Oregon State University Extension Service

Silage Corn Nutrient Management Guide for Western Oregon

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Figure 1. Silage corn is an excellent feed for dairy cattle.

Credit: Troy Downing, © Oregon State University

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Silage corn quick reference

Soil testing. Apart from nitrogen (N), nutrient recommendations in this guide are based on a preplant soil test. Collect the preplant soil sample in the fall or in spring prior to corn seeding. Recommendations in this guide are valid only when the laboratory employs soil test methods as described for western Oregon in the *Soil Test Interpretation Guide*, (https://catalog.extension.oregonstate.edu/ec1478) EC 1478.

Liming. Silage corn grows best at a soil pH greater than 5.5. Apply lime, based on soil test, according to Table 2.

Nitrogen. On dairy farm fields that receive annual manure or lagoon water application, additional N fertilizer application in the form of urea or ammonium sulfate is usually not required to meet crop N need.

Soil nitrate testing is recommended to determine the balance between N supply and crop N requirement. The most important time to collect a soil sample for nitrate analysis is when the corn has four to six collared leaves (V4 to V6 growth stage). Soil nitrate-N greater than 25 ppm at this stage indicates that N supply is sufficient; additional N will not increase crop yield.

Several diagnostic tests can be used to determine balance between N supply from all sources and crop N uptake capacity. See "Monitoring soil and crop N."

Phosphorus. If soil test P is below 50 ppm, apply P according to Table 9.

Potassium. If soil test K is below 200 ppm, apply K according to Table 10.

Magnesium. If soil test Mg is below 100 ppm or 0.8 meq/100 g soil, band 10 to 15 lb Mg/acre at planting or apply 1 t dolomitic lime/acre and incorporate it in fall.

Zinc. If soil test Zn is below 0.8 ppm (1.5 ppm in the Stayton area), band 3 to 4 lb Zn/acre at planting or broadcast 10 lb Zn/acre before planting. (Table 12)

Soil, climate, crop rotation and corn variety all affect silage corn yield potential. Silage corn yields are greater in the Willamette Valley than near the coast in Tillamook and Coos counties because the longer growing season is suited to higher-yielding corn varieties.

Most silage corn in western Oregon is grown on soils with silt loam or silty clay loam surface horizons. These soils have a high water-holding capacity but vary in drainage. Soils with better drainage (NRCS Hydrologic Group B) are usually more productive than more poorly drained soils (Hydrologic Groups C and D). Soils used for silage corn production in the Willamette Valley include Amity, Chehalis, Cloquato, Coburg, Concord, Helvetia, McAlpin, Willamette and Woodburn. Soils used for silage corn production near the coast in Tillamook and Coos counties include Kirkendall, Nestucca, Nehalem and Quosatana.

Silage corn is an excellent feed for dairy cattle because of its high dry-matter yield, energy content and palatability, especially when supplemented by other feed. This guide addresses silage corn produced in western Oregon with conventional tillage or by direct seeding using a no-till drill.

This guide is applicable to fields that receive manure and for those that do not. Recommendations in this guide are adequate to produce high yields where weeds, insects and diseases do not limit crop yield. Soil pH above 5.5 is required for maximum crop yield response to nitrogen and other nutrient inputs.

Nutrient removal

Table 1 shows typical nutrient removal values for silage corn at a high yield level. Here, *high yield* means 8-ton DM/acre or approximately 32 ton *as harvested* silage. Nutrient concentrations in biomass remain relatively constant across silage yield levels; use the *concentration in DM* column to calculate expected nutrient removal for site-specific silage DM yields.

Table 1. Nutrient removal by silage corn, based on estimated yield of 8-ton DM/acre

Nutrient	Yield, ton DM/acre	Concentration, % in DM	Nutrient removed in lb/ton (100%DM)	Nutrient removed in lb/ton (25% DM)	Nutrient removed in lb/acre
N	8	1.3	26	6.5	205
P	8	0.2	4	1.0	32
K	8	1.2	24	6.0	192

Silage corn removes approximately the same amounts of N and K, while P removal is lower (Table 1). When applied nutrients are not removed by harvest, they are lost to air or to water or they accumulate in soil. The major pathways for N loss are 1) ammonia loss to the atmosphere during the first days after manure application, and 2) nitrate leached during fall and winter months. About half of the total N applied in manure is in organic form. Some of the organic N is converted to nitrate in the year of application; the remainder is incorporated into soil organic matter. The amount of manure N that is held in soil organic matter for longer than a year is approximately 10–30% of manure N applied. By contrast, P and K are not lost to the atmosphere, and they are relatively insoluble in soil. Therefore, P and K accumulate in topsoil when inputs (manure) exceed nutrients removed in the harvested crop.

On dairy farms, silage corn is often double-cropped with annual ryegrass or a cereal cover crop. This protects soil from erosion and increases annual crop nutrient removal. A fall-seeded annual ryegrass cover crop, when harvested in April with a dry matter yield of 3-ton/acre, removes approximately 115 lb N, 18 lb P and 150 lb K per acre.

Manure also supplies other nutrients that are required for corn, including sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn) and micronutrients. Usually, when manure has been applied annually, application of these nutrients does not increase silage corn yield.

Soil pH and liming

Corn for silage grows best at a soil pH greater than 5.5. When soil pH is less than 5.5, silage corn yields can be reduced by excess aluminum (Al) or manganese (Mn) in soil solution. Soil pH less than 5.5 can also inhibit root growth to the point that plants appear to be P deficient, exhibiting purple color early in the growing season.

Lime application increases soil pH (reduces soil acidity). To be effective, incorporate lime into the soil by tillage prior to seeding. To determine the need for lime, we recommend testing soil for pH (1:2 soil:water method) and for lime requirement (SMP buffer method or other OSU Extension-approved test method).

The lime requirement test does not measure the actual soil pH in the field; it only serves as an index value for a lime rate recommendation (Table 2). If soil pH in water is greater than 5.5), no lime is required.

Keep in mind that soil pH fluctuates 0.3 to 0.5 units seasonally. It is lowest (most acidic) in late August and September, before the fall rains begin, and highest in February or March, when the soil is wettest. To track trends in soil pH across years, sample at the same time each year.

Applying Lime to Raise Soil pH for Crop Production (Western Oregon) (https://catalog.extension.oregonstate.edu/em9057), EM 9057, provides additional details on interpretation of lime requirement test results.

Table 2. Lime rate recommendations for western Oregon using the SMP buffer lime requirement test

Apply lime to maintain soil pH (in water) above 5.5.

Lime requirement test result (SMP buffer)	Apply this amount of lime (ton/acre) Based on 100-score lime
Below 5.5	3–4
5.5–5.8	2–3
5.8–6.2	1–2
Over 6.2	none

Calcium and magnesium

Calcium is an essential plant nutrient. Agricultural lime is calcium carbonate, so it supplies calcium as it increases soil pH. Some sandy soils such as the Newberg series have a soil pH above 5.5 but have less than 5 meq Ca/100 g soil. In such cases, 1-ton lime/acre is recommended to supply Ca, even if the SMP buffer test is above 6.2.

Manure supplies Mg. Soil test values less than 0.8 meq/100g are unusual in manured fields. Apply Mg when soil test indicates that Mg is below 100 ppm (0.8 meq/100 g soil). When Mg need is identified by a spring soil test, apply magnesium sulfate as a banded starter fertilizer application at 10 to 15 lb Mg/acre at seeding. If magnesium deficiency is identified by a fall soil test and the field will benefit from liming, fall-applied dolomitic lime can be used to supply Mg.

Nitrogen

Timing of corn N uptake

Corn grows slowly during the first 30–40 days after seeding. At the six-leaf growth stage (V6), corn contains 15 to 25 lb N per acre. Corn N uptake is most rapid from V6 to silking (VT). Between the six-leaf and silking growth stages, corn accumulates N at a rate of 3–4 lb N per acre per day. Crop N uptake rate declines as ears mature. Crop N uptake nears completion at the milk stage (R3).

The line in Figure 2 represents average crop N uptake values determined in three grower fields near Modesto, California (Geisseler et al., 2012). Unharvested stubble contained approximately 25 lb N per acre.

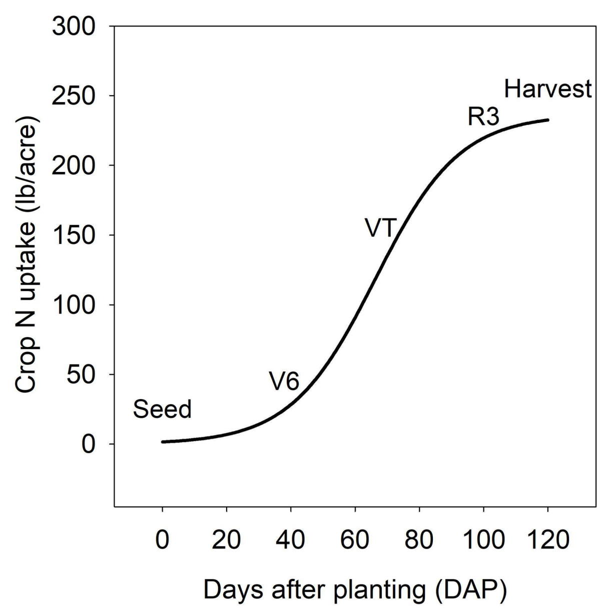

Figure 2. Cumulative crop N uptake for silage corn.

Credit: Geisseler et al., 2012

Nitrogen supplied by manure

The most common time to broadcast manure is prior to seeding. Base manure application rate on manure N analyses. Table 3 shows the volume of liquid or slurry manure required to achieve N application rates of 50, 100 and 150 lb/acre. Table 3 is based on manure N analyses. Units shown for manure N analysis in the same row (left side of the table) are equivalent. For example, an N concentration of 2 lb N per thousand gallons equals 240 ppm N. To use Table 3, find a manure analysis value in lb per thousand gallons or ppm in the columns on left. Then choose an application rate (50, 100, or 150 lb/acre) in the row at the top of the table. Find the volume of manure to apply in the body of the table. *Calculating Dairy Manure Nutrient Application Rates,* (https://catalog.extension.oregonstate.edu/em8768) EM 8768, provides guidance for calibration of manure application equipment.

The amount of N supplied by manure, as indicated in Table 3, is an approximate value that may vary by + or -30% from the target value. This variability in actual N application is due to manure N analyses variability and the lack of precision in manure application methods. We strongly recommend a midseason soil nitrate test (also referred to as a pre-sidedress nitrate test or PSNT) to assess the balance between soil N supply and crop N requirements.

Most fields with a history of manure application require no starter N fertilizer at planting. Fields that have not received manure for more than three years may require a small amount of N (20–40 lb/acre) at planting time.

Table 3. Volume of lagoon water or slurry manure required to achieve N application rates of 50, 100 and 150 lb/acre, based on manure N analyses

Manure analysis		Target manure N application rate (lb/acre)		
Lagoon water				
lb N per thousand gal	**Parts per million (ppm)**	**Acre-inches to apply**		
2	240	0.9	1.8	2.8
4	480	0.5	0.9	1.4
6	720	0.3	0.6	0.9
8	960	0.2	0.5	0.7
Slurry				
lb N per thousand gal	**Parts per million (ppm)**	**Thousand gal/acre to apply**		
10	1,200	5	10	15
15	1,800	3	7	10
20	2,400	3	5	8
25	2,990	2	4	6
30	3,590	2	3	5

Using soil nitrate testing to fine-tune N management

Soil nitrate testing is a valuable diagnostic tool to measure nitrate present at the time of sampling. Interpretations of a soil nitrate test vary, depending upon when the sample is collected.

In western Oregon, most nitrate moves below the rooting zone in winter by leaching. In February, soil nitrate concentrations are low, regardless of manure applied during the previous year.

Table 4. Midseason nitrogen application recommendations for western Oregon, based on the pre-sidedress nitrate test (PSNT)

Soil test nitrate-N (NO3-N)	Apply this amount of N
0-10 ppm	100-175 lb/acre
11-20	50-100
21-25	0-50
Above 25	None

Based on a soil sample collected between rows (0–12 inch depth) when corn has four to six collared leaves (V4–V6 growth stage)

Preplant soil nitrate in May usually underestimates the amount of nitrate available to the crop for the full growing season. Additional nitrate is mineralized after planting, as the soil warms. Therefore, a preplant soil test cannot accurately determine the need for additional N inputs.

Table 5. Overview of soil and plant tissue testing methods for monitoring N

Method	Test reliability (1 = most reliable)	Timing	Sample instructions	Target nitrate-N value	Additional comments
PSNT (pre-sidedress soil nitrate test)	1	Corn at V4–V6 growth stage	15 cores. 0–12 inch depth. Sample between rows.	25–30 ppm	Avoid starter fertilizer bands when sampling
PHNT (post-harvest soil nitrate test)	2	Sample before Oct. 1 at the coast (Tillamook), or by Oct. 15 (Willamette Valley)	15 cores. 0–12 inch depth. Sample between rows.	Less than 20 ppm	See Postharvest Soil Nitrate Testing for Manured Grass and Silage Corn (West of the Cascades), EM 8832
At-harvest cornstalk nitrate test	3	7 days before or after harvest	15 stalks	3,500 to 5,000 ppm	Submit an 8-inch length of stalk cut 6–14 inches above the ground for sampling. See Figures 1 and 2.

Soil nitrate measured at midseason (PSNT, described below) provides the most useful management information for the current year (Tables 4 and 6).

Postharvest soil nitrate tests are not useful for this year’s N management decisions but can provide feedback to use in planning for future years (Table 7).

Midseason soil nitrate testing

The recommended timing for PSNT soil sample collection is at the four- to six-leaf growth stage, before the period of rapid N uptake in corn (Figure 1).

Soil nitrate-N values of 5-15 ppm at planting can increase to over 30 ppm by PSNT sampling time, because of mineralization of soil organic matter to nitrate.

PSNT sampling protocol

Collect PSNT samples when the corn has four to six collared leaves (V4-V6 growth stage). This usually coincides with a plant height of about 12 inches at the center of the whorl.

Sample between rows, away from any fertilizer bands. Avoid irregular areas, such as low spots, field entries or places where manure accumulates.

- Collect at least 15 cores.
- Sample soil to a depth of 12 inches.
- Mix the sample thoroughly in a clean container.
- Fill a soil sample bag with a subsample of the composite soil sample.

The sample should be delivered to the lab immediately. Keep the sample cool until it arrives at the laboratory. Changes in N occur as the soil warms. To avoid shipping delays over the weekend, do not mail samples on Thursday or Friday. Send the sample to a soil testing lab to be analyzed for nitrate-N (NO_3-N). Request results from the laboratory in units of ppm or mg/kg, not lb/acre.

Soils that are high in clay may pose difficulty in sampling to the 12-inch depth at PSNT sampling time. PSNT soil test interpretations (Tables 4 and 6) should be used with caution when soil samples were collected from 0–6 or 0–8 inches, as all PSNT calibration research employed a soil sampling depth of 12 inches. Soil nitrate concentrations generally are highest in the plow layer near the soil surface.

Using PSNT to determine midseason N application rate

Table 4 shows recommended midseason sidedress N inputs (fertilizer or lagoon water) based on PSNT testing. If soil nitrate is below 25 ppm, additional N from fertilizer or lagoon water is likely to increase silage corn yield. Table 3 shows the volume of lagoon water required to supply a target amount of N, based on water or slurry N analysis. If PSNT values are greater than 25 ppm, additional in-season N application as fertilizer or as lagoon water is *not* recommended.

The following sections provide additional details on interpretation of N monitoring tests.

Pre-sidedress nitrate test, or PSNT

Soil samples are collected for the PSNT when corn has four to six collared leaves (V4–V6 growth stage). Although the main purpose of the PSNT is to determine the need for in-season lagoon water or N fertilizer application (Table 4), it can also serve as an indicator of excess N supply for silage corn. PSNT values above 45 ppm NO_3-N (0–12 inch depth) indicate excess soil N supply relative to corn uptake capacity (Table 6).

Table 6. Interpretation of the PSNT as a predictor of postharvest soil nitrate for silage corn produced on manured fields in western Oregon

PSNT (ppm)	Category	Interpretation
Less than 25	Deficient	Crop yield increase expected in response to N input (fertilizer or lagoon water).
25–30	Target	Crop N requirement met. Minimal postharvest nitrate accumulation expected if no additional N inputs are applied after PSNT.
30–45	Above target	Soil nitrate is above crop N uptake capacity. Any additional fertilizer or lagoon water application applied after PSNT will likely increase postharvest nitrate-N.
More than 45	Excess	Soil nitrate exceeds crop N uptake capacity by a considerable margin. Any additional fertilizer or lagoon water applied after PSNT will almost always increase postharvest nitrate-N.

Postharvest soil nitrate test, or PHNT

The PHNT measures soil nitrate-N not used by the crop. The PHNT is a look backward in time to evaluate the balance between N supply and crop N uptake. Nitrate accumulates in the soil when the total of applied N plus plant-available N mineralized from soil organic matter exceeds corn N uptake. Although we are inclined to think of this as an annual process being evaluated, it's important to remember that soil organic matter content and manure application history over the past five to 10 years also influence PHNT results.

Low postharvest soil nitrate concentrations are difficult to achieve in fields that have been manured for many years. In manured fields, late summer soil N mineralization is often rapid. At the same time, crop N uptake capacity is limited as the crop matures (Figure 1). This late season imbalance between N supplied by mineralization and N removed by the crop results in an accumulation of soil nitrate in August and September. Silage corn grown in fields that have not been manured can often achieve maximum yield with low postharvest soil nitrate-N concentrations (less than 10 ppm NO_3-N), because late-season N mineralization rates in such fields are lower.

Table 7. Interpretation of the Postharvest Nitrate Test (PHNT) (0–12-inch depth) for silage corn on western Oregon dairy farms

Postharvest soil nitrate-N (ppm)	Interpretation
Less than 20	Target
20-45	Above target
Over 45	Excess

See Postharvest Soil Nitrate Testing for Manured Grass and Silage Corn (West of the Cascades), EM 8832, for additional context to interpret the PHNT and suggested management actions to reduce PHNT values in future years.

Target soil test values listed in Table 7 are based on best professional judgment, as informed by field research studies (Source: Marx; Cogger; See Appendix 1). Target values listed in the table assume near-maximum crop yield, with some late season nitrate release via soil organic matter mineralization in manured soils.

If postharvest soil nitrate-N is above target, consider ways to reduce the N surplus in the future. Evaluate the overall N supply, including the timing and amount of current-season application(s) of N fertilizer, manure or lagoon water. Also consider managing corn and a winter cover crop to maximize crop N removal. See *Postharvest Soil Nitrate Testing for Manured Grass and Silage Corn (West of the Cascades),* *(https://catalog.extension.oregonstate.edu/em8832)* EM 8832, for management options to reduce fall soil nitrate concentrations.

Note that a low PHNT test value (less than 20 ppm NO_3-N) does not indicate that too little N was applied. Continual mineralization of plant-available N from soil organic matter can provide enough N to meet crop need without accumulation of high concentrations of nitrate-N in the soil in the fall. Heavy rainfall or excess irrigation can also leach nitrate below the 12-inch PHNT soil sampling depth.

Cornstalk nitrate test

The cornstalk nitrate-N test is performed at harvest and can be a valuable diagnostic tool to determine the N status of the corn crop. Unlike soil nitrate tests, the stalk nitrate test will identifies whether N supply limited crop yield. If silage yield is low, but the stalk nitrate-N test is adequate, an N deficiency was not the cause of the low yield.

For this test, collect an 8-inch-long section of stalk from 15 plants. Make the lower cut in the stalk about 6 inches above the soil surface. Submit samples to the laboratory immediately. See *End-of-Season Corn Stalk Nitrate-Nitrogen Test for Postharvest Evaluation,* (https://pubs.extension.wsu.edu/end-of-season-corn-stalk-nitrate-nitrogen-test-for-post-harvest-evaluation-2) WSU FS336E, for sample preparation details. A 2017 study (Source: Ketterings) reported that stalks could be stored at room temperature or in a refrigerator for up to eight days after collection without affecting nitrate test values.

Figure 3. Collect an 8-inch portion of the cornstalk between 6 and 14 inches above the ground.

Credit: Haiying Tao

Figure 4. Prepare cornstalk for analysis by removing leaves and leaf sheaths.

Credit: Haiying Tao.

Interpretive categories in Table 8 reflect Oregon-based research (Source: Marx). Research findings from Iowa showed a similar target value (3,500 ppm) for cornstalk nitrate in manured fields (Source: Kyverga). Iowa researchers also found a strong correlation between soil nitrate at the six-leaf stage (PSNT) and the cornstalk nitrate test values taken from the same fields at harvest (Source: Balkcom). Oregon-based research confirmed this finding (Appendix 2).

Table 8. Interpretation of at-harvest cornstalk nitrate test for silage corn grown on dairy fields receiving manure in western Oregon

Cornstalk nitrate-N (ppm)	Category	Interpretation
Below 3,500	Low	Nitrogen supply may have been inadequate or late. Poor root growth may have reduced crop capacity for N uptake.
3,500–5,000	Target	Adequate N supply at time of maximum crop N demand. Nitrogen did not limit crop yield.
Above 5,000	Excess	Nitrogen supply was excessive, late or both.

Interpretive values based on Marx (1995)

Phosphorus

Manure is an excellent source of phosphorus for silage corn. Phosphorus from manure or lagoon water is 100% plant-available and equivalent to P from mineral fertilizer. When manure is applied at a rate to satisfy the silage corn N requirement, the amount of manure P applied often exceeds the amount of P removed by the crop. On dairy farms, soil test P is an indicator of the long-term balance between P inputs from manure and fertilizer versus crop removal of P via silage harvest.

Too much P in soil is not a crop production issue. However, P lost from the field and transported to surface water can stimulate algal or other aquatic plant growth and reduce water quality. Often, P is the limiting nutrient for aquatic plant growth. Soil phosphorus is only very slightly soluble in water, so P loss via leaching is small. Phosphorus can be lost from fields via soil erosion and surface runoff. When fields are not tilled routinely, P can also move through soil cracks or vole holes to reach subsurface tile drains.

Table 9. Phosphorus recommendations based on soil text

Soil test P, Bray P1 soil test method	Apply this rate to maximize silage corn yield*	
ppm	**lb P_2O_5/acre**	**lb P/acre**
8-15	60-80	26-35
16-30	40-60	17-26
31-50	20-40	9-17
Over 50	None required; soil alone will supply sufficient P	

*1 lb P_2O_5 = 0.44 lb P. Fertilizers are marketed in units of P_2O_5. Manure P analyses may be expressed in units of P_2O_5 or in units of elemental P.

Table 9 shows that when soil test P exceeds 50 ppm, applied P is not expected to benefit corn yields. Elevated soil P levels are slow to change in response to management actions; it cannot be easily or quickly reduced. Soil test P in western Oregon soils typically declines at a rate of approximately 10–20 ppm *per decade* in response to forage crop P removal, provided no additional P input is provided. Annual soil testing is not useful to document changes in soil test P in response to management. A big change in soil test P over a few years is likely caused by inconsistency in soil sampling methods or in laboratory analytical techniques.

Temporary phosphorus deficiency in young corn plants

Although manure usually provides more than enough P, silage corn occasionally appears P deficient. Purple leaves at the three- to six-leaf stage (Figure 5) indicate P deficiency. This symptom is rarely visible before development of three leaves, and typically disappears as the corn "grows out of" the problem as the season advances and the soil warms. Research in British Columbia indicates that the purple color is associated with tissue P deficiency even when the Bray soil test for P is in the adequate range—above 50 ppm (Source: Bittman). Symptoms of early season P deficiency are common with early planting dates, cool and wet spring weather, and in areas of compacted soil such as field entry and exit areas.

Figure 5. Young corn plant with the purple leaves typical of a phosphorus deficiency.

Photo: John Hart, © Oregon State University

Corn roots must be colonized by mycorrhizal fungi if corn is to grow normally without turning purple. These mycorrhizal fungi extract nutrients from soil and deliver it to the crop, in exchange for carbohydrates – the products of photosynthesis. On the commercial scale, amending soils with mycorrhizal fungi has not been successful. Rather, crop rotation and reduced tillage practices are the best ways to encourage mycorrhizal fungi. Mycorrhizal fungi will be present in soil if the previous crop was a host. Annual ryegrass is commonly grown in rotation with silage corn on dairies. It is a host of mycorrhizal fungi. Planting corn after fallow provides fewer mycorrhizal fungi for corn root colonization. In research trials conducted in lower mainland British Columbia, minimum tillage was superior to plowing for reducing the incidence of purple color in young corn plants (Source: Bittman). Mycorrhizal fungi grow much like roots and must remain intact to function. Tillage disrupts the fungal network in the soil.

Recommendation: If silage corn turns purple between the three- and six-leaf stages, even when soil test P exceeds 50 ppm, adopt the following management practices in subsequent years:

- Plant corn after a crop that hosts mycorrhizal fungi. Most crops support mycorrhizal fungi. However, crops in the beet and brassica families do not.
- Reduce tillage. Most important, do not plow.
- At planting, apply P fertilizer in a band 2 inches from the seed at a rate of 30 lb P_2O_5/acre.

Potassium

Manured soils usually supply adequate or excess potassium (K). When manure is used as an N source for silage corn, more K is added than the crop can remove. Soil test K is often highest in fields near the barn and in fields that receive the most manure. Potassium has limited mobility in soil and remains near the site of placement. Soil test K is usually highest in the surface foot of soil or to the tillage depth.

High soil K concentrations in forage can contribute to milk fever (hypocalcaemia) and other metabolic disorders in dry cows. However, silage corn does not accumulate high levels of K in forage as cool-season grasses do. Even when soil test K is high, K concentration in silage corn is usually between 0.8 and 1.8% and is typically 1.2%. Cool-season grasses can contain 5% K in fields receiving manure. The lower K concentration in corn silage compared to grasses is related to crop growth stage at harvest. Leaf K in young corn plants 18 to 24 inches tall can be greater than 4.5%.

Table 10. Potassium recommendations based on soil test

Soil test K, ammonium acetate extraction method	**method Apply this rate to maximize corn silage yield***	
ppm	**lb K_2O/acre**	**lb K/acre**
0-75	80-120	66-100
76-100	60-80	50-66
101-150	40-60	33-50
151-200	0-40	0-33
Over 200	None required; soil alone will supply sufficient K	

*1 lb K_2O = 0.83 lb K. Fertilizers are marketed in units of K_2O. Manure K analyses may be expressed in units of K_2O or in units of elemental K.

If a soil test indicates that K is needed (Table 10), it can be supplied by banding or broadcasting mineral fertilizer (K chloride or K sulfate) or by manure or lagoon water application. Potassium from manure or lagoon water is 100%

plant-available and is considered equivalent to K from mineral fertilizer.

Corn is sensitive to salt damage from fertilizer, especially at germination. Potassium and nitrogen fertilizers are water soluble, so placing too much near the seed can kill or injure seedings. Table 11 shows maximum N plus K application rates.

Table 11. Maximum application rates of banded nitrogen plus potassium for silage corn

Distance between fertilizer band and seed row	Do not apply more than:
1 inch	40 lb (N + K_2O)/acre
2 inches	100 lb (N + K_2O)/acre

Micronutrients

Because western Oregon soils are acidic and contain relatively high amounts of organic matter, metal micronutrients such as Mn, Zn, Cu and Fe are usually adequate for corn production. These micronutrients are more soluble in acidic soils and are thus more available to plants. Manure application also supplies these micronutrients. Micronutrient deficiencies are rare. Corn research trials conducted in western Oregon have not shown economic benefit from fertilization with micronutrients other than Zn.

Commercial soil testing laboratories working under OSU guidelines use a chelate extractant (DTPA) when analyzing soil for metal micronutrients (Zn, Mn, Fe and Cu).

Zinc

It is unusual to observe zinc deficiency on manured soils in western Oregon. Manure is considered an excellent source of plant-available zinc because the organic matter from manure can serve to chelate Zn and maintain it in plant-available form in soil solution. When corn is severely deficient in zinc, the upper leaves are yellow between the veins. Zinc deficiency in corn is likely when the uppermost fully expanded leaves contain less than 25 ppm Zn. Corn plants with a poorly developed root system may exhibit zinc deficiency symptoms, even when there is plenty of plant-available Zn present in soil.

Sweet corn and field corn have similar Zn requirements. OSU research conducted with sweet corn is the basis for the recommendations in Table 12. When the Zn soil test results are less than 0.8 ppm, a yield increase from Zn application is expected on any soil. Where Zn is required, broadcast 10 lb Zn/acre and incorporate into soil before planting to meet crop requirements for two or three years. An alternative approach is to band 3 to 4 lb Zn/acre at planting. Gravelly, dark-colored soil such as the Sifton and Salem series in the Stayton area require higher Zn application rates to supply the crop with adequate Zn. The reduced plant-availability of Zn in these soils is probably associated with the presence of volcanic ash in the soil parent material.

Figure 6. Young corn plant with stripes typical of zinc deficiency.

Credit: Troy Downing, © OSU

Table 12. Zinc fertilizer recommendations for silage corn in western Oregon based on the DTPA soil test

Soil	Soil test Zn (ppm)	Apply this amount Zn (lb/acre)	
		Banded Zn	Broadcast Zn
Sifton and similar dark-colored gravelly soils near Stayton*	Below 1.6	3-4	10
Other soils	Below 0.8	3-4	10

* Field research on dark-colored gravelly soils in the Stayton area demonstrated that these soils required a higher Zn soil test level for maximum corn yields.

Figure 7. Typical zinc and copper footbath in a dairy barn. Applying footpath solutions to the field with manure increases zinc and copper levels.

Credit: © Oregon State University

Dairy farms sometimes employ foot baths containing Cu and Zn sulfate to maintain hoof health. Footbath effluent is often mixed with slurry manure or lagoon water, and then applied to fields.

Although Cu and Zn are plant-essential nutrients, in excess they can injure plants and produce feed with elevated Cu and Zn concentrations. Elevated soil test Cu and Zn have been measured in western Oregon fields where footbath Cu and Zn have been routinely applied (Source: Downing). More than 75% of soil samples collected from western Oregon dairy farms in 2010 had soil test Cu concentrations (DTPA method) considered high (greater than 2 ppm), and 38% of the soil samples had extremely high Cu (greater than 5 ppm). This interpretation is of DTPA Cu and Zn soil tests is based on *Soil Test Interpretation Guide,* (https://catalog.extension.oregonstate.edu/ec1478) EC 1478. To avoid buildup of Cu and Zn to excessive levels in soil, we recommend regular monitoring of soil test Cu and Zn in fields receiving footbath effluent.

A summary of published research (Source: Reuter) provides general guidance for interpretation of corn leaf Zn and Cu concentrations:

- Typical Zn concentrations in corn leaf tissue are 25–50 ppm.
- Leaf Zn concentration above 100–300 ppm can reduce yields.
- Leaf Zn concentrations greater than 500 ppm can severely reduce yields.
- Leaf Cu concentrations above 20 ppm can reduce yields.
- Leaf Cu above 50 ppm can severely reduce yields.

Appendix 1: Postharvest soil nitrate distribution in soil profiles

The recommended sampling depth for the PHNT is 12 inches. This appendix provides supporting data for the choice of a 12-inch sampling depth. This data was collected from N monitoring trials on Willamette Valley dairies (Source: Marx). At harvest, an auger mounted on a tractor was used to collect soil samples in 12-inch depth increments.

At all field locations, the 0–12-inch depth contained the highest concentration of postharvest soil nitrate in the top 36 inches of the soil (Figure 8). On average, nitrate in the top 12 inches represented 78% of the total nitrate present in the top 36 inches of soil. Postharvest nitrate-N was at or below the target PHNT concentration (20 ppm in 0–12 inches; Table 7) in eight of 26 fields.

Postharvest soil nitrate showed a similar distribution with depth (highest concentrations in 0–12 inch depth) in field trials conducted near Lynden in Whatcom County, Washington (Source: Cogger).

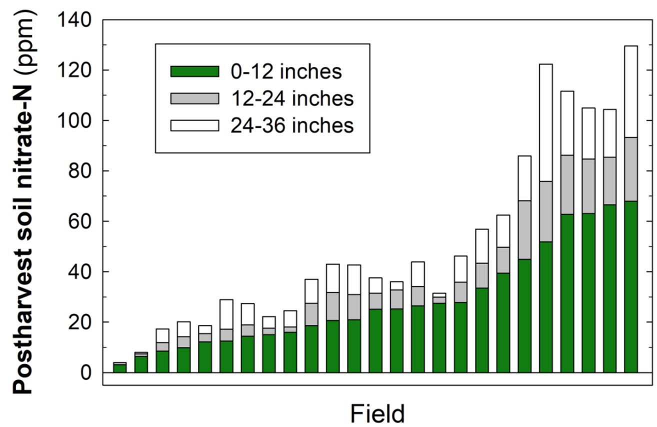

Figure 8. Postharvest soil nitrate-N measured at 25 field sites in the Willamette Valley. Each bar represents one field site-year. Soils were sampled in 12-inch depth increments. Fields are sorted left to right on the x axis by nitrate-N concentration in 0–12 inch depth. Data for one field with very high soil nitrate (90 ppm in 0–12 inch depth) is not shown. Source: Marx, 1995.

Credit: © Oregon State University

Appendix 2: Relationship between midseason and postharvest indicators of N sufficiency

A series of N monitoring trials was conducted on dairy farms producing silage corn in the Willamette Valley in 1993–94 (Source: Marx). Twenty-six replicated field experiments were conducted on 17 dairy farms. Most trials (24 out of 26) were conducted in fields receiving manure application. Dairy farmers applied manure and lagoon water according to their usual crop production practices. Data was collected on crop yield response to N fertilizer (urea) applied at sidedress time (V6 growth stage) to small plots within each field. Soil nitrate was measured near the time of planting, just prior to sidedress N fertilizer application, and at harvest. These trials provided an opportunity to evaluate the relationships among three N monitoring tests: PSNT, PHNT and stalk nitrate concentration at harvest. The guidance provided in the *Monitoring soil and crop N* section of this publication is based on these field trials.

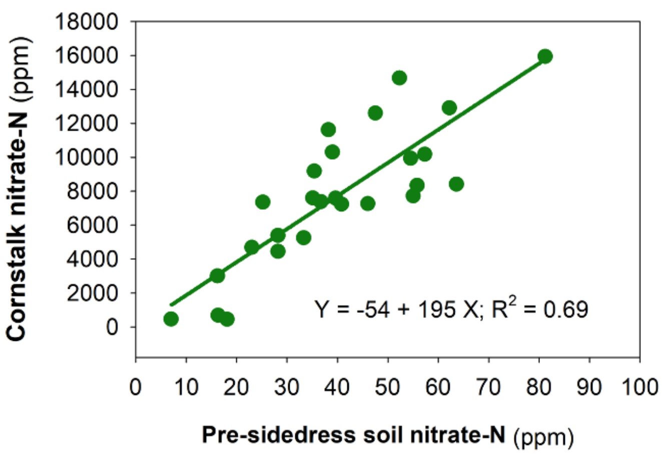

Figure 9. Relationship between pre-sidedress soil nitrate (PSNT; 0–12-inch depth) collected at V6, and cornstalk nitrate concentrations at harvest. Soil samples were collected from dairy farm fields in the Willamette Valley. Each data point represents a field site-year. Eight of the 26 data points represent fields that received lagoon water application after the PSNT soil sample was collected. Source: Marx, 1995.

Credit: © Oregon State University

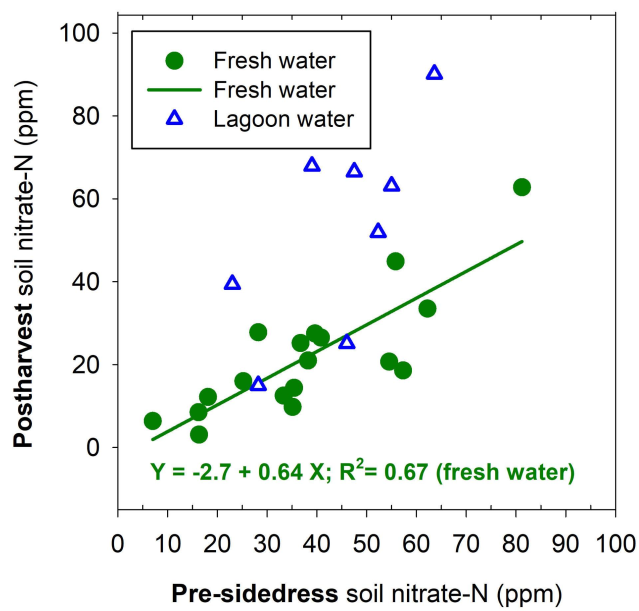

Figure 10. Relationship between pre-sidedress soil nitrate (collected at V6) and postharvest soil nitrate concentrations in 26 field experiments on Willamette Valley dairies. Each data point represents a field site-year. Both PSNT and PHNT samples were collected from 0–12 inch depth. Eighteen fields were irrigated solely with fresh water and eight fields received some dairy lagoon water application during the growing season. The regression line shown above is based on data from fields irrigated with fresh water. Source: Marx, 1995.

Credit: © Oregon State University

Silage corn yields demonstrated that in most fields, N supply from manure plus other nonfertilizer N sources (for example, N mineralization from organic matter) was adequate or more than adequate to maximize crop yield. Silage corn yield was increased by sidedress N fertilizer application at four of 26 field sites. At the other 22 sites, there was no statistical difference between silage yield with or without sidedress N fertilizer. When PSNT soil nitrate concentrations at the 0–12-inch depth were greater than 25 ppm, sidedress N fertilizer application did not increase corn yield. Interpretive ranges for the PSNT (Tables 4 and 6) are based on data from this study.

A linear relationship was demonstrated between soil PSNT concentrations (V6 growth stage) and stalk nitrate at harvest for field plots that did not receive N fertilizer application at midseason (after the PSNT soil sample was collected; Figure 9). A soil nitrate-N concentration of 25–30 ppm at the recommended level at PSNT time resulted in a stalk nitrate-N concentration of about 5,000 ppm at harvest (Figure 9). Stalk nitrate-N concentrations of 3,500 to 5,000 ppm are considered adequate (Table 8). When soil nitrate-N at PSNT was considered excessive (greater than 45 ppm; Table 6), stalk nitrate-N was also at a level considered excessive (above 5,000 ppm; Table 8).

Soil nitrate concentrations in fields receiving irrigation from fresh water only demonstrated a strong correlation between midseason (PSNT) and at harvest (PHNT, Figure 10) values. Postharvest soil nitrate concentrations represented two-thirds (64%) of PSNT values (slope of line in Figure 10). A PSNT test value at the recommended concentration (less than 30 ppm; Table 6) was correlated with postharvest soil nitrate-N concentrations of less than 20 ppm (Figure 10).

Fields that received dairy lagoon water applications had some of the highest postharvest soil nitrate values (Figure 10). For these fields, the PSNT was not a reliable indicator of postharvest soil nitrate.

Basis for recommendations given in this publication

This publication is an update of the 2009 guide. John Hart, Extension soil fertility specialist (emeritus), led the preparation of the 2009 guide, based on research published in 1997 and 1995 (Source: Hart; Marx) and on recommendations in *Field Corn—Western Oregon*, FG-10. OSU has not conducted field research with silage corn in western Oregon since 2009. The nutrient recommendations for liming, P, K, Mg and Zn presented in this guide are similar to those in the 2009 guide. Recommendations in the *Monitoring soil and crop N* section in this guide have been updated to reflect the professional judgment of the primary author (Sullivan).

The nutrient recommendations presented here for liming and N, P, K, Mg, S and Zn management are similar to those in *Nutrient and Soil Health Management for Sweet Corn (Western Oregon)* (https://catalog.extension.oregonstate.edu/em9272), EM 9272, published in 2020, and summarize research conducted in 2010–2016. Silage corn growers may be interested in information presented in the sweet corn guide. The 2020 sweet corn guide includes research findings on midseason soil nitrate test calibration, crop response to banded P fertilizer, crop response to urea treated with urease or nitrification inhibitors, and the establishment of winter crops by interseeding (relay cropping).

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