# OSU Organic Fertilizer & Cover Crop Calculator: Predicting Plant-available Nitrogen

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The OSU Organic Fertilizer and Cover Crop Calculator is a tool to assist with preplant nitrogen (N) input decisions. It forecasts the quantity of plant-available nitrogen (PAN) provided by inputs such as fresh organic materials, cover crop residues, and finished compost. The calculator is an Excel-based worksheet available for free download via the OSU Small Farms Program website.

## Why use the OSU calculator?

Organic fertilizers are complicated. Plants cannot use organic N directly. Organic fertilizers release an unknown quantity of "active ingredient" (PAN) after application to soil. The activity of soil organisms transforms organic N fertilizers into PAN through a process called mineralization. Mineralization converts organic N to plant-available forms (ammonium and nitrate-N).

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The calculator predicts how much of the total N present in an organic material will transform to PAN during the first growing season after application in the field. By using the calculator, you can apply an appropriate amount of PAN for your crops, which will save money and protect groundwater from nitrate contamination. With the calculator, you can compare the cost of PAN from different organic materials. The calculator takes only a few minutes to perform calculations that would be time consuming and prone to error if done by hand.

## Calculator data input

To use the calculator, you need to specify these organic input characteristics:

- Category of organic input—fresh organic material, cover crop residue, or finished compost.
- Percentage of dry matter (DM) in the fresh, "as-is" organic material.
- Total N analysis (% of N in dry matter).
- Application rate in the field (chosen by user).

To obtain this input data:

- See "Matching calculator PAN to crop N requirements" (page 7) for crop PAN input requirements.
- Refer to the fertilizer label or ask suppliers of bulk organic materials to provide an analysis for dry matter and percent total N. A guaranteed total N analysis is required for products registered with the Oregon Department of Agriculture (see: https://www.oregon.gov/oda/programs/pesticides/fertilizers/pages/fertilizers.aspx). Assume that dry matter in bagged products is 90% to 100%.
- Send a sample of a specific organic material to an analytical laboratory, and request an analysis for total N and dry matter percentage. See Analytical Laboratories Serving Oregon (EM 8677) for additional guidance.

If the above information is not available, then use the following resources to approximate the necessary input data:

- Fertilizing with Manure and Other Organic Amendments (PNW 533) provides "book values" for typical total N analysis and dry matter percentage for uncomposted manures, and a worksheet for manure spreader calibration to determine application rate.
- Estimating Plant-Available Nitrogen Release from Cover Crops (PNW 636) illustrates several methods for measuring or estimating above-ground cover crop biomass, its dry matter percentage, and the total N percentage present in dry matter.

## Categories of organic inputs

The calculator organizes organic inputs into three categories: fresh organic materials, cover crop residue, and finished compost. It predicts PAN at 4 and 10 weeks after application for each category of organic input. PAN predictions are based on the total N concentration present in dry matter.

Table 1 (page 3) shows that the percentage of N present in organic materials can vary over a large range (1% to 12%), while the percentage of carbon (C) varies over a much more limited range, especially for fresh organic materials or cover crop residues.

The calculator uses the N concentration on a dry weight basis in an organic material as the input for all PAN prediction equations. Carbon to nitrogen ratio (C:N) is not used in the calculator's prediction equations. We show the C:N ratio in Table 1 because many other publications discuss PAN in terms of C:N ratio.

Fresh organic materials and cover crop residues decompose rapidly in soil. Fresh organic materials provide a little or a lot of PAN, depending on the percentage of N they contain. Uncomposted animal manures and specialty fertilizers from fish, feather, blood, and seed meals are considered fresh organic materials.

Finished composts result from a controlled decomposition process that includes the addition of water. Finished composts are usually actively managed for 60 to 90 days. Once finished, composts decompose slowly and release PAN slowly. Calculator predictions of PAN release from composts are less than 10% of total N.

Organic materials that are stacked and allowed to self-heat without active management are not finished composts. A pile of organic matter that is not regularly watered will have an interrupted, incomplete decomposition. Manures that are more fresh than composted usually smell like ammonia; finished compost does not. Most organic fertilizers derived from chicken manure (pelleted or "composted") release PAN at rates expected for fresh organic materials.

In reality, organic inputs do not always fit neatly into the three categories noted in Table 1. Ultimately, you must decide whether an organic material you work with is "fresh" or "finished compost."

**Table 1. Categories of organic inputs used to predict PAN release from organic inputs in the calculator**

| Category | Decomposition rate in soil | Total C[1] | Total N | C:N ratio[1] | Cumulative PAN release | |
|---|---|---|---|---|---|---|
| | | | | | 4 weeks | 10 weeks |
| | | % of dry wt. | % of dry wt. | | % of total N[2] | % of total N |
| Fresh organic material | Moderate to rapid | 35–45 | 1–12 | 40:1 to 4:1 | <0–60 | 0–75 |
| Cover crop residue | Rapid | 35–45 | 1–4 | 40:1 to 10:1 | <0–40 | 0–50 |
| Finished compost | Very slow | 15–30 | 1–3 | 20:1 to 10:1 | 0–5 | 0–10 |

[1]Total C and C:N are not used by the calculator to estimate PAN release. Calculator PAN estimates are based on total N concentration.

[2]For organic materials with low N concentrations (<1% in DM) predicted PAN is negative, indicating that PAN is consumed by microbes in soil (PAN is immobilized in microbial biomass).

## Calculator assumptions

The calculator assumes that:

- The C concentration of fresh organic materials is relatively constant (near 40%) and the percentage of total N concentration varies widely (from approximately 1% to 12%). Therefore, it is reasonable to use the N concentration rather than C:N as the predictor of PAN in the soil.
- Sufficient soil moisture or irrigation is present to support the mineralization process.
- Soil temperatures are warm enough to support the mineralization process.
- After mineralization, PAN is retained as nitrate-N in the soil.

## Caveats

The calculator assumes that PAN loss from the soil is minimal under conditions present in summer vegetable crop production systems in the Willamette Valley of Oregon. In typical Willamette Valley cropping systems, organic inputs are incorporated by tillage, summer precipitation is minimal, and adequate but not excessive irrigation is supplied to meet crop requirements.

The calculator does not adjust PAN predictions based on soil temperature. See sidebar “Temperature effects on PAN” (page 6) for explanation.

The OSU calculator does not forecast long-term PAN via mineralization from organic amendments. The calculator estimates PAN only during the first 10 weeks after the application of organic amendments. After the application year, only rough estimates of PAN release are possible. Research shows that approximately 5% to 10% of the total N provided by an organic input is converted to PAN during the second year after application.

The calculator is a tool for making preplant N input decisions. The calculator and this guide are not a substitute for monitoring the supply of soil nitrate-N during the growing season. We always recommend in-season soil nitrate testing because it evaluates all sources of PAN, including the N mineralized from soil organic matter. A companion publication, Soil Nitrate Testing for Willamette Valley Vegetable Production (EM 9221), describes how to sample soil and interpret the soil nitrate test results.

This publication does not provide cost comparisons among PAN sources. Use the OSU online calculator to compare the cost of PAN and other nutrients provided by different organic materials.

## Calculator predictions of PAN from organic materials

This section shows calculator inputs and outputs for:

- Fresh organic materials
- Cover crop residues
- Composts

PAN predictions in the online calculator are listed in units of “% of total N” on a dry weight basis, and in units of “lb PAN/100 lb product” on a fresh weight or as-is basis. This publication lists PAN predictions only on a dry weight basis, using two units:

- percent of total N
- lb PAN per dry ton

The Appendix (pages 11–18) discusses the research that supports the PAN prediction equations in the calculator.

## PAN from fresh organic materials

Fresh organic materials include animal manures that have not been composted and specialty fertilizers from fish, feather, blood, and seed meals.

PAN predictions for fresh organic materials are given in two units: percent of total N and lb/dry ton (Table 2). Figure 1 illustrates the PAN predictions (lb/dry ton).

***Note:*** *See pages 11–13 for research data that supports calculator predictions for PAN from fresh organic materials.*

## PAN from cover crop residues

PAN predictions are given in two units:

- percent of total N (Table 3, page 5)
- lb PAN per dry ton (Table 3 and Figure 2, page 5)

***Note:*** *See pages 14–18 for research data that supports calculator predictions for PAN from cover crops.*

## PAN from finished compost

A controlled decomposition process, where compost remains moist during composting and curing, results in finished composts. About 60 to 90 days of active management are required to produce finished compost.

PAN predictions for composts are given in two units: percent of total N and lb/dry ton (Table 4, page 5). Figure 3 (page 5) illustrates the PAN predictions (lb/dry ton). The range of PAN predicted from different composts is small (from 0% to 10% of total N). Research shows a weak relationship between total N concentration in compost and PAN provided by compost (Hartz et al., 2000; Gale et al., 2006; Prasad, 2009), so only a rough estimate of PAN is justified.

A few high N composts contain more than 2% total N and supply more PAN than is forecast in Table 4. Examples include some composted animal manures (without bedding) or compost derived from green, leafy crop residues (for example, peppermint). When compost total N is greater than 2% and an improved PAN estimate is desired, additional compost analyses (C:N, ammonium-N, nitrate-N) can

**Table 2. Predicted PAN release from fresh organic materials at 4 and 10 weeks after field application[1]**

| Fresh organic material N concentration | Plant-available N (PAN) predicted by the OSU calculator | | | |
|---|---|---|---|---|
| % total N in dry matter[2] | % of total N | | lb/dry ton | |
| | 4 wk | 10 wk | 4 wk | 10 wk |
| 1 | -15 | 0 | -3 | 0 |
| 2 | 0 | 15 | 0 | 6 |
| 3 | 15 | 30 | 9 | 18 |
| 4 | 30 | 45 | 24 | 36 |
| 5 | 45 | 60 | 45 | 60 |
| 6 | 60 | 75 | 72 | 90 |
| 9 | 60 | 75 | 108 | 135 |
| 12 | 60 | 75 | 144 | 180 |

[1]PAN estimated via calculator prediction equations. Source: OSU calculator

[2]For bagged fertilizer products, assume that total N in percentage in dry matter is equivalent to the %N listed on the fertilizer bag. For other amendments, obtain a total N analysis (on DM basis) from a laboratory analysis report or a database. For additional explanation, see "Calculator data input" (page 2).

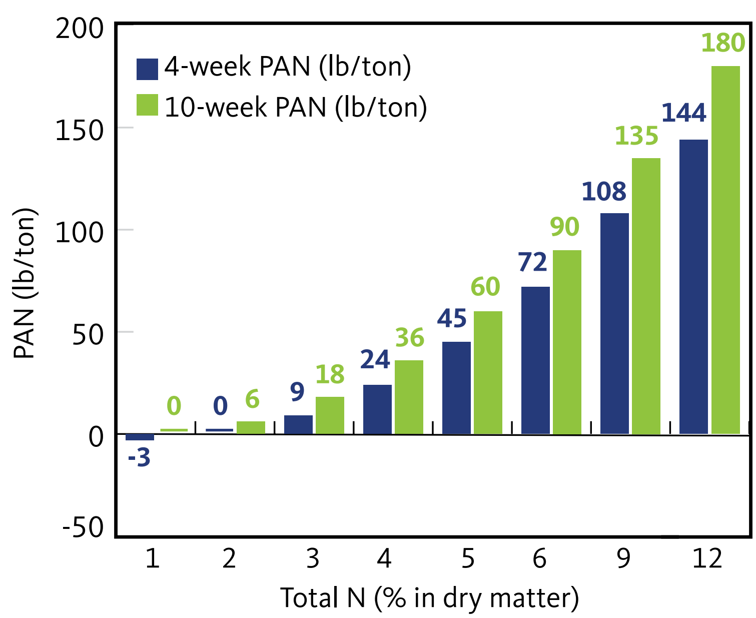


Figure 1. Calculator predictions for PAN from fresh organic materials. PAN in units of lb/dry ton.

be useful. See Interpreting Compost Analyses (EM 9217) for additional information.

Although PAN from compost is a small percentage of total N, it is still important to consider PAN from compost when it is applied at high rates for improving soil tilth. An inch of compost spread on an acre is equivalent to an application of approximately 30 to 40 dry ton per acre. An inch of a compost containing 2% total N (dry weight basis) supplies approximately 120 to 160 lb PAN/acre during the first 10 weeks after application.

**Table 3. Predicted PAN release from cover crop residues at 4 and 10 weeks after field application[1]**

| Cover crop N concentration | Plant-available N (PAN) predicted by the OSU calculator | | | |
|---|---|---|---|---|
| % total N in dry matter[2] | % of total N | | lb/dry ton | |
| | 4 wk | 10 wk | 4 wk | 10 wk |
| 1.0 | -32 | -12 | -6 | -2 |
| 1.5 | -11 | 7 | -3 | 2 |
| 2.0 | 11 | 26 | 4 | 10 |
| 2.5 | 28 | 38 | 14 | 19 |
| 3.0 | 34 | 42 | 20 | 25 |
| 3.5 | 39 | 46 | 28 | 32 |
| 4.0 | 45 | 50 | 36 | 40 |

[1] PAN estimated via OSU calculator prediction equations. Source: OSU calculator

[2]Obtain a total N analysis (on DM basis) from a laboratory analysis report or a database. For additional explanation, see "Calculator data input" (page 2).

**Table 4. Predicted PAN release from finished compost at 4 and 10 weeks after field application[1]**

| Compost N concentration | Plant-available N (PAN) predicted by the OSU calculator | | | |
|---|---|---|---|---|
| % total N in dry matter[2] | % of total N | | lb/dry ton | |
| | 4 wk | 10 wk | 4 wk | 10 wk |
| Less than 1 | 0 | 0 | 0 | 0 |
| 1 to 2 | 0 | 5 | 0 | 1–2 |
| More than 2 | 5 | 10 | 2+ | 4+ |

[1]PAN estimates are valid only for finished composts that are biologically stable. Some organic materials marketed as "compost" do not meet this criteria (for example, dry stacked poultry litter). Source: OSU calculator

[2]Obtain a total N analysis (on DM basis) from a laboratory analysis report or a database. For additional explanation, see "Calculator data input" (page 2).

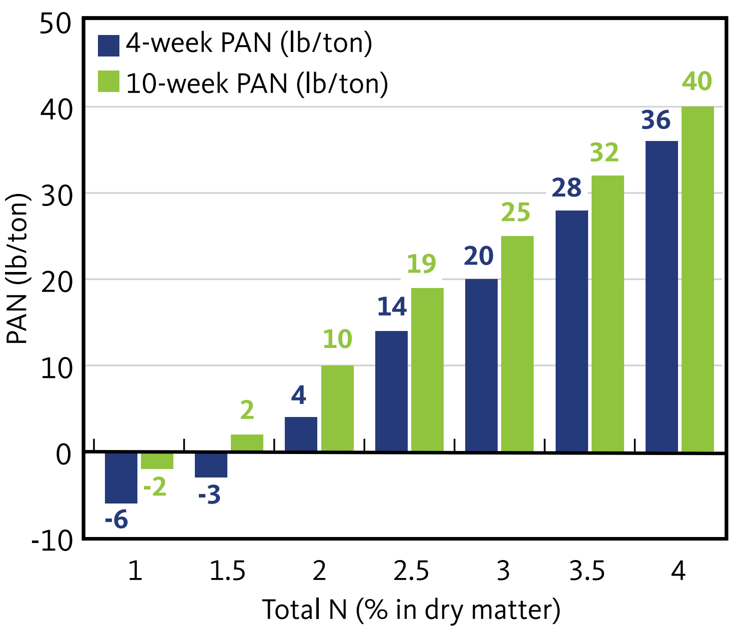


Figure 2. Calculator predictions for PAN from cover crop residues; PAN in units of lb/dry ton

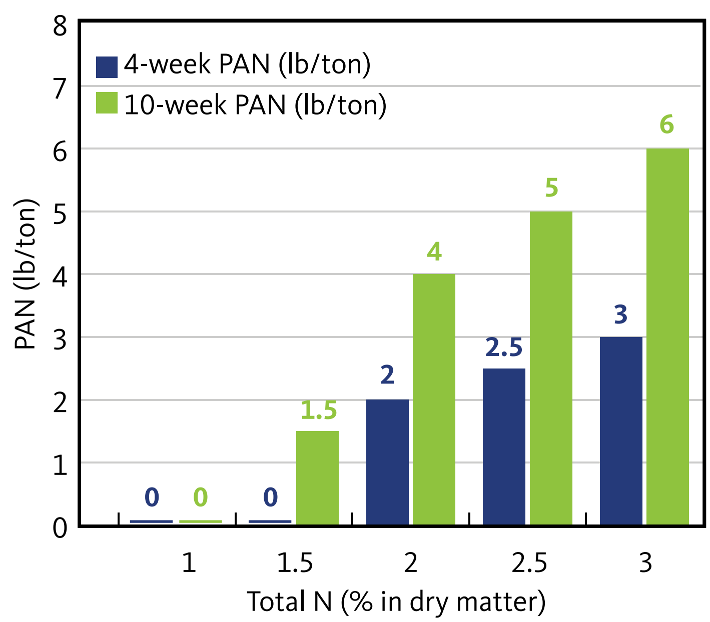


Figure 3. Calculator predictions for PAN from compost; PAN in units of lb/dry ton

## Temperature effects on PAN

Research presented in this publication was performed in the field in summer or in the laboratory at 72°F (22°C). The OSU Organic Fertilizer and Cover Crop Calculator does not provide temperature-specific predictions for the reasons outlined below.

In general, the rate of biological activity in soil, including the N mineralization process that produces PAN, doubles with every temperature increase of 18°F (10°C). This estimate, with a $Q_{10}$ temperature coefficient of 2, has been shown to be approximately correct for most decomposition and N mineralization processes in soil.

Because the rate of decomposition and PAN release in soil is rapid for most organic inputs, we did not include temperature as a variable in the calculator.

Research conducted by others supports our assumption that temperature is not a major constraint for PAN release at 4 and 10 weeks after application of organic materials to soil (Griffin and Honeycutt, 2000; Agehara and Warnke, 2005; Hartz and Johnstone, 2006). For example, Hartz and Johnstone (2006), incubated feather meal, fish powder, blood meal, or seabird guano in moist soil at temperatures ranging from 50°F to 77°F (10°C to 25°C). See Figure 4. After 4 weeks, PAN across all specialty products averaged 53% of total N when applied at 50°F (10°C) and 63% when applied at 77°F (25°C).

Organic materials that we tested differed in their resistance to decomposition. Table 5 shows the time required for decomposition of different classes of organic materials at two temperatures. The shorter the time to 25% decomposition, the more easily decomposed the organic material is. For all organic inputs, except compost, a 25% loss of organic matter (via decomposition) occurred during the first 2 weeks, when soil temperature was 72°F (22°C). After 4 weeks at 54°F (12°C), all organic inputs (except compost) demonstrated 25% decomposition.

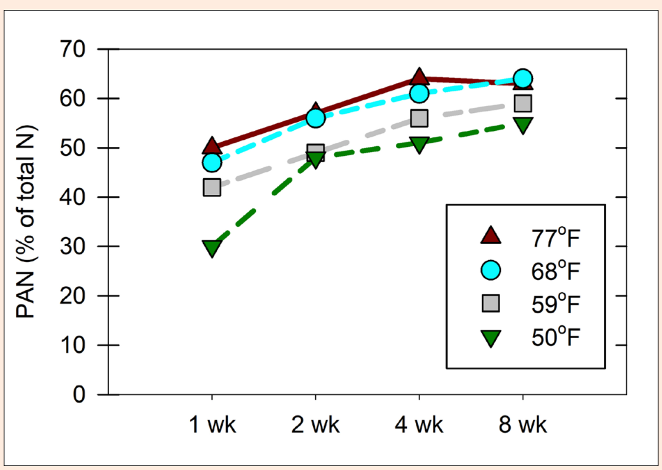


Figure 4. Temperature effects on PAN from feather meal (adapted from Hartz and Johnstone, 2006)

**Table 5. Weeks required for 25% decomposition of organic inputs at two temperatures**

| Organic material (OM)[1] | Weeks to 25% decomposition of OM | |
|---|---|---|
| | 72°F (22°C)[2] | 54°F (12°C)[3] |
| Specialty products (e.g., fish, feather meal) | <1 | 1 |
| Broiler litter | 1–2 | 2–4 |
| Fresh manure | 1–2 | 2–4 |
| Composts | 10–30 | 20–60 |
| Vetch cover crop | <1 | 1 |
| Phacelia cover crop | 1 | 2 |
| Oat cover crop | 1 | 2 |

[1]Organic materials: Specialty products included pelleted fish, feather meal, and canola meal. Fresh manure included separated dairy solids and rabbit manure. Composts were derived from a variety of on-farm feedstocks. Cover crops (at late vegetative growth stage): common vetch = *Vicia sativa*; phacelia = *Phacelia tanacetifolia*; Oat = *Avena sativa*

[2] Weeks required for decomposition of 25% of organic matter applied at 72°F (22°C). Decomposition ($CO_2$ loss) was measured in laboratory incubations in moist soil amended with organic fertilizers or compost (Gale et al., 2006) or with cover crop residue (Datta and Sullivan, unpublished).

[3]Weeks to 25% decomposition at 54°F (12°C) was estimated as twice the value as weeks to 25% decomposition at 72°F (22°C) ($Q_{10}$ = 2).

References:


Hartz, T.K. and P.R. Johnstone, 2006. Nitrogen availability from high-nitrogen-containing organic fertilizers. *HortTechnology*, 16:39–42.

Griffin, T.S. and C.W. Honeycutt, 2000. Using growing degree days to predict nitrogen availability from livestock manures. *Soil Science Society of America Journal*, 64:1,876–1,882.

Agehara, S. and D.D. Warncke, 2005. Soil moisture and temperature effects on nitrogen release from organic nitrogen sources. *Soil Science Society of America Journal*, 69:1,844–1,855.

**Table 6. Nitrogen input requirement for vegetable crops in organic transition or in established organic cropping systems**[1]

| Crop N requirement | Organic Transition | Established Organic | Crops |
|---|---|---|---|
| | lb PAN input/acre[2] | | |
| Low | 60–100 | <50 | Baby greens, snap bean, cucumber, radish, spinach, squash, table beet |
| Medium | 100–150 | 50–100 | Carrot, corn (sweet), garlic, lettuce, melon, onion, pepper, tomato |
| High | 140–200 | 70–140 | Broccoli, cabbage, cauliflower, celery, potato |

[1]Relative crop N input requirements (low, medium, high) adapted from Gaskell et al. (2007).

[2]PAN input estimated for vegetables grown in the summer in the Willamette Valley. We strongly recommend using in-season soil nitrate testing to verify crop N input need for your fields, as described in Soil Nitrate Testing for Willamette Valley Vegetable Production (EM 9221).

## Matching calculator PAN to crop N requirements

The calculator assumes that you have a target value in mind for crop N need (lb PAN required per acre). This section will help you estimate N input requirements for vegetable crops.

Table 6 provides general guidance for crops grown in fields undergoing organic transition or in established organic fields that have received organic inputs for many years. Generally, fields transitioning from conventional to organic management require greater PAN inputs than fields that have been managed organically for many years.

Vegetable crops require less N input when grown in midsummer than at other times of the year because of increased supply of PAN provided via decomposition of soil organic matter. For example, lettuce requires less PAN input in summer (June to August) than it does in spring (April to May).

## Questions and answers

The calculator is a screening tool for estimating the timing and amount of PAN released from organic inputs during the first growing season after application. Some common questions that arise include: calculator predictions versus reality, nutrient management decisions, rate of N release from organic inputs, and making economic decisions with the calculator.

### Calculator predictions versus reality

- *Does the calculator take into account PAN release from soil organic matter or are the numbers based on PAN release from inputs alone?*

The calculator predicts only PAN from current season inputs. It does not predict PAN mineralized from further decomposition of preexisting soil organic matter. This is the same approach used in OSU nutrient management guides. OSU nutrient management guides provide estimates of PAN input requirements based on field trials where the optimum PAN input rate was determined experimentally.

- *How accurate are the PAN predictions in the calculator? Can I rely on them?*

Field data from Willamette Valley cropping systems (western Oregon) support the calculator's predictions for PAN from organic inputs. See the Appendix (page 10).

- *Are calculator estimates of PAN from cover crops applicable to other regions and other cropping systems?*

Research to support our recommendations was performed in the Willamette Valley, Oregon, where cover crops are normally seeded in fall and killed in spring prior to a summer vegetable crop.

We expect a strong relationship between cover crop %N and PAN to be found in most locations. However, the timing of PAN release will differ in regions outside of western Washington and Oregon. Our cover crop PAN predictions are in general agreement with a recent PAN model developed by the University of Georgia (Gaskin et al., 2019).

- *I don't have time to collect cover crop data for all of my fields. What do you suggest?*

Cover crop species, coverage, and growth stage affect biomass. If you can't measure it, use typical values from previous years at about the same growth stage. We recommend that you measure biomass (via sampling) and submit cover crop samples for total N analysis regularly as a way to check your estimates. See Estimating Plant-Available Nitrogen Release from Cover Crops (PNW 636) for cover crop sampling and testing instructions.

In our experience, biomass for a winter cover crop in the Willamette Valley in mid- to late April (a few weeks ahead of reproductive growth stage) is 3,000 lb to 5,000 lb DM/acre, with 2% to 3% total N in dry matter.

## Nutrient management decisions

- *I want to apply 100 lb PAN for my crop. Can I use the calculator to estimate the quantities of different nutrient sources I would need to fulfill that?*

Use the "Nutrients Provided" tab in the calculator. Choose different input application rates for each organic input until you get a PAN estimate of 100 lb N/acre.

- *I've been using chicken manure to provide N, and my soil-test P values are in the "excess" range. What should I do to avoid adding more P?*

Cover crops don't add P to the soil. Whenever feasible, grow a legume cover crop instead of using chicken manure or other manure-based fertilizer. If you do use an organic fertilizer, choose one that is low in P, such as feather meal or blood meal. Generally, fertilizers derived from plant materials are lower in P than those derived from animal manure or from fish.

- *My field is high in soil organic matter (>5 %). Can I reduce N inputs?*

The calculator does not make predictions for PAN mineralized from soil organic matter. Crops grown on soil with 5% soil organic matter often require lower N inputs compared to soils with 2% soil organic matter, but it is difficult to make quantitative predictions.

Instead of a prediction for PAN based on soil organic matter percentage, we recommend using in-season soil testing to determine whether N supplied by your fertilizer program and cropping practices is sufficient or excessive. See Soil Nitrate Testing for Willamette Valley Vegetable Production (EM 9221) for more details.

- *If I fertilize my cover crop, will that change the PAN predictions in the calculator?*

Fertilization often increases cover crop biomass and N concentration in biomass at a given stage of crop development, thereby increasing PAN released in soil after cover crop kill. Fertilizing cover crops that are planted to scavenge residual soil nitrate after harvest of the summer crop (for example, squash, corn, tomato) is not recommended.

## Rate of N release from organic inputs

- *I use fish or feather meal or pelleted chicken manure to supply N for overwintering vegetable crops. I apply fertilizer in February when soil temperatures are cold. Are calculator PAN predictions for an early spring application reliable?*

You can use the calculator to guide specialty product application when soils are cold. The release of nitrate by mineralization of these products occurs more rapidly than crop uptake of N, even in cold soils. See "Temperature effects on PAN" (page 6) for additional explanation.

- *Are cover crops an important source of slow-release nitrogen?*

Data collected to support the calculator PAN estimates show that most of the PAN release from cover crops occurs within the first 4 weeks after soil incorporation. The quantity of PAN released during the first 4 weeks at 72°F (22°C) ranges from -6 to 36 lb per ton of dry matter incorporated (Table 3, page 5). Between 4 and 10 weeks, additional PAN release is 4 to 6 lb/ton. After 10 weeks, the release of PAN from any soil-incorporated cover crop is negligible and can be ignored when making N management decisions.

- *Does the method used to kill a cover crop affect PAN?*

Local research has not addressed whether the method used to kill a cover crop (tillage, herbicide, roller-crimper, mowing) affects PAN. Research from other regions suggests that the cover crop kill method does not affect the amount of PAN released during the year following the cover crop. Compared to incorporation of crop residue, we would expect PAN release to be slower when cover crop residues remain on the soil surface, especially where surface moisture is limited.

- *How much PAN is produced by decomposition of cover crop roots?*

Cover crop roots contribute only a small amount of PAN for the following crop and are ignored in calculations used in this publication. Research conducted in western Washington showed that Austrian pea and hairy vetch cover crops contained approximately 100 lb N/acre above ground, but only 10 lb N/acre in roots (Kuo et al., 1997). Roots also had a low N concentration in dry matter (% N less than 2 percent; C:N ratio greater than 20), suggesting that PAN release would be near zero.

## Using the calculator for economic decisions

- *How do I find the least expensive fertilizer program with the calculator?*

Enter the costs of the fertilizers you are comparing in the "Cost Comparisons" tab in the calculator. View the cost per pound of PAN, given product characteristics (price, total N analysis, and dry matter percentage). Try different options to find the least expensive alternative.

- *How does the calculator estimate the value of PAN from cover crops?*

The calculator includes a "Your Costs" worksheet to determine input costs ($/acre) to grow and kill a cover crop, including seed, labor, fuel, irrigation, and equipment depreciation. PAN from cover crop residue is then estimated (lb PAN/acre) based on equations that are discussed in this publication:

Cost per lb of PAN = $/acre ÷ PAN (lb/acre)

- *Can I customize estimated costs for a cover crop in the calculator to fit my situation?*

You can update costs for seed, tractor fuel, number of irrigations, and labor. You can enter current seed, fuel, and labor rates. Equipment costs for seeding and incorporating a cover crop are based on 2010 depreciation estimates. Irrigation costs to establish the cover crop are based on 2010 electricity rates.

## Long-term PAN management considerations in organic systems

Composts and some manures are important tools for building soil organic matter (SOM) in young organic systems. Frequent, high-rate compost or manure applications are not recommended in mature organic systems. Repeated compost or manure applications can result in very high levels of soil-test P and K. Also, it is difficult to control the timing of PAN release in soils that have elevated SOM concentrations. The timing of PAN release from SOM is controlled primarily by temperature. The PAN mineralized from SOM in late summer and fall is often not efficiently utilized by crops.

Over the long term, cover crops need to be considered as a priority organic matter input because they bring long-term soil health benefits without building up other nutrients to excessive levels in soil.

Figure 5 shows the challenge of supplying nitrogen for crop production when a cropping system moves from a conventional system (System 1) to a more mature organic system (System 3 or 4).

When a shift is made in management toward greater input of organics (compost, cover crop, and organic fertilizer), the amount of PAN provided by mineralization of SOM gradually increases (progression from System 1 to System 4). This occurs because not all of the N in organic inputs is mineralized in the year of application. Depending on the intensity of organic inputs, it may take a few years or decades to change the capacity of the soil to mineralize nitrogen.

The long-term management goal should be to reach System 4, where the system still has capacity to use the extra N fixed by a legume cover crop. System 3 or 4 is also likely the most economical way to manage N on organic farms, since routine application of compost is not required and use of expensive organic fertilizer inputs is minimized.

Continuing to increase soil organic matter is not recommended once System 4 is reached. When nitrate from SOM mineralization supplies adequate N for the crop (System 5), PAN supplied from the current year's cover crop or other N inputs is wasted. It is difficult to manage the timing of PAN relative to crop need when the only PAN source is nitrate from SOM mineralization. Some crops have lower yield or quality or both when too much PAN is supplied. Nitrate produced from SOM mineralization in late summer or early fall (after summer vegetable crop harvest) is subject to leaching during fall and winter.

The midseason soil nitrate test is recommended as a site-specific tool to assess overall supply of nitrate-N provided by all inputs plus N from mineralization of soil organic matter. Soil nitrate testing provides an overall assessment of PAN supply that cannot be obtained by use of the calculator. See Soil Nitrate Testing for Willamette Valley Vegetable Production (EM 9221) for additional information.

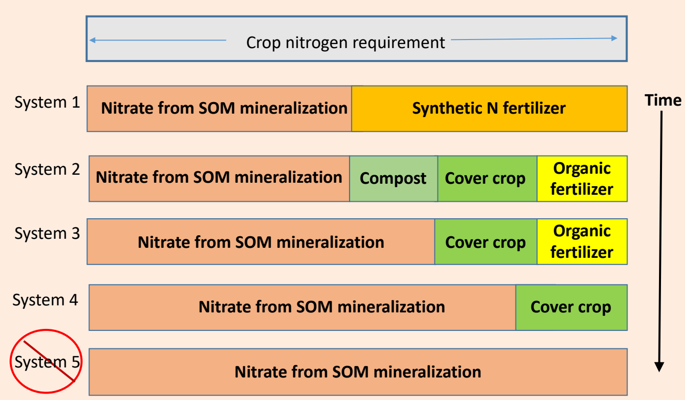


Figure 5. Effect of "soil building" on the quantity of nitrate-N mineralized from soil organic matter and the need for current-season inputs in organic systems. The overall goal is to reach System 3 or 4, in which crops have adequate, but not excess, PAN supply.

## Appendix: Calculator equations and supporting verification data

Equations **A**, **B**, and **C** (page 11) reference “total N” and “PAN.” These terms correspond to the following values:

- total N = total N analysis (% in dry matter) of fresh organic material, cover crop, or compost
- PAN = plant-available N (% of total N applied)

## Calculator prediction equations

### *Equation A: PAN from fresh organic materials (includes manures and specialty products)*

PAN is predicted by segmented equations, as shown in Figure 6. The “change point” between the two linear equations is 6% total N at both 4 and 10 weeks after application. Inputs and outputs for these equations are shown in Table 2 (page 4) and Figure 6. In equation form:

- ***At 4 weeks after application***

  When total N is less than 6%:

  PAN = −30 + (15 × total N)

  When total N is more than 6%:

  PAN = 60%

- ***At 10 weeks after application***

  When total N is less than 6%:

  PAN = −15 + (15 × total N)

  When total N is more than 6%:

  PAN = 75%

### *Equation B: PAN from cover crops*

PAN is predicted by segmented equations, as shown in Figure 7. The “change point” between the two linear equations is approximately 2.3% total N at both 4 and 10 weeks after application. Inputs and outputs for these equations are shown in Table 3 (page 5) and Figure 7. In equation form:

- ***At 4 weeks after application***

  When total N is less than 2.34%:

  PAN = −31 + [(total N−1.03) × 43.3]

  When total N is more than 2.34%:

  PAN = 25.8 + [(total N−2.34) × 11.7]

- ***At 10 weeks after application***

  When total N is less than 2.26%:

  PAN = −11 + [(total N−1.03) × 37.9]

  When total N is more than 2.26%:

  PAN = 35.6 + [(total N−2.26) × 8.5]

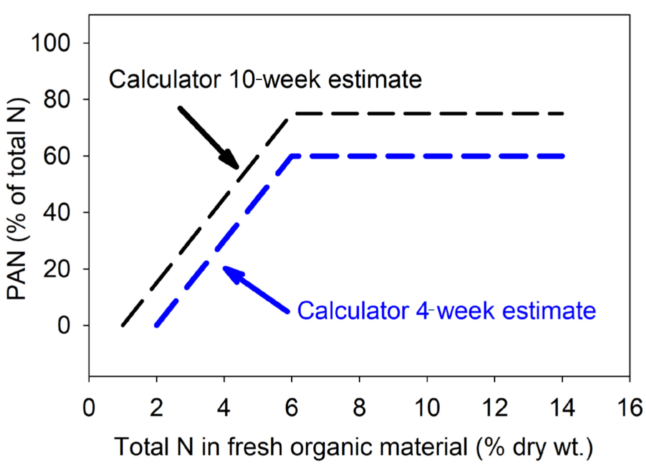


Figure 6. Relationship between the total N analysis of **fresh organic materials** and predicted PAN produced at 4 and 10 weeks after application to soil. Source: OSU calculator.

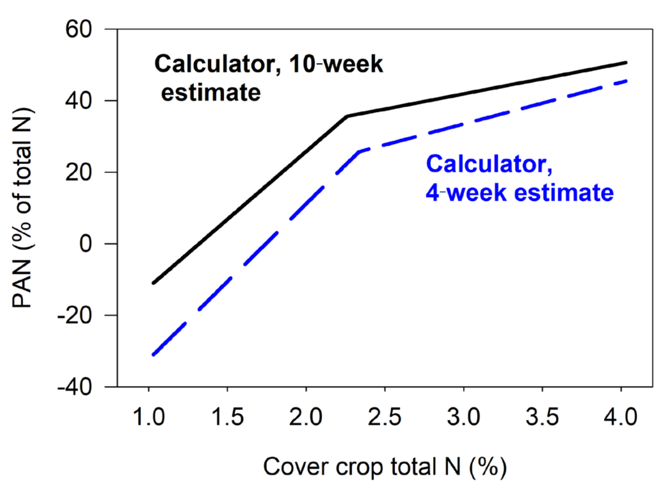


Figure 7. Relationship between the total N analysis of **cover crop residues** and predicted PAN produced at 4 and 10 weeks after application to soil. Ten-week estimate is solid line, 4-week estimate is dashed line.
Source: OSU calculator

### *Equation C: PAN from finished compost*

PAN is predicted by tabular look-up values, based on the total N percentage in DM. See Table 4 (page 5). In equation form:

- ***At 4 weeks after application***
  When total N is less than 1%: PAN = 0
  When total N is 1 to 2%: PAN = 0
  When total N is more than 2%: PAN = 5%
- ***At 10 weeks after application***
  When total N is less than 1%: PAN = 0
  When total N is 1 to 2%: PAN = 5%
  When total N is more than 2%: PAN = 10%

### *PAN from fresh organic materials and composts: field and laboratory trials*

- *Methods: PAN from fresh organic materials and composts—field trials*

Field trials were conducted in Aurora, Oregon on a Willamette silt loam soil and in Puyallup, Washington on a Puyallup sandy loam soil (Gale et al., 2006). PAN was determined in field trials with sweet corn. Each field trial included plots on which no organic material was applied (soil-only control), plots receiving preplant application of fresh organic materials or compost, and plots receiving urea-N at rates of 0, 50, 100, 150, and 200 lb N/acre. Organic materials were applied on approximately May 1. Organic materials were incorporated by tillage on the day of application. Corn was seeded about 30 days later, and corn ears were harvested September 4 to 12. PAN release from organic materials was estimated using an N fertilizer equivalency method.

- *Methods: PAN from fresh organic materials and composts—laboratory trials*

Laboratory incubations of organic materials in moist soil were used to develop calculator PAN predictions (Gale et al., 2006). Subsamples of each organic material were ovendried to determine dry matter percentage and total N concentration. Fresh or frozen organic materials (for example, manure, specialty products, cover crop, and compost) were added to moist soil at the start of incubation (Figure 11, page 14). The organic materials that were incubated in soil to determine PAN were not oven-dried or finely ground. Previous research in our laboratory showed that incubating fresh or frozen organic materials in soil gave more realistic PAN estimates than using oven-dried, ground organic materials.

After incubation for 4 and 10 weeks, soil was analyzed for both forms of PAN (ammonium and nitrate-N). Because ammonium-N concentrations were always low after 4 weeks of incubation, only soil nitrate-N was used to estimate PAN.

### *Equation D: Experimental determination of PAN*

In laboratory incubations, PAN released from organic inputs was determined experimentally by difference from a soil-only control treatment:

% PAN from organic input = [(Amended - Control) ÷ Input N] x 100
where:

% PAN = percentage of total input N that is recovered from soil as nitrate-N after incubation

Amended = Soil nitrate-N with organic material added (ppm)

Control = Soil nitrate-N without organic input (ppm)

Input N = amount of total N added to soil via organic input (fresh organic material, compost, or cover crop residue; ppm)

- *Results: PAN from fresh organic materials and composts—field and laboratory trials*

Field measurements of PAN collected at the time of corn ear harvest (Table 7, page 12) were highly correlated with measurements of PAN at 10 weeks in the laboratory (Figure 8).

Segmented linear equations were a reasonable fit to the observed PAN data (Figure 9A, page 12).

Few composts were included in the field and laboratory trials (Gale et al., 2006). PAN estimates for compost in the calculator are primarily based on data (not shown) from other experiments.

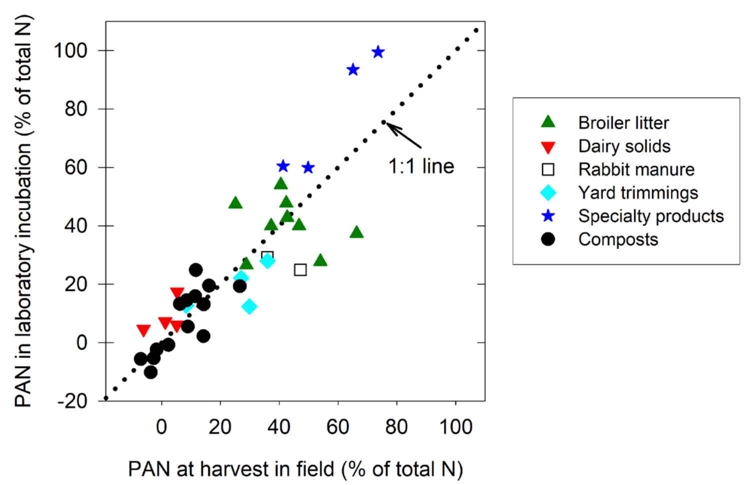


Figure 8. PAN release from organic materials in a series of four field experiments (x-axis) versus PAN measured in a laboratory incubation (72°F or 22°C for 10 weeks; y axis). The dotted line represents a 1:1 correlation between field PAN estimates (Table 7, page 12) and laboratory PAN estimates. Adapted from Gale et al., 2006.

**Table 7. Timing and amount of PAN recovered following preplant application of organic inputs to a sweet corn crop.[1]**

| | | Input analysis | | Field trial PAN[2] | |
|---|---|---|---|---|---|
| Organic input | Number of field trials | Total N | C:N | At time of ear harvest | |
| | | % in DM | | lb/dry ton | % of total N applied |
| Canola meal | 1 | 5.7 | 8 | 62 | 60 |
| Feather meal | 1 | 13.7 | 4 | 256 | 99 |
| Pelleted fish byproduct | 2 | 9.4 | 5 | 160 | 77 |
| Broiler litter | 4 | 3.8 | 10 | 31 | 42 |
| Bagged broiler litter | 1 | 4.1 | 8 | 40 | 47 |
| Broiler litter "compost"[3] | 4 | 4.0 | 9 | 29 | 38 |
| Dairy solids | 4 | 1.6 | 27 | 3 | 9 |
| Rabbit manure | 2 | 3.0 | 12 | 16 | 27 |
| Dairy solids compost | 5 | 1.9 | 21 | 1 | 3 |
| Rabbit manure compost | 2 | 1.8 | 10 | 8 | 22 |
| Yard trimmings compost | 4 | 1.7 | 17 | 2 | 5 |

[1]Source: Field trials conducted at Aurora, Oregon and Puyallup, Washington; adapted from Gale et al., (2006).

[2]PAN was determined by a N fertilizer equivalency method at harvest.

[3]Composts are stable organic materials with low decomposition rates. They have an earthy odor with no discernable ammonia odor. The "composted" broiler litter had ammonia odor, so it was not considered finished compost.

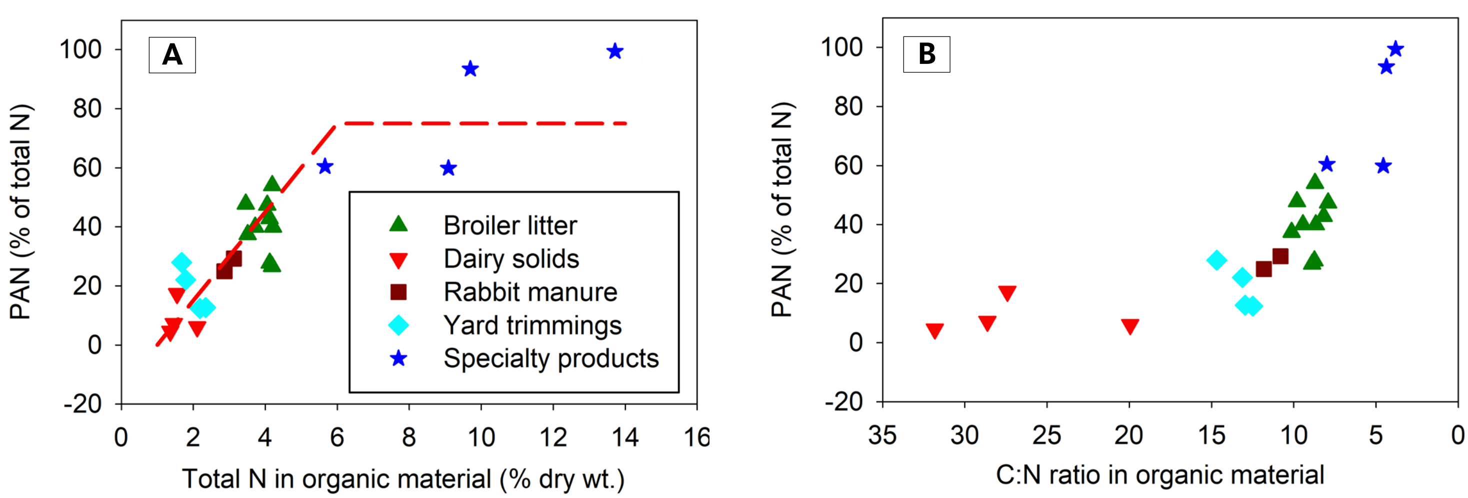


Figure 9. PAN provided by uncomposted organic materials in four field trials, plotted versus total N (A) or C:N ratio (B). PAN was estimated by an N fertilizer equivalency method (Gale et al., 2006). Dashed line is the prediction equation used to predict PAN at 10 weeks using the OSU calculator. The relationship between PAN and C:N ratio (B) is not employed in the calculator. It is included here for information purposes because many other publications use C:N to predict PAN.

### ***PAN from specialty products***

Specialty products are considered "fresh" organic materials in the calculator since they have not been stabilized by composting. We evaluated organic fertilizer products offered for sale to organic farmers in the north Willamette Valley, Oregon.

To determine PAN, we performed a 4-week laboratory incubation at 72°F (22°C). Specialty products included seed meals, fish byproducts, and animal byproducts. We also measured decomposition as a loss of C as carbon dioxide during the incubations.

Specialty products that contained 8% to 14% total N (in DM) released approximately 60% of total N as PAN after 4 weeks in soil (Table 8 and Figure 10). Measured PAN from specialty products was close to that predicted by the OSU calculator equation for fresh organic materials (Figure 10).

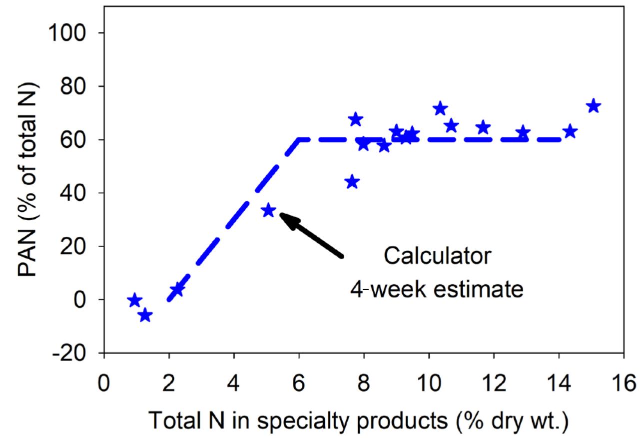


Figure 10. PAN provided by specialty product fertilizers in a 4-week incubation in a moist Chehalis silt loam soil at 72°F (22°C). Dotted line is the 4-week estimate for fresh organic materials from the OSU calculator. Table 8 shows the same dataset. Source: D. Sullivan, N. Andrews, and J. McQueen (unpublished).

**Table 8. Specialty product fertilizer PAN determined in a 4-week incubation in moist soil**

| Specialty product[1] | Product analysis | | PAN | Decomposition | |
|---|---|---|---|---|---|
| | Total N | C:N | 4 wk | 1 wk | 4 wk |
| | % in DM | | % of total N | % of total C | |
| Seaweed extract | 1 | 29 | 0 | 21 | 38 |
| Kelp meal | 1 | 26 | -6 | 8 | 14 |
| Alfalfa meal | 2 | 17 | 4 | 32 | 48 |
| Ground fish bone | 5 | 3 | 33 | 20 | 33 |
| Meat and bone meal | 8 | 5 | 44 | 41 | 53 |
| Soybean meal | 8 | 5 | 68 | 49 | 69 |
| Fish/feather/alfalfa meal | 8 | 5 | 58 | 43 | 59 |
| Bone meal | 9 | 5 | 58 | 49 | 59 |
| Feather meal, bone meal | 9 | 4 | 63 | 27 | 54 |
| Fish meal | 9 | 4 | 62 | 50 | 65 |
| Corn gluten meal | 10 | 5 | 72 | 49 | 69 |
| Granulated feather meal | 11 | 4 | 65 | 31 | 55 |
| Fish protein digest | 12 | 4 | 64 | 52 | 61 |
| Feather meal | 13 | 4 | 63 | 41 | 59 |
| Blood meal | 14 | 4 | 63 | 39 | 57 |

[1]Incubation method: Specialty products were incorporated into soil at 300 ppm total N in moist (25% gravimetric moisture) Chehalis silt loam soil at 72°F (22°C). Figure 10 shows same dataset. Source: D. Sullivan, N. Andrews, and J. McQueen (unpublished)

## *PAN from cover crop residues*

PAN prediction equations for cover crop residues were developed from laboratory incubation experiments. PAN was also measured in selected field trials following plowdown of cover crop residues.

- *Methods: PAN from cover crop residues—laboratory incubation Experiments A and B*

Cover crop biomass samples were harvested from field plots in April at vegetative growth stage or in May at early reproductive growth stage (Tables 9 and 10, pages 16 and 17). Cover crop species included legumes (common vetch, clovers), cereal rye, and phacelia. Cover crop samples were refrigerated or stored in a freezer for less than 1 week prior to the start of incubations. Cover crop samples were not oven dried or ground prior to laboratory incubations to determine PAN.

On the day an incubation began, cover crop samples were cut into small pieces (less than half an inch long) with a knife, then added to moist soil (20% to 25% gravimetric moisture, Figure 11). Subsamples of cover crop biomass were collected at the start of the incubation for determination of dry matter and total N.

The soils used for the cover crop incubations varied with year. Soil textures included silt loam, loam, and sandy loam. Soils were collected in moist condition from the field, sieved to pass a 0.3 inch (8 mm) screen, and refrigerated until a week prior to the start of an incubation. Some soils were misted with a spray bottle prior to incubation to bring soil moisture to the target level (20% to 25% gravimetric moisture).

Cover crops were added to moist soils and incubated at 72°F (22°C) in a zippered plastic freezer bag. Cover crop dry matter was added at a rate of 0.5% to 1.0% of soil dry weight so that the cover crop total N addition rate was a minimum of 100 ppm (mg N/kg dry soil). Each incubation included a soil-only control (no cover crop added). After the addition of the cover crop, the bags were zippered closed. A drinking straw was inserted at the edge of the zipper in each bag to allow air entry. The bags were then placed in a large plastic tub that had a sheet of wet polyurethane foam on the bottom and a loose-fitting lid to allow air entry (Figure 11).

After 4 and 10 weeks of incubation at 72°F (22°C), soil from the incubation bags was subsampled and nitrate-N was determined. Cover crop PAN was determined by difference, by subtracting the nitrate-N present in the no-cover-crop control bags (Equation D, page 11).

A combined dataset from the three laboratory incubations was used in the development of the calculator equations to predict PAN from cover crop residues. In Experiments A and B, a wide range of cover crop total N (% in DM) was attained by mixing non-legume biomass (cereal rye, oat, or phacelia) with legume biomass (common vetch or clover) at specified DM ratios (for example, 25% legume, 75% non-legume as shown in Table 9, page 16). In Experiment C, mixed species cover crop samples for incubation were obtained from field plot harvest of cover crops (Table 10, page 17).

Segmented linear regression was used to develop prediction equations for cover crop PAN. This regression technique represents the relationship between cover crop N (% in DM) and PAN (% of total N) as two lines that come together at a change point where the slope of the regression line changes.

- *Results: Laboratory incubation experiments A and B*

The regression equations shown in Figure 12 (page 15) and also listed in "Calculator prediction equations: PAN from cover crops" (page 10) were developed as a replacement for the cover crop prediction equation present in the original (2010) version of the calculator. The original calculator equation was adopted from PAN data for Kansas crop residues (Vigil and Kissel, 1991) with an unspecified time interval after crop residue incorporation for PAN prediction. Equations currently employed in the calculator (Equation B and Figure 7, page 10) provide 4- and 10-week PAN predictions.

1) Chop cover crop residue 2) Mix cover crop with moist soil 3) Transfer to 1-quart freezer bag
4) Incubate at 72°F (22°C) for 4 and 10 weeks. 5) Measure soil nitrate-N

Figure 11. Incubation method for cover crop residues in the laboratory

The segmented PAN prediction equations have a change point at approximately 2.3% total N. When a cover crop N concentration is less than 2.3% total N, the PAN produced (% of total N) by mineralization is strongly related to cover crop total N concentration, as indicated by a steep slope to the PAN prediction line (Figure 12). When cover crop N concentration is above 2.3%, PAN (% of total N) is less sensitive to changes in cover crop N concentration (shallower slope to PAN prediction line). The change point in the calculator regression equations (2.3% N in DM) corresponds with a cover crop C:N ratio of 17.

As with any regression relationship developed from real data, the actual PAN reported for an individual cover crop sample was not exactly equal to the calculator PAN prediction. Figure 12 shows this variability. For example, when cover crop total N (% in DM) is 3.0%, predicted PAN is 42% for 10 weeks, but observed data ranges from 35% to 55% PAN.

- *Methods: PAN from cover crops—field experiment C*

Predicted PAN from cover crops was computed by the OSU calculator (Equation B, page 10) based on measurements of biomass and total N (% in DM) present at each field location (Table 10, page 17). Actual PAN was determined in the field by soil sampling for nitrate-N early in the summer vegetable crop growing season. Winter cover crops were incorporated in April, and soil nitrate was measured 6 to 7 weeks later, on approximately June 10. Soil was collected from fertilized and unfertilized cover crop treatments in each field, and the net increase in soil nitrate-N (cover crop treatment minus no cover crop treatment) was calculated. Values for PAN prediction by the calculator were converted to soil nitrate-N (0- to 12-inch depth) assuming a soil bulk density of 81 lb per cubic foot (1.3 g/cm³). Using this conversion factor, 35 lb PAN per acre = 10 ppm nitrate-N.

- *Results: PAN from cover crops— field experiment C*

PAN measured at four on-farm, northern Willamette Valley field sites monitored in 2009 is shown in Figure 13 (page 18). Table 10 (page 17) shows the cover crop kill dates and cover crop biomass present at the field sites. Actual PAN, measured by soil sampling at 6 to 7 weeks after cover crop incorporation, was equal to or slightly greater than PAN predicted by the calculator for 4 and 10 weeks (Figure 13). Actual PAN measured by soil

*(continues page 18)*

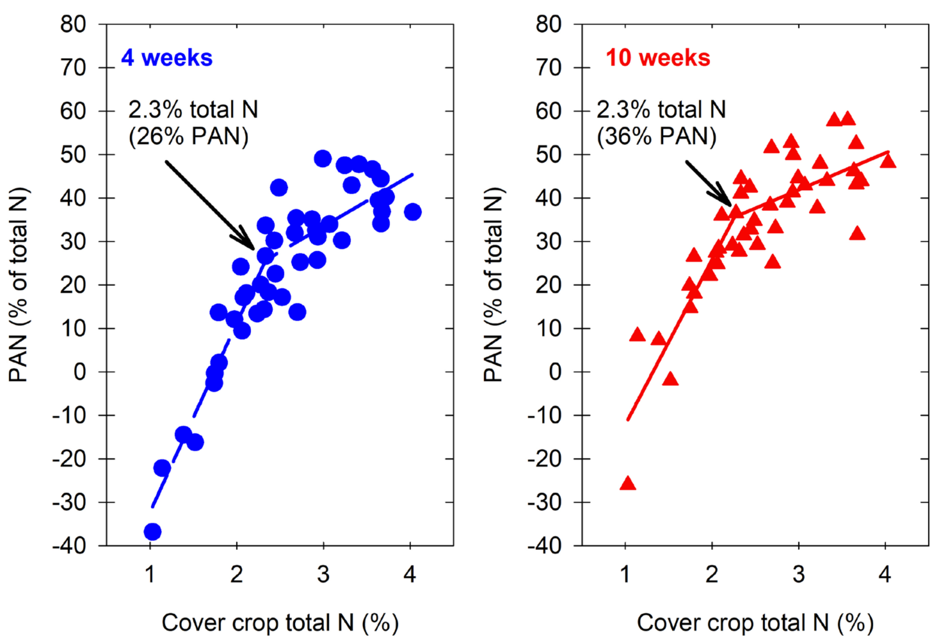


Figure 12. Plant-available N provided by cover crop residues after 4 and 10 weeks in moist soil at 72°F (22°C). Dataset details in Table 9 (page 16) and Table 10 (page 17). Segmented regression equations have endpoints (1% and 4% total N), with a midpoint at 2.3% total N. The adjusted $R^2$ values for segmented regression equations are 0.87 at 4 weeks and 0.78 at 10 weeks. The PAN prediction equations are given in "Equation B: PAN from cover crops" (page 10).

**Table 9. PAN from cover crop mixtures incubated in moist soil at 72°F (22°C). Laboratory incubation Experiments A and B[1]**

| Cover crop mixture | | | | | PAN | |
|---|---|---|---|---|---|---|
| Non-legume (%) | | Legume (%) | | Total N | 4 weeks | 10 weeks |
| | | | | % of DM | % of total N | |
| **Laboratory incubation Experiment A** | | | | | | |
| _ | _ | Vetch | (100) | 4.0 | 37 | 48 |
| Oat | (13) | Vetch | (87) | 3.6 | 39 | 46 |
| Oat | (25) | Vetch | (75) | 3.2 | 48 | 48 |
| Oat | (38) | Vetch | (62) | 2.9 | 35 | 39 |
| Oat | (50) | Vetch | (50) | 2.5 | 42 | 35 |
| Oat | (63) | Vetch | (37) | 2.1 | 18 | 36 |
| Oat | (75) | Vetch | (25) | 1.7 | 0 | 15 |
| Oat | (88) | Vetch | (12) | 1.4 | -14 | 7 |
| Oat | (100) | _ | _ | 1.0 | -37 | -26 |
| Phacelia | (13) | Vetch | (87) | 3.7 | 34 | 43 |
| Phacelia | (25) | Vetch | (75) | 3.3 | 43 | 44 |
| Phacelia | (38) | Vetch | (62) | 3.0 | 49 | 45 |
| Phacelia | (50) | Vetch | (50) | 2.7 | 32 | 38 |
| Phacelia | (63) | Vetch | (37) | 2.4 | 18 | 31 |
| Phacelia | (75) | Vetch | (25) | 2.1 | 17 | 28 |
| Phacelia | (88) | Vetch | (12) | 1.8 | 2 | 18 |
| Phacelia | (100) | _ | _ | 1.5 | -16 | -2 |
| **Laboratory incubation Experiment B** | | | | | | |
| _ | _ | Clover | (100) | 2.7 | 14 | 25 |
| Oat | (25) | Clover | (75) | 2.5 | 17 | 29 |
| Oat | (50) | Clover | (50) | 2.3 | 14 | 28 |
| Oat | (75) | Clover | (25) | 2.1 | 9 | 25 |
| _ | _ | Vetch | (100) | 3.7 | 40 | 44 |
| Oat | (25) | Vetch | (75) | 3.2 | 30 | 38 |
| Oat | (50) | Vetch | (50) | 2.7 | 25 | 33 |
| Oat | (75) | Vetch | (25) | 2.2 | 13 | 29 |
| Oat | (100) | _ | _ | 1.7 | -3 | 20 |
| Cereal rye | (25) | Vetch | (75) | 3.1 | 34 | 43 |
| Cereal rye | (50) | Vetch | (50) | 2.4 | 30 | 42 |
| Cereal rye | (75) | Vetch | (25) | 1.8 | 14 | 27 |
| Cereal rye | (100) | _ | _ | 1.1 | -22 | 8 |

[1]Cover crop biomass samples were mixed in the laboratory at listed percentages. Experiment A had two replications, Experiment B had three replications of each cover crop mixture. Experiment A source data: D. Sullivan, A. Garrett, and R. Datta (unpublished). Experiment B: D. Sullivan, N. Andrews, and R. Datta (unpublished)

**Table 10. PAN from cover crop samples collected from grower fields. PAN was determined in laboratory incubation in moist soil at 72°F (22°C). Experiment C[1]**

| Field | Seeded cover crop species[2] | Spring cover crop harvest | Cover crop biomass | Cover crop N | Non-legume | Legume[2] | PAN at 4 weeks | PAN at 10 weeks |
|---|---|---|---|---|---|---|---|---|
| | | | ton/ac DM | % of DM | % of biomass DM | | % of total N | |
| B | Phacelia/ Vetch | 9-Apr | 1.3 | 3.6 | 10 | 90 | 47 | 58 |
| B | Rye/ Vetch | 9-Apr | 2.5 | 2.7 | 56 | 44 | 35 | 51 |
| B | Vetch | 9-Apr | 2.2 | 3.7 | 5 | 95 | 44 | 52 |
| M | Phacelia/ Vetch | 20-Apr | 1.8 | 2.9 | 38 | 62 | 31 | 50 |
| M | Rye/ Vetch | 20-Apr | 2.8 | 2.3 | 60 | 40 | 20 | 36 |
| M | Vetch | 20-Apr | 1.9 | 2.9 | 41 | 59 | 26 | 41 |
| P | Phacelia/ Vetch | 30-Apr | 2.6 | 2.4 | 68 | 32 | 23 | 33 |
| P | Rye/ Vetch | 30-Apr | 2.6 | 2.3 | 64 | 36 | 27 | 41 |
| P | Vetch | 30-Apr | 2.3 | 2.9 | 39 | 61 | 33 | 53 |
| X | Phacelia/ Vetch | 21-Apr | 1.3 | 2.0 | 88 | 12 | 24 | 27 |
| X | Rye/ Vetch | 21-Apr | 2.9 | 2.3 | 89 | 11 | 34 | 44 |
| X | Vetch | 21-Apr | 2.0 | 3.4 | 38 | 62 | 48 | 58 |
| W | Rye/ Vetch | 24-Apr | 4.2 | 2.0 | 95 | 5 | 12 | 22 |
| W | Vetch | 24-Apr | 1.8 | 3.7 | 44 | 56 | 37 | 32 |

[1]Cover crop biomass samples were collected from grower fields in the North Willamette Valley at late vegetative growth stage, just prior to cover crop incorporation in 2009. Values are the mean of 4 replications within each field experiment. Source: N. Andrews and D. Sullivan (unpublished)

[2]Volunteer clover at Field B was counted as a legume.

(continued from page 15)

testing was more variable than calculator PAN estimates. Across field locations, the actual net increase in PAN with cover crops ranged from 9 to 23 ppm (approximately 30 to 80 lb/acre), while PAN predicted by the calculator ranged from 9 to 14 ppm (30 to 50 lb/acre). Across the four field locations, the actual increase in PAN with cover crops averaged 15 ppm (50 lb/acre).

- *Methods: PAN from cover crops—field experiment D*

PAN for cover crop treatments in a replicated field trial conducted on a Chehalis soil at the OSU Lewis-Brown Farm is shown in Figure 14 (Luna et al., 2018). Winter cover crops were killed and incorporated at early flowering growth stage in May, 2007. Net soil nitrate-N from cover crops was measured at 10 weeks after cover crop incorporation using the same protocol described for experiment C.

- *Results: PAN from cover crops—field experiment D*

Oat and phacelia immobilized N (negative PAN) while vetch alone or in vetch mixtures provided PAN. At 10 weeks, predicted PAN was near zero (1 ppm nitrate-N; 4 lb/acre) for non-legumes (phacelia and oat), while actual PAN at 10 weeks was -4 to -1 ppm (-14 to -4 lb/acre). At 10 weeks, predicted net PAN from vetch, oat/vetch, or phacelia/vetch mixtures was 10 to 14 ppm nitrate-N (35 to 49 lb N/acre), while actual PAN was 6 to 13 ppm (21 to 46 lb/acre).

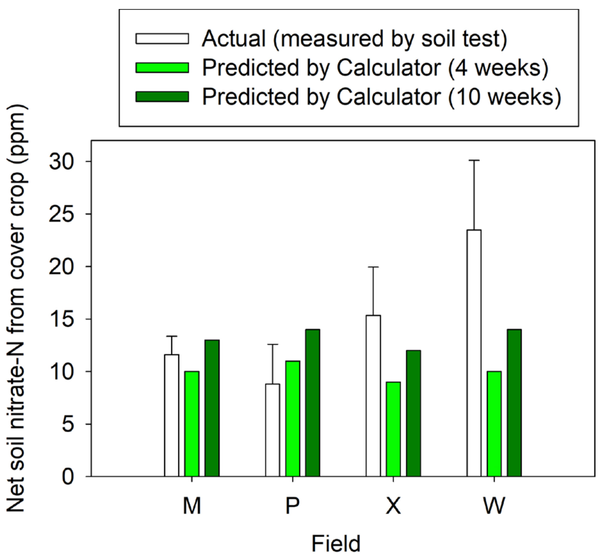


Figure 13. Actual net increase in soil nitrate-N (0- to 12-inch depth) as determined by soil nitrate testing (6 to 7 weeks after cover crop incorporation) versus that predicted by the calculator. Cover crop biomass and %N were determined at the time of cover crop kill (Table 10, page 17). Error bar is the standard error of the mean across all cover crop mixtures (vetch, phacelia/vetch, and rye/vetch) present at each field location. Experiment C. Source: N. Andrews and D. Sullivan (unpublished)

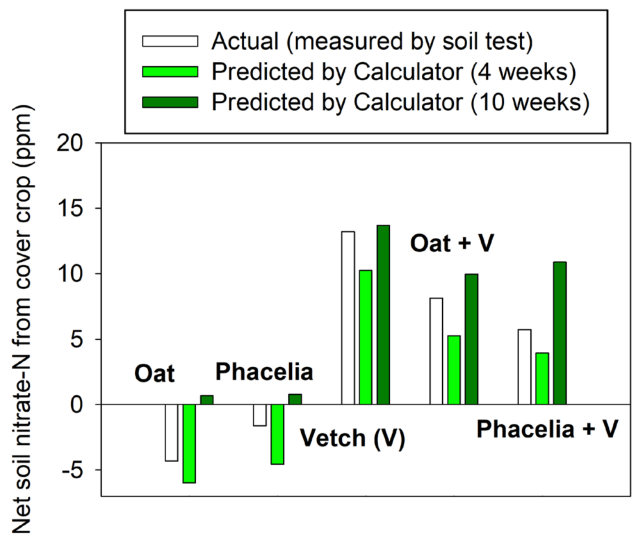


Figure 14. Actual net increase in soil nitrate-N (0- to 12-inch depth) at 10 weeks following cover crop incorporation versus that predicted by the calculator. Winter cover crops were killed and incorporated at the late vegetative growth stage in May, 2007. Experiment D. Adapted from Luna et al., 2018

## For more information

### OSU Extension resources

*Analytical Laboratories Serving Oregon* (EM 8677) https://catalog.extension.oregonstate.edu/em8677

*Soil Nitrate Testing for Willamette Valley Vegetable Production* (EM 9221) https://catalog.extension.oregonstate.edu/em9221

*Interpreting Compost Analyses* (EM 9217) https://catalog.extension.oregonstate.edu/em9217

*Nutrient Management for Sustainable Vegetable Cropping Systems in Western Oregon* (EM 9165) https://catalog.extension.oregonstate.edu/em9165

*Fertilizing with Manure and Other Organic Amendments* (PNW 533) https://catalog.extension.oregonstate.edu/pnw533

*Estimating Plant-Available Nitrogen Release from Cover Crops* (PNW 636) https://catalog.extension.oregonstate.edu/pnw636

### Additional resources

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