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SEASONAL NITROGEN MINERALIZATION ON ORGANIC FARMS

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SOIL BUILDING PRACTICES CREATE A BANK OF SLOW-RELEASE NUTRIENTS

Increasing organic matter in soils is one way to build soil health. Cover cropping, compost, and manure additions increase soil organic matter and improve the soil's ability to hold and supply nutrients, water, and air to plants and animals.

Soil organic matter is formed from dead and decaying plants, animals, and other organisms. The organic component of soil is generally only a very small portion of the total soil mass. The largest portion is composed of weathered rocks of varying sizes, known as sand, silt, and clay. Nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, and iron are the building blocks of plants and are taken up by plant roots, generally with soil water. Nutrients that are in the organic matter "bank" are not able to be incorporated by plants. As soil bacteria and fungi forage on decaying organic matter they release nutrients in a plant-available form, converting organic nutrients to their mineral form. The process whereby nutrients are converted from organic matter to plant-available minerals is called mineralization.

Percentage soil organic matter can be determined in a routine soil fertility test. Soil organic matter is one of the best indicators of soil quality. If soil organic matter is low, this value can be monitored over time to see if soil-building practices, such as cover cropping or amendment application, are having a positive effect. The total soil organic matter is composed of both humus and active organic matter. The active organic matter is fresher organic matter from recent additions of amendments or crop residues. This portion of the total organic matter is most directly responsible for providing slow-release nutrients. One drawback of the soil organic matter test from a soil fertility lab is that both the humus and active organic matter are combined into one number. Some soil labs provide a figure called estimated nitrogen release (ENR) that is derived from the total organic matter number. Some soils mineralize plant available nitrogen in amounts that vary widely from this estimated release, making it an unreliable number to use for fertility planning.

In 2012, we undertook a study to estimate the amount of nitrogen mineralized from plots on eight different certified organic farms in western Washington (Figure 1). Our goals were to describe regional variability of nitrogen mineralization and relate in-season mineralization to preceding...*continued on page 4*

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Figure 1. Location of cooperating farms in western Washington

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farm management practices and soil type.

ESTABLISHING A ZERO-N PLOT AND ESTIMATING N-MINERALIZATION

To estimate the plant-available nitrogen from organic matter over one season we established experimental plots on cooperating farms. N-mineralization was estimated via plant-uptake and with buried soil tubes where mineral nitrogen was directly measured from the soil over one season.

The experimental plots are called "zero-N" plots; they were prepared as they normally would be by the farmers except no nitrogen-containing fertilizers or amendments were added to the soil in 2012. Plots were all 300 square feet and were sampled in March 2012 to determine soil properties and gather soil for the buried tube test. The ground was bare or weed-covered on most sites. Where plots had active spring growth of cover crops, these plants were removed with a hoe to avoid any nitrogen contribution from cover crops.

The plant uptake study was designed to calculate how much total nitrogen was taken up by plants from the zero-N plot over the course of the season. Since no fertilizer was added, virtually all of the nitrogen in the plants would have come from the soil organic matter. For this study, 120 Acadia broccoli seedlings were transplanted to the zero-N plots in early May at each site. Starting with the transplants, farmers sent 9 plants to the soil lab at Washington Statue University Puyallup at two-week intervals throughout the growing season. Plants were dried, weighed, and analyzed for total nitrogen content.

The buried soil tube study was designed to calculate the total nitrogen mineralized from soil exposed to weather and irrigation conditions typical for western Washington. For this study, we packed soil from each site into tubes. The bottom of each tube consisted of a ½ inch of a special resin designed to capture any mineral nitrogen that leached out of the soil. There were 30 tubes for each site, for a total of 240 tubes. Soils in the tubes were analyzed for mineral nitrogen from March to September at 10 different dates, using 3 tubes at each date.

Site	Previous Management (2007-2010)	Fertilizer/ amendment in 2011
5	Cover crop, pastured poultry, and annual compost addition	Compost, biofish 7-7-7, kelp meal
2	Consistent winter cover cropping and annual spring application of organic fertilizer	550 lbs/A 9-3-4
3	Grass hay and cattle	2000 lbs/A 4-3-3
7	Compost applied 2010, 2008	None
6	Consistent winter cover cropping	1500 lbs/A feather meal
4	Consistent winter cover cropping	1000 lbs/A 4-3-3 processed poultry manure
1	Yearly application of dairy manure	1000 lbs/A 4-4-4 organic fertilizer
8	Yearly chicken manure and compost	Chicken manure and compost

Table 2. Previous management practices at on-farm sites.

PREVIOUS MANAGEMENT PRACTICES AND SITE DESCRIPTIONS

The soil texture, total organic matter, and estimated nitrogen mineralization at the 8 different sites are listed in Table 1 and previous management practices are listed in Table 2. Total organic matter ranged from 3.6 to 12.8 percent. Sand, silt, and clay content

Site	Sand (%)	Silt (%)	Clay (%)	Texture Class	BD	OM	Head wt (lbs)	Uptake (lbs/acre)	N-Min (mg/kg)	N-Min (lbs/A)
5	66	28	6	Gravelly Sandy Loam	0.89	8.8	1.10	117	47	112
2	40	49	12	Loam	1.04	5.6	1.00	116	38	100
3	69	24	7	Gravelly Sandy Loam	1.2	5.2	0.71	101	38	116
7	58	29	12	Sandy Loam	1.13	4.0	0.68	116	44	129
6	88	10	3	Sand	1.15	12.8	0.68	79	48	141
4	24	61	15	Silt Loam	1.16	4,8	0.20	61	31	89
1	36	52	12	Silt Loam	1.01	4.0	NA	60	33	86
8	42	47	12	Loam	1.19	3.6	0.16	38	28	86

Table 1. BD=Bulk Density (g/cm3); OM=Organic matter (%); Head wt = Average per head fresh weight (lbs); Uptake = Estimated N-uptake by broccoli (lbs/acre); N-Min=Estimated nitrogen mineralized from buried soil tubes. N-Min lbs/A was estimated from the concentration of N mineralized (mg/kg soil) and each farm's individual bulk density, over 1 foot depth.

varied widely across the sites. 1 site was sand, 3 sites were sandy loam, 2 were silt loam, and 2 were loam. Most farms used a combination of cover cropping and compost additions to build soil fertility and supplemented these additions with organic fertilizer.

NITROGEN MINERALIZED FROM ORGANIC MATTER

In the plant uptake study, we estimated the range of seasonal nitrogen mineralization to be 38 to 117 lbs/acre. In the buried soil tube study the range of nitrogen mineralization was estimated to be 86 to 141 lbs/acre. The larger mineral nitrogen from the soil tube study could be due to the longer period of time allowed for this study. While the broccoli was grown from early May through early August, the soil tube study ran from late March to mid-September. The two methods for estimating N-mineralization were positively correlated (r^2=0.5).

5 of the 8 farms had estimated N uptake above 78 lbs/acre via the plant uptake method and over 100 lbs/acre via the soil tube method. These farms all produced acceptable, marketable fresh weights of broccoli without any additional nitrogen fertilizer. Only farms 1,4, and 8 did not produce marketable head weights and these farms also yielded the lowest nitrogen uptake and nitrogen mineralization. Farm 5 produced the largest fresh head weights (Figure 2). Several participating farmers commented that they were surprised to see how well their broccoli grew in the zero nitrogen plots without additional fertilizer. They also noted that adjacent broccoli plants that had been fertilized did not grow any better than the unfertilized plants.

Figure 2. Final harvest from Farm 5. *Photo by Doug Collins*

CONCLUSIONS AND RECOMMENDATIONS

Soil building practices such as cover cropping and addition of compost or manure build soil organic matter. Soil organic matter provides a bank of nutrients, including nitrogen, that are made available through mineralization. Our study did not include enough farm sites or have sufficiently detailed plot histories to completely describe how previous management interacts with soil type to provide plant-available nitrogen from organic matter. However, we found that most of the plots on organic farms in our experiment did mineralize sufficient nitrogen to produce marketable broccoli heads.

Organic fertilizers supplement the nutrients mineralized from organic matter. Determining how much organic fertilizer to apply is a delicate process; too much fertilizer is a potential waste of money and can lead to nitrogen leaching while too little fertilizer will not optimize yield. Experimenting with zero-N plots on your farm is one way to accurately estimate nitrogen mineralization potential from organic matter. A fall nitrate test is another method to gauge the efficiency of fertilizer applications (see Report card nitrate test for assessing fertilizer efficiency. Tilth Producers Quarterly. 21 (3): 11).

ORGANIC FARMING RESEARCH FOUNDATION

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