvested from corn rows nearby that were fertilized by the cooperating farmer. All of the plant N in the zero-N plots came from soil (decomposition of soil organic matter to release plant-available nitrate-N). These field measurements are realistic, but not always precise, because many site variables (not just soil N mineralization rate) affect plant N uptake. **Over two years of measurement (2011 and 2012), we found that sweet corn obtained about half of its N from mineralization, with fertilizer supplying the other half.** Over a full season, corn plants usually take up about 150 to 200 lb N/acre. Our measurements showed that mineralization of N from soil organic matter (to silking growth stage) supplied an average of 74 lb/acre in 2012, and 95 lb N/acre in 2011.

**Forecasting N fertilizer need with at-planting soil nitrate test.** The Pre-SideDress Nitrate Test (PSNT) is used to forecast N fertilizer need in the OSU Nutrient Management Guide for Sweet Corn (EM9010; 2010). The PSNT test was shown to be a good predictor of the rate of N fertilizer needed for sweet corn in our N-rate field trials in 2010 and 2011. In 2012, we did not have PSNT trials with N fertilizer rates (to measure crop response to N fertilizer rate). Instead, we measured at-planting soil nitrate-N (NO3-N) and soil NO3-N at 6-leaf stage (PSNT) at seven field sites (same fields where we measured N mineralization in the field; see above). The objective was to determine whether at-planting soil testing could provide useful information to predict N fertilizer needs. **Soil NO3-N was always higher in the PSNT samples compared to**

**the at-planting samples.** We found that soil nitrate increased by an average of 35 lb N/acre between planting date and PSNT sampling date (corn at six leaf stage). Using the at-planting soil nitrate value with the current PSNT interpretive guidance (Table 10 in EM9010) would result in a slight over-application of N fertilizer. **For next year (2013), we propose additional data collection to confirm the relationship between soil sample collection date (at-planting or 6 - leaf) and soil nitrate-N accumulation.**

**N mineralization rate in the laboratory vs. the field.** We measured soil N mineralization rate in the laboratory in an effort to use a laboratory test to forecast N mineralization rate in the field. Based on 2011 data, we designed the 2012 laboratory trials to evaluate N mineralized under short incubation time (7 days), aerobic conditions, and elevated temperature (35C). **We found that amount of soil N mineralized in a 7-day aerobic incubation test at 35C in the laboratory was of the same approximate magnitude as the N uptake by unfertilized plants (at silking) in our field plots (about 70 lb N per acre).** We found that the anaerobic N mineralization test (7 days incubation at 40C) was about 2X greater than crop N uptake in the field. Nitrogen uptake in the field (to silking) or N mineralized in the laboratory (7 days aerobic incubation at 35 C) was equivalent to about 1% of total soil N present in a 0-12 inch soil sample. **We recommend the 7-day aerobic laboratory N mineralization test at 35C for further evaluation in 2013.**

<u>Phosphorus</u>

- **In four field trials, ear yield and quality did not increase with P fertilization.** Phosphorus fertilizer (11-48-0) was banded at rates up to 120 lb P2O5/acre at planting. Two farm-scale trials were conducted, and two trials (early and late planting date) were conducted at the OSU Vegetable Research. On-farm trials were seeded in May, when soil was cold, and seedbed conditions were generally not optimal for seedlings.
- **Ear yield and quality did not respond to P fertilizer application at early (May 11) or late planting (June 27)** dates at the OSU Vegetable Farm site.
- At all fields, soil test P (Bray P-1 method) was above 50 ppm, the threshold for P fertilizer response identified in the OSU Nutrient Management Guide for Sweet Corn (EM-9010-E; 2010). Soil test P at field trial locations ranged from 77 to 108 ppm. **The lack of benefit from P fertilizer addition at these sites supports current OSU recommendations: zero P or low rate P application when soil test P is above 50 ppm.**
- Plant-Root Simulator Probes (PRS; Western Ag Innovations, Inc.), were placed into field soils (with no P fertilizer applied) to measure P supply to roots under field conditions. The PRS measurements assessed P supply as affected by prevailing soil moisture, temperature, physical and biological conditions. Phosphorus supply (P flux to the PRS probe anion exchange membrane) varied among field sites, even though all sites had similar (high) Bray soil test P. **PRS measurements at the early and late planting at OSU Vegetable Farm showed a two-fold increase in P supply due to planting date. The PRS measurements support the practice of reducing or eliminating P fertilizer application for late corn plantings.**

**Background: Nitrogen.** Land planted to sweet corn and other row crops (vegetables) can make a substantial contribution of nitrate-N to groundwater and nitrous oxide-N to the atmosphere. Failure to accurately forecast the amount of nitrogen needed to produce a crop not only increases the risk of loss, but it also reduces profitability for growers. Excess N fertilizer application increases the rate of soil acidification and future liming expense. Nitrogen fertilizer prices spiked several years ago, and threatened profitable current sweet corn production in the Willamette Valley. Sustained higher N fertilizer costs are expected in the future because energy (natural gas) is approximately 90% of the cost of producing N fertilizers. Much of domestic N fertilizer use is supplied from sources outside the US. Practical tools are needed to reliably predict the amount of N fertilizer that is needed for sweet corn to maintain profitable production and to reduce the potential losses of unused nitrogen to groundwater or the atmosphere.

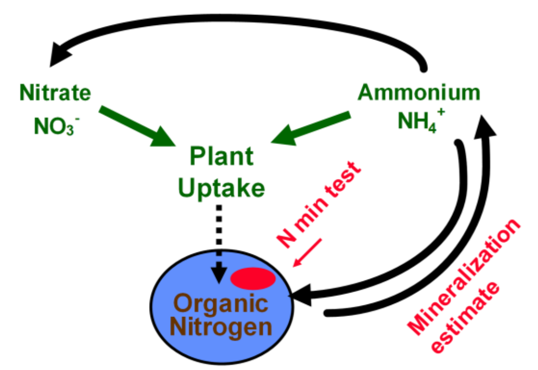

Figure 1. A spring soil test for N mineralization potential measures a fraction of total soil organic matter that is active. Results for useful soil Nmin tests are strongly correlated with the amount of plant available N (ammonium + nitrate N) produced by decomposition of soil organic matter during the crop growing season (summer).

In spite of the demonstrated accuracy of PSNT test, alternative N tests to guide N management are needed because growers don't always find PSNT logistics easy to fit into management programs. There is usually only a 1 to 2-wk window between collection of soil samples for the PSNT and application of sidedress N fertilizer. An alternative approach to the PSNT test is to collect soil samples preplant, and forecast sidedress N needs using a soil test for nitrogen mineralization potential (N min test; Figure 1). The preplant N min test allows producers more time to make sidedress N fertilizer decisions, and to arrange for application. Soil tests for N mineralization potential have been slow to be adopted by commercial soil testing laboratories for N fertilizer recommendation. A major barrier to Nmin test adoption is the lack of locally relevant test calibration data. Calibration is needed to verify the relationship between N min test values and crop response to N fertilizer.

**Background: Phosphorus.** Determination of P sufficiency via soil testing is difficult, since the ability of sweet corn to obtain P from the soil is influenced by soil temperature, biological activity, and root diseases. Ensuring an adequate P supply for sweet corn production is complicated by the insolubility and immobility of biologically available P forms. Phosphorus moves only a short distance from where it is placed in the soil, so it is commonly banded near the seed where seedling roots proliferate. Root growth and P solubility are both reduced in cold soils, thereby limiting plant P uptake. Low soil temperature also reduces the rate at which soil organic P is mineralized to soluble plant-available P (orthophosphate, $H_2PO_4^-$). Research from California showed a 40 percent reduction in available P with a 20°F decrease in soil temperature. In western Oregon, the minimum soil temperature at the 4-inch depth increases approximately 20°F between mid-April and early July. Thus, soil P is less available at early planting dates. Band application of P fertilizer at planting can increase yield, but does not completely overcome the effect of low soil temperatures. Past field research in western OR showed no consistent advantage to banded P application when corn was planted in early May and soil test P (Bray P-1 method) was near 100 ppm (MacAndrew, 1983). The OSU Nutrient Management Guide for Sweet Corn (EM9010; Hart et al., 2010) recommends that starter P application be omitted or reduced to the lowest rate that can be applied with the planter when Bray soil test P is above 50 ppm.

**Research Objectives**

Nitrogen:

1. Measure crop N uptake in the field (with zero N fertilizer applied).
2. Measure N mineralization rate potential in the laboratory using a variety of testing protocols.
3. Determine the effect of soil incubation temperature on rate of N mineralization in the laboratory, using an aerobic incubation method.
4. Relate lab measurements of soil N mineralization potential to N uptake by corn in zero N field plots.
5. Determine the utility of an at-planting soil nitrate test.

Phosphorus:

1. Determine the effect of banded P fertilizer rate on crop yield and quality for early and late season planting dates.
2. Measure P supply to roots under actual field conditions using Plant-Root Simulator probes. The PRS measurements assessed P supply as affected by prevailing soil moisture, temperature, physical and biological conditions at each site.

## Methods for Nitrogen

**Crop N uptake in the field (no N fertilizer).** Crop N uptake in aboveground biomass at ~1200 growing degree days (GDD) was measured by harvesting aboveground biomass, grinding it with a chopper, then measuring dry matter and %N. Crop N uptake was calculated as: Above-ground plant dry matter (lb/acre) x plant N%/100. Plants were also harvested from corn rows nearby that were fertilized by the cooperating farmer. The relative amount of crop N uptake (%) from mineralization was calculated as: Crop N uptake with no N fertilizer (in zero N plot)/crop N uptake with farmer fertilization (in adjacent field area) x 100.

**Nitrogen mineralization rate potential in the laboratory using a variety of testing protocols.** Soil samples collected at-planting were incubated in the laboratory to measure N mineralization potential. This measurement is called "potential" because soil is given optimum physical and moisture conditions for N mineralization (it is sieved and moistened to near field capacity). Soil N mineralization, the conversion of soil organic N to mineral N was measured using the following methods:

A. Anaerobic incubation test (40C, 7 days). This test was performed by OSU Central Analytical Laboratory using the standard protocol used for soil Nmin test for winter wheat (cite XX method ref).
B. Aerobic incubation test (23 or 35C for 7, 21 and 42 days). This test was performed in our laboratory. Before incubation soil moisture was adjusted to near field capacity: approximately 25 to 30% gravimetric moisture for the silt loam and silty clay loam soils present at 2012 field sites.

For both N mineralization test methods, N mineralized during incubation was calculated as: Nmin = Nfinal – Ninitial, where Nmin is the net increase in NO3-N during incubation, and Nfinal is NO3-N at termination of incubation, and Ninitial is the NO3-N present at the start of laboratory incubation (the “as-is” NO3-N present in the sample as collected from the field).

**Effect of soil incubation temperature on rate of N mineralization in the laboratory.** We evaluated soil N mineralized (in aerobic incubation) at 23 and 35C. The increase in N mineralization rate due to temperature was calculated as Nmin increase = (net N min at 35C)/(net N min at 23 C). This data is of importance when forecasting N mineralization in the field, based on a laboratory soil test of Nmin potential. From a lab test expediency standpoint, faster results (from high temperature incubation) are desired. However, it is important to know how the lab result (high temperature) relates to N mineralization at summer field soil temperatures (field temperatures are closer to 23 C).

**Relating lab measurements of soil N mineralization potential to N uptake by corn in zero N field plots.** We compared the amount of N mineralized in the laboratory incubations to the amount of N uptake by the crop in the field. Laboratory tests that correlate to field data are considered more useful

**Uplantingtility of an at-planting soil nitrate test.** We collected soil samples from 7 cooperator fields at planting and at the PSNT sample timing (~V6 growth stage). Net N mineralized between sample dates (at-plant and PSNT sampling times) was calculated. The basic idea here is to see how much soil NO3-N accumulated between planting and V-6, and how much N fertilizer recommendations (using OSU EM 9010) were affected by soil sample collection date.

## Methods for Phosphorus

**Determine the effect of banded P fertilizer rate on crop yield and quality for early and late season planting dates**. At two on-farm field sites (Gervais and Independence), P fertilizer treatments of 0, 15, 30, 60 and 120 lb P2O5 per acre were banded at planting time. Each on-farm trial contained 20 field plots (4 replications per P fertilizer treatment). Each treatment plot measured 15 x 60 ft. Field experiments were established in mid-May so that the “worst case” (cold soils that limit P solubility) could be evaluated. At the Gervais site, ears were hand harvested. At the Independence site, ears were harvested with commercial headers. Ear harvest weight, dry matter, and other parameters (tip fill, length, width, etc) were measured.

A similar experimental protocol was used in two additional field trials at the OSU Vegetable Research Farm (Corvallis). Banded P fertilizer effects were evaluated at two planting dates (early May and late June). Banded P fertilizer was applied at 0, 30 and 60 lb P2O5 per acre.

**Measure P supply to roots under actual field conditions using Plant-Root Simulator probes.** The PRS measurements assessed P supply as affected by prevailing soil moisture, temperature, physical and biological conditions at each site. At both on-farm and OSU field sites, P flux (estimate of amount of P supplied to root surfaces) was measured quantitatively using Plant-Root Simulator Probes (Western Ag Innovations, Inc., Saskatoon, SK, Canada). Each PRS probe consists of an anion exchange membrane mounted on a flat plastic stake. The PRS probes were allowed to adsorb P from soil solution on the zero P plots to get a measure of the cumulative effects of temperature, moisture, and soil test P on phosphorus solubility. PRS probes were buried in soil for 2-week intervals (2-wk exposure time for each burial) starting at planting, and ending at the 6-8 leaf stage to determine changes in P supply in response to soil temperature and other environmental factors. Each 2-wk PRS probe burial generated a measurement of P supply. Preplant soil samples (0-12 inches) from each site were analyzed via routine procedures to measure soil test nutrients as per OSU recommended protocols (Table 6).

# Results for Nitrogen

## Characterization of soils.

Table 1 shows soil characteristics for 2012 nitrogen field sites. Soils from each field site were incubated in the laboratory to determine N mineralization potential, and crop N uptake was measured at each field site. Soils from our 2012 field locations had silt loam or silty clay loam textures. Compared to samples from 2011 (n=17 samples), the 2012 soils had a slightly higher OM and total N content. Soils from 2011 and 2012 had similar NO3-N at planting.

Table 1. Soil characteristics (0-12 inches) for field sites used in nitrogen studies in 2012. Analysis perfomed by Brookside Laboratories (New Bremen, OH).

| Site | Location | NRCS mapped soil | Sample date | pH | OM[1] | Total N | NO3-N | NH4-N | K | Bray I P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | % | % | ------------------ ppm | | | -------------------- |
| 1 | Brooks | Amity sil | 15-May | 6.5 | 3.0 | 0.18 | 17 | 3 | 171 | 103 |
| 2 | Lebanon | Cloquato sil | 5-Jun | 5.9 | 2.4 | 0.13 | 10 | 3 | 116 | 38 |
| 3 | N. Albany | McBee sicl | 8-Jun | 5.8 | 3.1 | 0.20 | 14 | 2 | 555 | 127 |
| 4 | N. Albany | Chehalis sicl | 14-Jun | 5.9 | 2.8 | 0.17 | 13 | 2 | 110 | 64 |
| 5 | Molalla | Huberty sil | 21-Jun | 6.2 | 2.7 | 0.14 | 11 | 4 | 69 | 155 |
| 6 | Monroe | Chehalis sicl | 26-Jun | 5.7 | 2.9 | 0.16 | 9 | 4 | 182 | 51 |
| 7 | Stayton | Nekia sicl | 29-Jun | 5.9 | 4.5 | 0.23 | 12 | 3 | 206 | 97 |
| 2012 Average | | | | 6.0 | 3.1 | 0.17 | 12 | 3 | 201 | 91 |
| 2011 Average | | | | NA | 2.6 | 0.13 | 12 | 2 | NA | NA |

1- estimated by 1.7 x total C; assumes soil OM contains 58% C

**Crop N uptake from N mineralization (field)**. Table 2 and Fig. 1 show crop N uptake in aboveground biomass at ~1200 growing degree days (GDD). In the zero N plot (no N fertilizer applied) and the adjacent grower fertilized soil, crop N uptake averaged 74 lb N/A (range 43-100) and 108 lb N/A (range 73-133), respectively. Air temperatures were similar in 2011 and 2012. Crop biomass collection may have occurred at a slightly earlier growth stage in 2012 than in 2011, thereby reducing measured crop N uptake. Because weather stations are not present at all grower locations, 1200 GDD is only an approximate estimate. Also, logistics of biomass harvest result in some deviation from the planned growth stage (1200 GDD). With addition of fertilizer (by cooperating growers), crop N uptake increased by an average of 34 lb N/A in 2012. The soil at 2012 sites supplied 69% (range 46-94%) of measured crop N uptake.

Table 2. Corn N uptake in aboveground biomass measured at ~1200 growing degree days (GDD) for zero N plot (no fertilizer N applied) vs. adjacent field area fertilized by the cooperating grower.

| Site | Location | Variety | Crop biomass date (~1200 GDD) | Crop N uptake in zero N plot | Crop N uptake in adjacent grower field | Increase in crop N uptake with grower N fertilization | Fraction of crop N uptake suppled by soil Nmin |
|---|---|---|---|---|---|---|---|
| | | | | lb N/A | lb N/A | lb N/A | zero N/grower N |
| 1 | Brooks | GH4927 | 6-Aug | 93 | 117 | 23 | 0.80 |
| 2 | Lebanon | Honey Select | 13-Aug | 43 | 93 | 50 | 0.46 |
| 3 | N. Albany | AC1138Y sup sweet | 13-Aug | 69 | 73 | 4 | 0.94 |
| 4 | N. Albany | AC1138Y sup sweet | 24-Aug | 100 | 116 | 16 | 0.86 |
| 5 | Molalla | Captain | 28-Aug | 52 | 107 | 54 | 0.49 |
| 6 | Monroe | SS jubilee | 4-Sep | 90 | 133 | 43 | 0.68 |
| 7 | Stayton | Kokanne SE | 11-Sep | 68 | 115 | 47 | 0.59 |
| | | | 2012 Average | 74 | 108 | 34 | 0.69 |
| | | | 2011 Average | 95 | 160 | 66 | 0.60 |

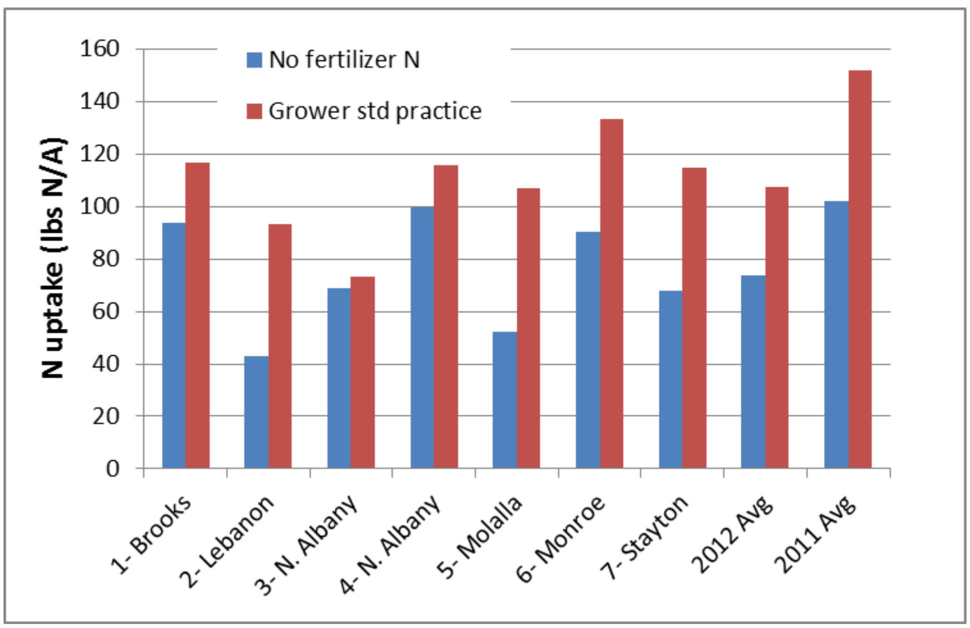


Figure 1. Crop response to fertilizer application at field sites (same data as Table 2). On average soil N mineralization supplied 69% (range 46 to 94%) of crop N needs. The increase in crop N uptake attributed to grower fertilizer addition averaged 34 lb N/A (range 4 to 54 lb N/A).

**N mineralization rate potential in the laboratory using a variety of testing protocols.** Tables 3 and 4 show nitrogen mineralization estimates for various anaerobic and aerobic N mineralization tests.

Table 3. Nitrogen mineralized from soil samples (0-12 inches), using anaerobic or aerobic N mineralization test methods. Also shown is crop N uptake from zero N field plots (full data set in Table 2). Assumed bulk density = 1.3 g/cm3. **Units = lb N/acre**.

| Site | Location | Soil total N (0-12" @BD of 1.3 g/cm3) | Anaerobic Nmin, 7d @ 40C | Aerobic 42d net Nmin @ 23C | Aerobic 7d net Nmin @ 35C | Aerobic 42d net Nmin @ 35C | Nmin estimate based on zero N plot crop N uptake | Increase in mineralization w/increase in temp from 23 to 35 C |
|---|---|---|---|---|---|---|---|---|
| | | lb N/acre | | | | | | Nmin@35/Nmin@23 |
| 1 | Brooks | 6,300 | 147 | 85 | 64 | 163 | 93 | 1.9 |
| 2 | Lebanon | 4,550 | 67 | 64 | 43 | 124 | 43 | 1.9 |
| 3 | N. Albany | 7,000 | 164 | 114 | 92 | 238 | 69 | 2.1 |
| 4 | N. Albany | 5,950 | 71 | 60 | 59 | 141 | 100 | 2.4 |
| 5 | Molalla | 4,900 | 109 | 67 | 63 | 155 | 52 | 2.3 |
| 6 | Monroe | 5,600 | 124 | 58 | 70 | 136 | 90 | 2.3 |
| 7 | Stayton | 8,050 | 244 | 78 | 86 | 191 | 68 | 2.4 |
| 2012 Average | | 6,050 | 132 | 75 | 68 | 164 | 74 | 2.2 |
| 2011 Average | | 4,681 | 66 | 39 | NA | 123 | 95 | 3.2 |

Table 4. Nitrogen mineralized from soil samples (0-12 inches), using anaerobic or aerobic N mineralization test methods. Also shown is crop N uptake from zero N field plots (full data set in Table 2). **Units: N mineralized as percentage of total soil N.**

| Site | Location | Soil total N | Anaerobic Nmin, 7d @ 40C | Aerobic 42d net Nmin @ 23C | Aerobic 7d net Nmin @ 35C | Aerobic 42d net Nmin @ 35C | Nmin estimate based on zero N plot crop N uptake |
|---|---|---|---|---|---|---|---|
| | | % of total soil N | | | | | |
| 1 | Brooks | 0.18 | 2.3 | 1.3 | 1.0 | 2.6 | 1.5 |
| 2 | Lebanon | 0.13 | 1.5 | 1.4 | 0.9 | 2.7 | 0.9 |
| 3 | N. Albany | 0.20 | 2.3 | 1.6 | 1.3 | 3.4 | 1.0 |
| 4 | N. Albany | 0.17 | 1.2 | 1.0 | 1.0 | 2.4 | 1.7 |
| 5 | Molalla | 0.14 | 2.2 | 1.4 | 1.3 | 3.2 | 1.1 |
| 6 | Monroe | 0.16 | 2.2 | 1.0 | 1.3 | 2.4 | 1.6 |
| 7 | Stayton | 0.23 | 3.0 | 1.0 | 1.1 | 2.4 | 0.8 |
| 2012 Average | | 0.17 | 2.1 | 1.3 | 1.1 | 2.7 | 1.2 |
| 2011 Average | | 0.13 | 1.4 | 0.9 | NA | 2.7 | 2.3 |

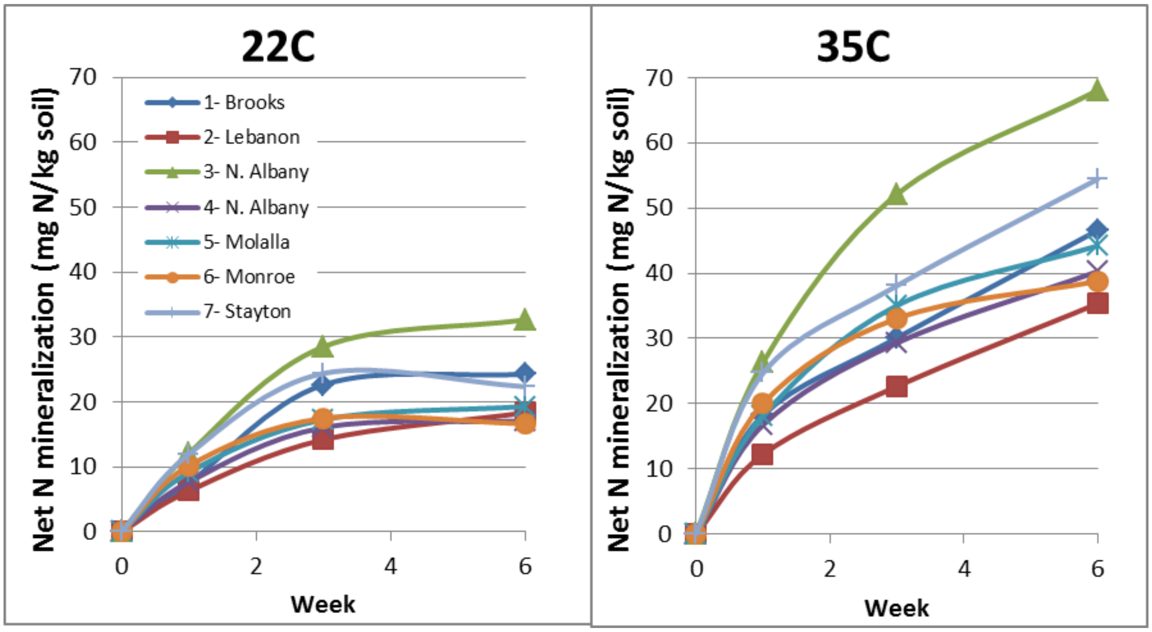

Figure 2. Net N mineralization of soil collected from 0-12" and incubated at 22 and 35C (72 and 95F). At 6 wks (42 d) mineralization appeared to be complete for soil incubated at 22C, but at 35C the soil was continuing to mineralize N.

**N mineralization rate in the laboratory vs. the field (Tables 3 and 4).** We measured soil N mineralization rate in the laboratory in an effort to use a laboratory test to forecast N mineralization rate in the field. Based on 2011 data, we designed the 2012 laboratory trials to evaluate N mineralized under short incubation time (7 days), aerobic conditions, and elevated temperature (35C). We found that amount of soil N mineralized in a 7-day aerobic incubation test at 35C in the laboratory was of the same approximate magnitude as the N uptake by unfertilized plants (at silking) in our field plots (about 70 lb N per acre). We found that the anaerobic N mineralization test (7 days incubation at 40C) was about 2X greater than crop N uptake in the field. Nitrogen uptake in the field (to silking) or N mineralized in the laboratory (7 days aerobic incubation at 35 C) was equivalent to about 1% of total soil N present in a 0-12 inch soil sample. We recommend the 7-day aerobic laboratory N mineralization test at 35C for further evaluation in 2013.

**Effect of soil incubation temperature on rate of N mineralization in the laboratory, using an aerobic incubation method.** We conducted aerobic N mineralization tests at two temperatures, 23 and 35C to evaluate the effect of temperature on the mineralization rate. At 23C, N mineralization was mostly complete by day 21 while at 35C, the soil was still mineralizing N at day 42 (Fig.2). Soil N mineralized (after 42 d) at 35C was 2.2X greater (range 1.9-2.4) than at 23C. In 2011, it was 3.2X greater. Existing models typically predict a mineralization rate increase of 2 to 3X when temperatures increase by 10C, so our data falls within the expected range.

**Utility of an at-planting soil nitrate test.**

Soil NO3-N was always higher in the PSNT samples compared to the at-planting samples (Table 5). We found that soil nitrate increased by an average of 35 lb N/acre between planting date and PSNT sampling date (corn at six leaf stage). Using the at-planting soil nitrate value with the current PSNT interpretive guidance (Table 10 in EM9010) would result in a slight over-application of N fertilizer.

Table 5. Soil nitrate concentrations (0-12 inches) in zero N plots (no fertilizer N applied). Soil samples were collected at time of planting or at ~V6 (as recommended for PSNT test).

| Site | Location | Previous crop | Sampling date | Sampling date | NO3-N | NO3-N | PSNT fertilizer N recommendations | | Additional N over recommended rate |
|---|---|---|---|---|---|---|---|---|---|
| | | | @ planting | @ PSNT | @ planting ppm | @ PSNT ppm | @ planting lb N/A | @ PSNT lb N/A | lb N/A |
| 1 | Brooks | Broccoli | 15-May | 29-Jun | 17 | 25 | 115 | 90 | 25 |
| 2 | Lebanon | Winter squash | 5-Jun | 13-Jul | 10 | 22 | 140 | 100 | 40 |
| 3 | N. Albany | Corn | 8-Jun | 9-Jul | 14 | 27 | 125 | 80 | 45 |
| 4 | N. Albany | Sudan grass | 14-Jun | 9-Jul | 13 | 21 | 130 | 105 | 25 |
| 5 | Molalla | Perennial ryegrass (3yrs) | 21-Jun | 24-Jul | 11 | 24 | 135 | 90 | 45 |
| 6 | Monroe | Wheat | 26-Jun | 30-Jul | 9 | 23 | 145 | 95 | 50 |
| 7 | Stayton | Wheat-strip till | 29-Jun | 27-Jul | 12 | 17 | 130 | 115 | 15 |
| | | | | Average | 12 | 23 | 131 | 96 | 35 |
| | | | | Median | 12 | 23 | 130 | 95 | 40 |

## Results for Phosphorus

### Effect of banded P fertilizer rate on crop yield and quality for early and late season planting dates.

Table 6 shows the soil characteristics for the field sites used in the P studies. Soil P was high, ranging from 77-108 ppm. OSU's Nutrient Management Guide for Sweet Corn-Western Oregon (publication EM 9010-E) recommends that when the Bray 1 P concentration is >50 ppm, no fertilizer P is usually necessary for maximum growth except when conditions could lead to a deficiency (i.e. cold soil temps and tillage history). Root growth is governed by temperature and can be minimal early in the season, limiting crop P uptake. Low soil temperature also reduces the rate at which organic P is converted to soluble plant-available P. We hypothesized that for early spring plantings when soil temperatures were low that the crop would respond to P fertilization despite high initial soil P test levels.

At all sites, there was no ear yield or ear quality response to fertilizer P (Table 7 and Fig. 3) despite low initial soil temperatures for the three May plantings (Fig. 4). These results validate OSU's P fertilizer recommendations for sweet corn that recommends no P fertilizer additions when test P levels are >50 ppm. Soil test P was well above 50 ppm at all sites. For fields with soil test P near 50 ppm, a low rate of P still might be beneficial for early spring plantings.

Apparently, current soil test P was high enough so that the application of additional P fertilizer did not provide positive economic returns. Table 8 shows additional soil test P values collected from fields used for this year's nitrogen mineralization trials (other soil characteristics for these sites is listed in Table 1). Most of the additional fields tested (6 out of 7) also had Bray soil test P in excess of the fertilizer response level (>50 ppm soil test P using the Bray method; OSU EM 9010).

Table 6. At-planting soil characteristics for P field sites (0-12") as analyzed by Brookside Laboratories.

| Location | NRCS mapped soil | pH | Total N | OM[1] | NO3-N | Bray P | K[2] | Ca[2] | Mg[2] |
|---|---|---|---|---|---|---|---|---|---|
| | | | % | % | ---------- | ppm | ---------- | meq/100g | |
| Corvallis I | Chehalis sicl | 6.1 | 0.17 | 2.8 | 12 | 93 | 153 | 12.3 | 5.4 |
| Gervais | Amity sil | 6.7 | 0.18 | 2.9 | 17 | 108 | 165 | 11.6 | 1.6 |
| Independence | Concord and Dayton sil | 5.0 | 0.18 | 2.8 | 48 | 81 | 113 | 6.2 | 1.0 |
| Corvallis II | Chehalis sicl | 6.0 | 0.16 | 2.6 | 12 | 77 | 148 | 10.9 | 5.0 |

1- estimated by 1.7 x total C; assumes soil OM contains 58% C

2- in a Mehlich III extractant

**P supply to roots under actual field conditions using Plant-Root Simulator probes.**

Soil temperature is a major factor affecting P supply to roots. The most critical period for P availability to corn is during seedling development, immediately after planting. Average daily soil temperatures were lower for the three May plantings than for the Corvallis II planting in late June (Fig. 4).

The PRS measurements assessed P supply as affected by prevailing soil moisture, temperature, physical and biological conditions. Phosphorus supply (P flux to the PRS probe anion exchange membrane) varied among field sites, even though all sites had similar (high) Bray soil test P (Table 8). PRS measurements at the early and late planting at OSU Vegetable Farm showed a two-fold increase in P supply due to planting date. The PRS measurements support the practice of reducing P fertilizer rates for late corn plantings.

PRS measurements were also collected at additional field sites for a two week period in June (Table 8; see Table 1 for additional soil test information for these sites). P supply, as measured by PRS, varied almost 8X among sites. However, the lowest P supply observed by PRS in June was greater than that observed for the May field trial sites (Gervais, Corvallis I, and Independence) where ear yield did not respond to P fertilizer addition (Figure 3). Therefore, although variation was found in soil P supply among fields (as measured by PRS), all of the sites likely had adequate P to support crop yields (all fields were high in P).

Table 7. Sweet corn yield and ear quality response to P2O5 treatments at 4 sites in the Willamette Valley, 2012.

| P2O5 (lb/A) | Obs | Ear no./A | Yield (t/A) | Avg. fresh ear wt (lbs) | Avg. husked ear wt (lbs) | Ear length (in) | % tip fill | Ear width (in) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|
| Corvallis I, Veg Res Farm, Planted May 11, Var. Captain, hand harvested | | | | | | | | | |
| 0 | 4 | 18400 | 9.8 | 1.07 | 0.72 | 7.98 | 95 | 2.07 | 72.0 |
| 15 | 4 | 17100 | 9.3 | 1.09 | 0.77 | 8.14 | 97 | 2.10 | 71.6 |
| 30 | 4 | 19200 | 10.6 | 1.10 | 0.76 | 8.10 | 97 | 2.11 | 72.4 |
| 60 | 4 | 18600 | 10.3 | 1.11 | 0.80 | 8.10 | 98 | 2.13 | 71.6 |
| 120 | 4 | 17600 | 9.5 | 1.07 | 0.73 | 8.03 | 96 | 2.07 | 71.8 |
| | *FPLSD(0.05)* | *ns* | *ns* | *ns* | *ns* | *ns* | *2* | *0.05* | *ns* |
| Gervais, planted May 16, Var. 4927, hand harvested | | | | | | | | | |
| 0 | 4 | 21500 | 10.4 | 0.96 | 0.64 | 8.1 | 100 | 2.00 | 71.8 |
| 15 | 4 | 20500 | 9.9 | 0.96 | 0.62 | 8.0 | 99 | 1.99 | 72.0 |
| 30 | 4 | 20700 | 9.8 | 0.95 | 0.61 | 7.9 | 99 | 2.01 | 71.6 |
| 60 | 4 | 22300 | 10.7 | 0.95 | 0.64 | 7.8 | 98 | 2.00 | 70.7 |
| 120 | 4 | 19500 | 9.5 | 0.97 | 0.63 | 8.0 | 100 | 2.03 | 70.4 |
| | *FPLSD(0.05)* | *ns* | *ns* | *ns* | *ns* | *0.2* | *2* | *ns* | *ns* |
| Independence, planted May 29, Var. Coho, machine harvested | | | | | | | | | |
| 0 | 2 | 29400 | 12.6 | 0.77 | 0.67 | 7.6 | 97 | 2.07 | 71.6 |
| 15 | 3 | 30700 | 11.7 | 0.77 | 0.63 | 7.5 | 97 | 2.05 | 71.7 |
| 30 | 2 | 29200 | 10.9 | 0.76 | 0.66 | 7.4 | 95 | 2.06 | 71.1 |
| 60 | 3 | 30400 | 11.5 | 0.77 | 0.67 | 7.5 | 95 | 2.05 | 70.7 |
| 120 | 3 | 31600 | 12.1 | 0.78 | 0.67 | 7.5 | 97 | 2.06 | 70.0 |
| | *FPLSD(0.05)* | *ns* | *0.7* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| Corvallis II, Veg Research Farm, planted June 27, Var. Captain, hand harvested | | | | | | | | | |
| 0 | 4 | 22000 | 14.63 | 1.16 | 0.77 | 8.1 | 99 | 2.08 | 74.6 |
| 15 | 4 | 21500 | 14.80 | 1.10 | 0.76 | 8.5 | 94 | 2.06 | 75.4 |
| 30 | 4 | 21000 | 14.52 | 1.10 | 0.72 | 9.0 | 90 | 2.11 | 75.3 |
| 60 | 4 | 21000 | 15.16 | 1.07 | 0.73 | 8.5 | 94 | 2.13 | 74.6 |
| | *FPLSD(0.05)* | *ns* | *ns* | *0.06* | *0.04* | *ns* | *ns* | *ns* | *ns* |

Table 8. Plant-Root Simulator Probes (PRS™) data. For the P field sites, the value of the P diffusion onto the PRS probes is an average of 4 replicates.

| **Location** | **Soil texture** | **Install date** | **Removal date** | **Initial Bray 1 P** | **Avg soil temp @4"** | **P diffusion onto PRS probes** |
|---|---|---|---|---|---|---|
| | | | | mg/kg | F | µg/10cm2/2-wks |
| Corvallis I | sicl | 11-May | 26-May | 93 | 60.5 | 3.72 |
| Corvallis I | sicl | 26-May | 8-Jun | 93 | 62.0 | 3.44 |
| Corvallis I | sicl | 8-Jun | 23-Jun | 93 | 65.2 | 5.56 |
| Corvallis I | sicl | 23-Jun | 6-Jul | 93 | 67.3 | 3.64 |
| Gervais | sil | 16-May | 30-May | 108 | 60.1 | 2.17 |
| Gervais | sil | 30-May | 14-Jun | 108 | 61.9 | 2.45 |
| Gervais | sil | 14-Jun | 28-Jun | 108 | 67.1 | 1.14 |
| Gervais | sil | 28-Jun | 12-Jul | 108 | 72.0 | 2.82 |
| Independence | sil | 31-May | 14-Jun | 81 | 60.2 | 2.35 |
| Independence | sil | 14-Jun | 28-Jun | 81 | 65.0 | 0.69 |
| Independence | sil | 28-Jun | 12-Jul | 81 | 70.0 | 1.98 |
| Independence | sil | 12-Jul | 26-Jul | 81 | 72.1 | 2.33 |
| Corvallis II | sicl | 29-Jun | 13-Jul | 77 | 67.3 | 5.79 |
| Corvallis II | sicl | 13-Jul | 27-Jul | 77 | 73.6 | 6.94 |
| Corvallis II | sicl | 27-Jul | 10-Aug | 77 | 71.9 | 9.30 |
| Brooks | sil | 28-Jun | 12-Jul | 103 | 67.3 | 3.2 |
| Lebanon | sil | 30-Jun | 13-Jul | 155 | 67.3 | 6.9 |
| N. Albany | sicl | 29-Jun | 13-Jul | 97 | 67.3 | 2.9 |
| N. Albany | sil | 29-Jun | 13-Jul | 38 | 67.3 | 3.9 |
| Talbot | sil | 29-Jun | 13-Jul | 146 | 67.3 | 11.1 |
| Molalla | sicl | 30-Jun | 13-Jul | 51 | 67.3 | 7.2 |
| Monroe | sicl | 29-Jun | 13-Jul | 127 | 67.3 | 18.6 |
| Stayton | sicl | 29-Jun | 13-Jul | 64 | 67.3 | 5.7 |

Figure 3. Sweet corn yield response to P2O5 rates applied at planting at 4 sites (+SE). Because there was no yield response to P fertilization at any site, factors other than P were controlling yields (i.e. soil, location, variety, etc). The 120 lb/A rate was omitted at Corvallis II.

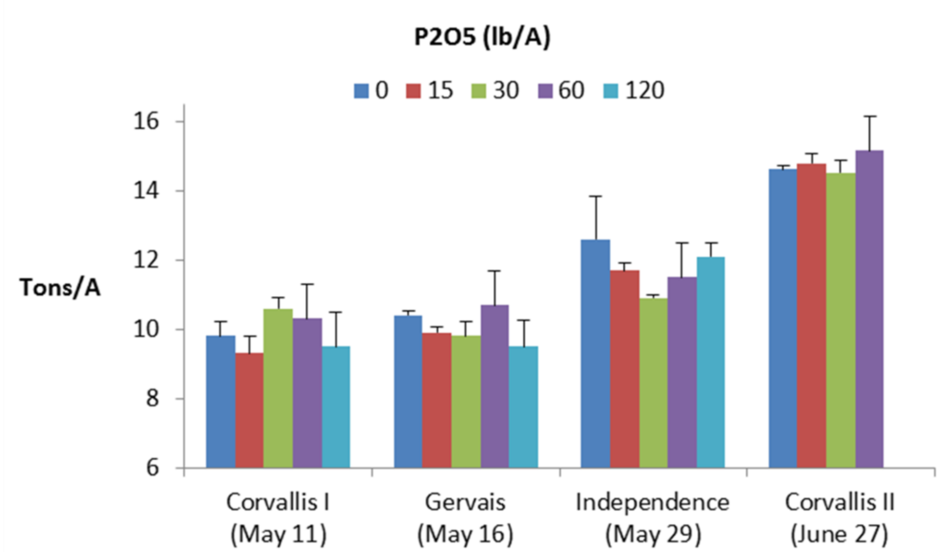


Figure 4. Daily average soil temperatures at 4" during growing season. Planting date is given in parenthesis. The shaded area represents the period when the PRS probes were in the soil.