EM 8978-E
June 2009

Silage Corn

(Western Oregon)

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Summary—Preplant management

Liming	A soil pH greater than 5.5 is desirable. If the soil pH is below 5.5, apply lime according to Table 1. See pages 2–3.
Nitrogen	If 3 years have passed since the last manure application, apply 30 to 40 lb/a N in a band at planting. See page 7.
Phosphorus	If soil test P is below 30 ppm, apply P according to Table 3. See page 3.
Potassium	If soil test K is below 150 ppm, apply K according to Table 6. See page 5.
Magnesium	If soil test Mg is below 100 ppm or 0.8 meq/100 g soil, add Mg from either a band application of 10 to 15 lb/a Mg or 1 t/a dolomitic lime. See page 3.
Zinc	If soil test Zn is below 0.8 ppm (1.5 ppm in the Stayton area), apply 3 to 4 lb/a Zn in a band at planting or 10 lb/a Zn preplant broadcast. See pages 6–7.

Silage corn makes excellent feed for dairy cattle because of its high dry-matter yield, energy content, and palatability, especially when mixed with other feed. Also, it does not accumulate potassium as do many cool-season grass species.

Nitrogen (N) is the most yield-limiting nutrient for silage corn production. Most dairies in western Oregon have sufficient N from manure to produce their silage corn crop. Liming to increase soil pH is sometimes needed.

Adding sulfur (S), phosphorus (P), potassium (K), or magnesium (Mg) is rarely needed when manure has been applied annually for more than 5 years.

This guide provides nutrient and lime recommendations for silage corn established after conventional tillage or with direct seeding. These recommendations are appropriate for fields that receive manure and for those that do not. This guide covers western Oregon.

To obtain the greatest return from your fertilizer investment, plants must be healthy and have an adequate root system. The nutrient recommendations in this guide assume adequate control of pests, including weeds, insects, and diseases. Lack of pest control cannot be overcome by the addition of nutrients. Common pest problems for silage corn production in western Oregon include insects such as corn rootworm (twelve-spot cucumber beetle, *Diabrotica undecimpunctata undecimpunctata*), armyworm (*Pseudaletia unipuncta*) in Coos County, and black cutworm (*Agrostis ipsilon*); grassy weeds, such as barnyardgrass (*Echinochloa crus-galli*) and wild proso millet (*Panicum miliaceum*); and broadleaf weeds, such as black nightshade (*Solanum nigrum*), redroot pigweed (*Amaranthus retroflexus*), and lambsquarters (*Chenopodium album*).

In western Oregon, silage corn is grown in rotation with cool-season grasses such as annual ryegrass. On Amity, Chehalis, Cloquato, Coburg, Concord, Helvetia, McAlpin, Willamette, and Woodburn soil series, grass is planted after corn harvest in the fall and harvested in spring before corn is planted. In Coos County, silage corn is commonly grown in rotation with grass for silage, pasture, forage cereals, and hay on silt loam soils, including Kirkendall, Nestucca, Nehalem, and Quosatana.

The average silage corn yield in western Oregon is approximately 25 to 28 t/a for corn with a 90- to 100-day maturity and 28 to 32 t/a for corn with a 100- to 110-day

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Organic dairy production

Soil testing adequately assesses soil nutrient status regardless of the production system (organic or conventional). Use this guide to determine which nutrients are needed and the amount to apply for organic dairy production.

Fields regularly receiving manure should have ample P and K for silage corn production. Manure can also supply N. Information about using manure to supply N for forage production is found in *Manure Application Rates for Forage Production,* EM 8585-E (see page 12).

If manure does not supply adequate N for all crops, several approaches can be used to supply additional plant-available N (PAN).

- Winter legume cover crops (common or hairy vetch grown with cereal rye or oats) can supply 50 lb/a or more PAN for the corn crop.
- Spring plow-down of a grass–clover pasture or alfalfa typically supplies 50 lb/a or more PAN for a silage corn crop.
- Spring plow-down of a perennial grass stand can also supply considerable PAN for silage corn.

Approximately 80 percent of cover crop N is contained in aboveground biomass, so harvest and removal of the winter cover crop reduces PAN supplied for silage corn.

Another strategy is to import N in the form of poultry manure or another source approved for certified organic production. However, imported N sources often are not economical for silage corn production, and most also supply considerable P and K, which usually is not needed. You can compare the costs of organic fertilizers in terms of PAN supply using the OSU Organic Fertilizer Calculator (http://smallfarms.oregonstate.edu/organic-fertilizer-calculator).

You can determine the amount of PAN supplied for silage corn using one or a combination of the approaches outlined above, together with early-season soil testing for nitrate-N (PSNT; see pages 8–9).

When the P soil test indicates P fertilizer is needed (Table 3, page 3), broadcast 300 to 600 lb/a rock phosphate. Not all rock phosphate materials supply equal amounts of P. For best results, use rock phosphate from North Carolina or Florida, as these sources usually provide more readily available P than others. For more information on organic P sources, see the article by Nelson and Mikkelsen (listed under "For more information," page 12).

Most lime products are allowed in organic production systems. To ensure organic status of a field, check with the certifying agency before applying any material.

maturity. In Coos County, 85-day maturity silage corn yields 20 t/a. The recommendations in this guide, especially for N, are adequate to produce higher yields where soil pH and drainage do not limit yield.

Nitrogen supplied beyond crop need is not taken up by the silage corn crop. The N concentration of silage corn at harvest is usually between 1.1 and 1.3 percent (7 to 8 percent protein on a 100-percent dry basis). Additional information about the nutrient content of silage corn is available in OSU Extension publication EM 8585-E, *Manure Application Rates for Forage Production* (see "For more information," page 12).

Research for this guide was conducted during the past 50 years. The N research was conducted in the mid-1990s on plots throughout western Oregon and western Washington. Information is also taken from other areas in the Pacific Northwest with similar conditions, such as lower mainland British Columbia (Fraser Valley).

Nutrient choices before field preparation

Lime, calcium (Ca), and magnesium (Mg)

Acidity (pH) is the most commonly measured chemical characteristic of soil. Soil pH indicates the chemical condition roots will experience. A decrease in soil pH is accompanied by increased solubility of iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), and aluminum (Al). With low soil pH, the concentration of aluminum can reach levels that inhibit root growth.

Soil pH changes 0.3 to 0.5 unit 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. Sample soil for pH at the same time each year to avoid confusion from seasonal fluctuation.

Silage corn tolerates moderately acidic soil, pH 5.5. A soil pH test will indicate whether lime is needed to raise soil pH. The SMP buffer (lime requirement) test estimates the amount of lime needed. Sample and test soil for pH, SMP buffer lime requirement, and Ca well before planting, since lime should be mixed into the seedbed before seeding.

If soil pH is below 5.5, use the SMP buffer test to determine how much lime to add. Lime application rates can be estimated from Table 1, page 3. A lime application is effective for several years. Refer to OSU Extension publication FG 52-E, *Fertilizer and Lime Materials*, for more information about liming materials.

Table 1.—Lime rate recommendations for western Oregon using the SMP buffer test when the soil pH is below 5.5. Note that the SMP buffer test is an index of lime needed and does not equal soil pH.

SMP buffer test for lime*	Apply this amount of lime** (t/a)
Below 5.5	3–4
5.5–5.8	2–3
5.8–6.2	1–2
Over 6.2	None

*Lime recommendations are based on SMP buffer test only. If other buffer tests are used, recommendations may differ. Liming rates cannot be determined based solely on soil pH.
**Lime rate is based on 100-score lime.

Sometimes, sandy soil types such as Newburg have a soil pH above 5.5 but have less than 5 meq Ca/100 g soil. In this case, a lime rate of 1 t/a is recommended to supply Ca, even if the SMP buffer test is above 6.2.

In silage corn, low soil pH is sometimes expressed as purple leaves. When people see purple corn leaves, they typically assume that P should be added, but this is not always the case. Table 2 provides soil and tissue data from a silage corn field near Coburg. The purple color was caused by low tissue P, but soil test P was adequate. Soil pH was low where the corn was purple and marginal in areas where the corn was normal (green).

Note that tissue Mn concentration in the purple corn is almost double the concentration in the normal corn. Tissue Mn is an excellent indicator of soil acidity, with higher tissue Mn corresponding to lower pH.

Although yield increases from Mg application to silage corn have not been documented in western Oregon, we advise adding Mg if soil test Mg is below 100 ppm or 0.8 meq/100 g soil. Mg can be supplied from dolomitic lime or from fertilizers such as Sul-Po-Mag and K-Mag. These materials also supply sulfur. A band application of 10 to 15 lb/a Mg is sufficient for silage corn production.

Phosphorus (P)

Silage corn produced on fields receiving manure is amply supplied with P. When manure is used to satisfy the silage corn N requirement, more than twice the needed P is added. Regular annual manure application quickly builds available P in the soil. For example, a dairy regularly applied manure to a field and left another field unmanured. The P soil test from the field receiving manure was 130 ppm, and the P soil test from the field not receiving manure was 30 ppm. Soil test P usually is highest closest to the barn or in the fields that receive most of the manure.

Most P remains near the area of placement. Figure 1 illustrates this concept. Soil test P is highest in the surface foot of soil or to the tillage depth. Below a depth of 12 inches, P values are uniform and usually are the same in manured and unmanured fields. Unfortunately, P will move through soil when soil test P exceeds 80 ppm. If P moves from soil through erosion or downward movement into tile lines, it eventually can reach surface water, where it can stimulate algal or other aquatic plant growth and reduce water quality, since P is usually the limiting nutrient for aquatic plant growth.

Elevated soil test P cannot be easily or quickly reduced. When soil P is above 60 ppm, soil test P will decline at most 1 or 2 ppm annually even if no P is applied and a forage crop is removed each year.

Choose P application rates using the guidelines for soil test P in Table 3.

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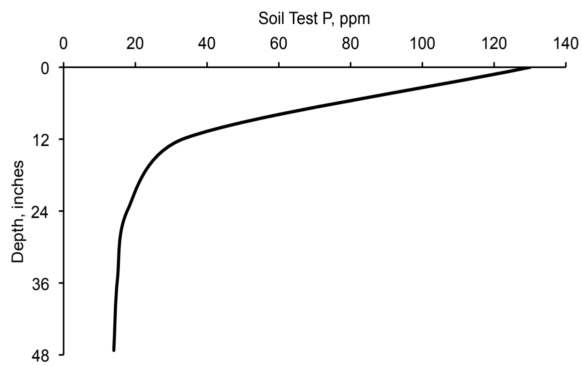

Figure 1.—Soil test phosphorus (Bray P1 extractant) with depth from a field of Woodburn soil regularly receiving manure. Created from data in Marx, E.S., 1995.

Table 3.—Fertilizer phosphorus rate recommendations for western Oregon using the Bray P1 soil test.

Soil test P* (ppm)	Apply this amount of P_2O_5 (lb/a)
0–7	80–100
8–15	60–80
16–30	40–60
Over 30	None

*Bray P1 soil test method.

Table 2.—Silage corn soil test and tissue test data from a field with normal and purple silage corn.

	Soil analyses*			Tissue analyses		
Corn appearance	P (ppm)	Ca (meq/100 g)	pH	P (%)	Ca (%)	Mn (ppm)
green	95	9.8	5.2	0.28	2.2	60
purple	87	10.3	4.8	0.14	2.6	100

*Soil test from the surface 6 inches.

Temporary P deficiency in young corn plants

Although manure supplies ample P to soil, silage corn occasionally turns purple (an indication of P deficiency) at the three- to six-leaf stage (Figure 2). Usually, visible symptoms do not appear before development of three leaves, and the purple color typically disappears as the corn "grows out of" the problem. Research in British Columbia indicates that the purple color is associated with P deficiency even when the Bray soil test for P is above 50 ppm.

This problem is more often seen with early planting dates and cool, wet spring weather and in areas of compacted soil such as field entry and exit areas. Development of purple color is not predictable, as it varies yearly and with corn variety.

P deficiency in young corn plants sometimes decreases silage yield. However, silage moisture is affected more than is whole-plant yield. The higher moisture is probably related to delayed maturity. Band application of P fertilizer lessens yield loss but does not eliminate it.

The limited effect of P application on corn yield was seen in grain corn production data collected from 1960 to 1971 in Central Point. More early-season vigorous growth and earlier tassel emergence were observed in plots receiving P compared to those not receiving P. Nonetheless, the grain yield of corn without added P was only slightly lower than that of corn with P fertilizer application (Table 4). Soil test P in the plots that did not receive P was 8 ppm. At this level of soil test P, application of P fertilizer sometimes, but not always, increases yield.

Increased early growth with no corresponding increase in grain yield was also observed in Lane County in 1956. Treatments receiving P fertilizer produced twice the vegetative growth by July 10 as did treatments not receiving P. In addition, treatments receiving P matured more rapidly than those not receiving P. However, yield was not significantly higher (Table 5).

Figure 2.—Young corn plant with the purple leaves typical of a phosphorus deficiency.

Colonization of corn roots by mycorrhizal fungi is necessary for corn to grow normally without turning purple. The mycorrhizal fungi help plants extract nutrients from soil. Adding mycorrhizal fungi to soil for corn production has not been demonstrated to be practical or successful. Crop rotation and tillage practices offer the best ways to encourage mycorrhizal fungi.

Mycorrhizal fungi will be present if the previous crop was a host. Annual ryegrass, commonly grown in rotation with silage corn on dairies, is a host for mycorrhizal fungi. Planting corn after fallow provides fewer mycorrhizal fungi for root colonization.

In research trials conducted in lower mainland British Columbia, minimum tillage (such as disking) was superior to plowing for reducing the incidence of purple color in young corn plants. Mycorrhizal fungi grow much like roots and must be 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 is above 30 ppm, use the following management practices next year.

- Plant corn after a crop that hosts mycorrhizal fungi. Most crops support mycorrhizal fungi. Avoid crops in the beet and brassica families, such as sugar beets, Swiss chard, spinach, cabbage, broccoli, and mustard.
- Reduce tillage. Most important, do not plow.
- Apply 30 lb/a P_2O_5 in a band 2 inches from the seed.

Table 4.—Twelve-year average grain corn yield influenced by broadcast P application rate at Central Point, Oregon.*

P application rate (lb/a P_2O_5)	Corn grain yield (bu/a)	Soil test P after 10 years** (ppm)
0	145	8 (low)
30	148	12 (medium)
60	156	17 (medium)
120	152	28 (high)

*Central Point loam–fine sandy loam. Soil test P was measured using a sodium bicarbonate extract. Soil was sampled in 1970, after 10 years of variable P fertilization rates.

**Soil test interpretation for sodium bicarbonate extract method used in research. Soil test P of 10 using the sodium bicarbonate method is approximately equivalent to 20 to 30 ppm P using the Bray soil test. The Bray test is recommended for routine use in western Oregon.

Table 5.—Grain corn yield as influenced by banded P at planting in Lane County during 1956.*

P application rate (lb/a P_2O_5)	Corn grain yield (bu/a)
0	97
40	113
80	99

*Soil test P measured with Bray extracting solution was 13 ppm (low).

Potassium (K)

Like P, K is amply supplied on manured dairy farm fields. P and K soil test values are usually closely related (Figure 3). When manure is used to satisfy silage corn N requirement, more K is added than removed by the silage corn crop. Regular annual manure application quickly builds available soil K. Soil test K usually is highest closest to the barn or in the fields that received most of the manure.

K has limited mobility in soil and remains near the area of placement. Figure 4 illustrates this concept. Soil test K is highest in the surface foot of soil or to the tillage depth. Below a depth of 24 inches, soil test K values are uniform and usually are the same in manured and unmanured fields.

Unlike many cool-season grasses, silage corn does not accumulate high levels of K in forage. Cool-season grasses grazed or harvested for forage can contain 5 percent K in fields routinely receiving manure. When high-potassium forage is fed to dry cows, hypocalcaemia (milk fever) and other metabolic disorders can develop.

K concentration in corn silage is lower—usually between 0.75 and 1.75 percent (typically 1.2 percent)—even when soil test K is high. The difference in K concentration between cool-season grasses used for forage and silage corn can be explained by the stage of maturity at harvest. Silage corn K concentration can be above 4.5 percent when the corn is 1.5 to 2 feet tall. At harvest, however, the same crop has approximately 1 percent K. Cool-season grasses are harvested at an earlier development stage than silage corn and thus have a higher K concentration.

If the soil test for K indicates K is needed (Table 6), it can be supplied by banding traditional fertilizer sources at planting, by preplant broadcast and incorporation of traditional fertilizer sources, by a combination of banding and broadcasting, or by application of manure or lagoon water. See OSU Extension publications EM 8585-E and EM 8586 (details on page 12) for more information about supplying K with manure.

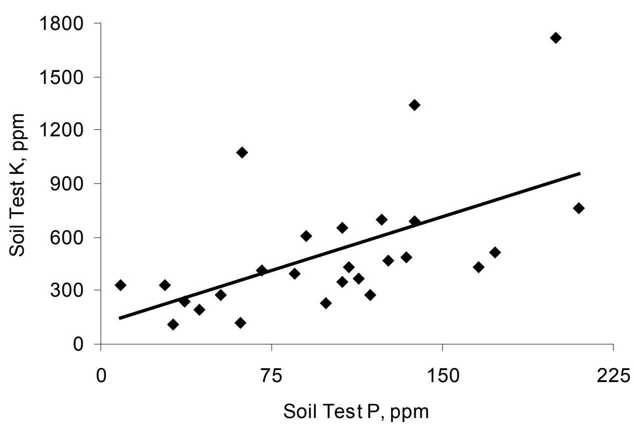

Figure 3.—The relationship between soil test P and soil test K on Willamette Valley dairy farm fields receiving manure. Created from data in Marx, E.S., 1995.

Corn, especially at germination, is sensitive to salt damage from fertilizer. To minimize fertilizer salt concentration near the seed, band no more than 50 lb/a K_2O when the band is at least 2 inches from the seed. The total of N and K_2O banded 2 inches from the seed should not exceed 100 lb/a. When fertilizer is banded within 1 inch of corn seed, do not apply more than 40 lb/a N plus K_2O in the band. If additional K is needed, broadcast and incorporate it before planting.

The K recommendations in Table 6 are taken from a 1983 fertilizer guide for field corn in western Oregon and likely are based on the results of a 12-year field experiment in Central Point. In this research, annual K fertilizer application did not increase grain corn yield when the K soil test was 150 ppm (Table 7).

Table 6.—Fertilizer potassium rate recommendations for western Oregon using the ammonium acetate soil test.

Soil test K* (ppm)	Apply this amount of K_2O (lb/a)
0–75	80–120
76–100	60–80
101–150	40–60
Over 150	None

*Ammonium acetate method.

Table 7.—Twelve-year (1960–1971) average grain corn yield influenced by potassium application rate at Central Point.

K application rate (lb/a K_2O)	Corn grain yield (bu/a)	Soil test K after 10 years* (ppm)
0	149	156
40	151	160
80	154	172
160	162	200

*Soil was sampled in 1970.

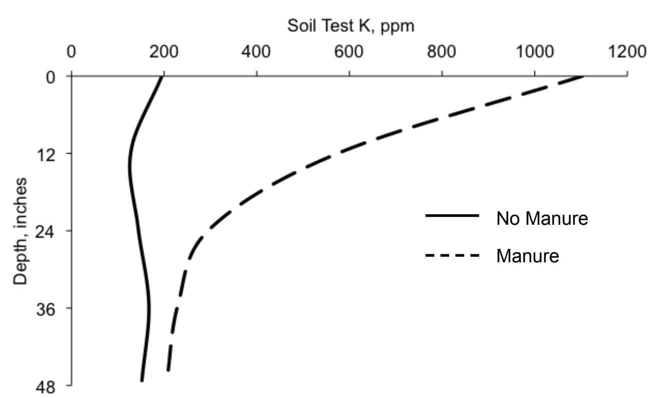

Figure 4.—Soil test potassium with depth from two fields on the same dairy. One field received manure; the other did not. Woodburn is the soil series in the field receiving manure, and Amity is the soil series in the field not receiving manure. Created from data in Marx, E.S., 1995.

Zinc (Zn)

Routinely test soil for Zn, to identify zinc deficiencies (Figure 5) and changing soil Zn levels. In the Stayton area, Zn application increased sweet corn yield in fields where corn had striped leaves and growth was "spotty" or uneven, especially on gravelly, dark-color soil such as the Sifton and Salem series. Sweet corn and field corn have similar requirements for Zn, so these data form the basis for the recommendations in Table 8 (page 7).

When the Zn soil test is less than 0.8 ppm, a yield increase from Zn application is expected on all soils.

Where Zn is required, broadcast 10 lb/a Zn and incorporate before planting to meet crop requirements for 2 or 3 years. An alternative approach is to band 3 to 4 lb/a Zn at planting.

Figure 5.—Young corn plant with stripes typical of zinc deficiency.

Footbath solutions and soil Zn and Cu

Dairy farmers often use copper sulfate ($CuSO_4$) or zinc sulfate ($ZnSO_4$) in footbath solutions to control hoof diseases (Figure 6). Solutions are often changed before each milking. Used solutions containing significant quantities of Cu and/or Zn are dumped into the manure handling system and applied to fields with liquid or slurry manure. A 2008 survey of 30 dairies found that some farms did not use a footbath, while others continually used one.

This practice is creating concern about increasing soil Cu and Zn levels on dairies in Oregon (Figure 7). In 56 fields on Oregon dairies, over 75 percent of soils tested were considered to have high Cu concentration (above 2 ppm), and 38 percent were extremely high (above 5 ppm). Soil Cu concentration ranged from 0.7 to 35 ppm (average 6 ppm). Cu concentration in forages ranged from 1 to 10 ppm (average 3 ppm). Cu concentration in fresh manure was consistent (typically 10 ppm), while Cu concentrations in stored manure ranged from 2 to 58 ppm (average 10 ppm).

On the same dairies, soil Zn concentration ranged from 0.6 to 42 ppm (average 11 ppm). Forage Zn concentration ranged from 3 to 51 ppm (average 13 ppm).

Increasing soil Cu and Zn concentrations are creating the potential for long-term environmental and cropping challenges on many Oregon dairies. Cu is required by plants in small amounts, generally between 2 and 20 ppm. It accumulates in roots, and the difference between sufficiency and toxicity is small. Organic additions to soil (such as manure) chelate Cu; i.e., they increase its availability to plants.

Continual application of Cu from dairy manure slurry to a sandy loam soil in New Mexico caused a DTPA extractable Cu concentration of 23 ppm, leading to copper toxicity in sudangrass and winter small grain crops.

Copper toxicity inhibits root growth and causes root membranes to "leak" K. Plants suffering from Cu toxicity can lose enough K to cause K deficiency even when soil test K is adequate. In grasses such as sudangrass, Cu toxicity is expressed as yellowing of the plant, similar to that caused by iron (Fe) or Zn deficiency.

If footbath Cu and Zn sulfate solutions are regularly added to manure storage, monitor soil Cu and Zn to avoid copper toxicity in crops.

Figure 6.—Typical footbath in which zinc and copper solutions are used. Footbath solution disposal with manure increases copper and zinc application rate.

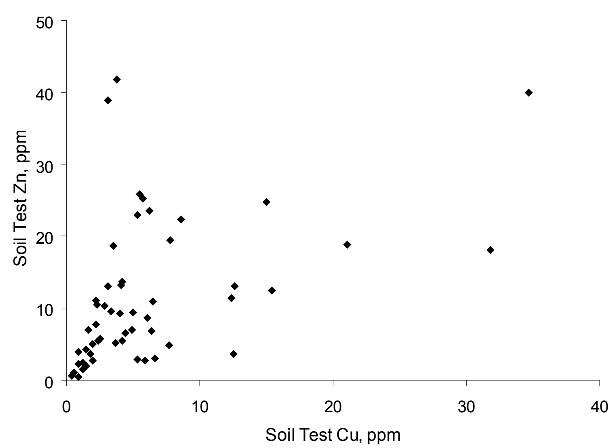

Figure 7.—The relationship between soil test Zn and Cu from the surface 6 inches of 56 fields on dairy farms.

Table 8.—Fertilizer zinc recommendations for western Oregon.

Soil test Zn* (ppm)	Apply this amount of Zn (lb/a)
below 0.8	3 to 4 banded or 10 broadcast
above 0.8	None except Stayton area**

*DTPA soil test method.

**When soil test Zn is between 0.8 and 1.5 ppm in the Stayton area, Zn application is expected to increase yield on most fields.

Other micronutrients

Need for addition of micronutrients other than Zn has not been demonstrated for silage corn production in western Oregon.

Nitrogen management

Starter N applications

Most fields with a history of manure application require no starter N fertilizer. If 3 years have passed since the last manure application, or the field has not regularly received manure, apply no more than 40 lb/a N as a banded starter fertilizer. Starter N can be supplied by manure or commercial fertilizer.

Understanding corn growth and N uptake

Early-season N uptake by corn is minimal, as corn grows slowly for the first 30 days, or until it has five or six leaves. After 10 leaves are produced, growth is rapid, with new leaves appearing every 2 or 3 days.

Early-season N uptake exceeds dry matter accumulation. A small amount of N (20 to 40 lb/a) is accumulated before the plant has 10 leaves. N uptake is rapid between the 10-leaf stage and silk emergence (end of July), when approximately 90 lb/a (almost 3 lb/a/day) is used by the crop. At silk emergence (Figure 8), approximately two-thirds of total seasonal accumulation of N is already in the crop, but less than half the dry matter has been accumulated (Figure 9).

Figure 8.—Corn showing silk emergence. One-third of seasonal N uptake occurs after silk emergence.

Nitrogen monitoring options

The following tests can be used to confirm the adequacy of N supply. On fields receiving frequent manure application, both early-season and postharvest tests can be used as planning tools for future years. The early-season pre-sidedress soil nitrate test (PSNT) test can also be used to adjust the current-season sidedress N fertilizer rate.

Early season

- **PSNT**. Used to evaluate N supply status of the field and make sidedress N rate recommendations. If the PSNT is above 25 ppm N, sidedress N fertilization is not needed. PSNT is often positively correlated with postharvest N values (see page 10).

Postharvest

- **Stalk nitrate test** (page 10). The adequate range is 3,500 to 5,500 ppm N (dry weight basis).
- **Silage crude protein** (CP; page 11). CP is adequate when silage protein is above 6.5 percent or silage N is above 1 percent (dry weight basis).
- **Postharvest nitrate test** (PHNT; page 11). Used after harvest to evaluate N application management. An end-of-season value below 20 ppm N indicates that the silage corn crop utilized most of the plant-available N in the soil.

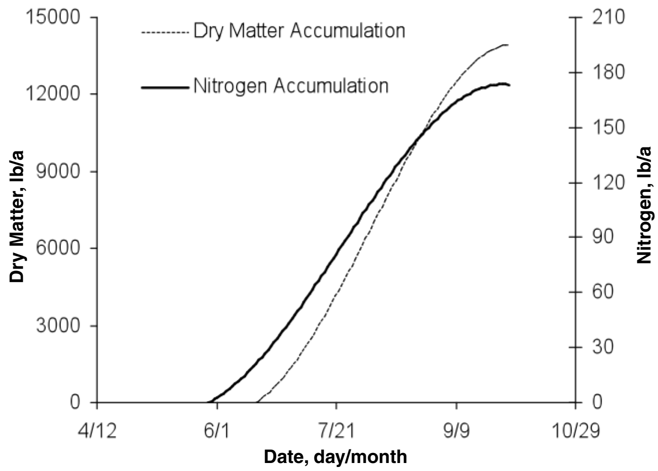

Figure 9.—Silage corn aboveground biomass (dry matter) and nitrogen accumulation. The graph is a compilation of silage corn N uptake information from California, Oregon, and New Jersey since 1984. One-third of seasonal N uptake is assumed to occur after silk emergence, which occurs at the end of July or when 1,000 growing degree-days have been accumulated.

Growing season N application

Because early-season N uptake by corn is minimal, wait until corn has five or six leaves before applying N. Use plant development (not the calendar) to determine when to apply N. Adequate N supply is extremely important for silage corn between the 10-leaf stage and the time silk appears. Therefore, N should be applied—if needed—shortly after the corn has five or six leaves.

Soil tests performed in early spring do not tell how much N will be available during the growing season, and so these tests cannot be used to make midseason fertilizer decisions. Most soil N is held in organic matter and is unavailable to plants. As the soil warms, increased biological activity converts organic N to plant-available N. To accurately predict the need for midseason N application, the N that becomes available early in the growing season should be measured.

In western Oregon, testing soil for nitrate-N when silage corn has five or six leaves is an excellent indicator of the need for additional N. This test is called the pre-sidedress soil nitrate test (PSNT). It measures soil nitrate-N (NO_3-N) during the growing season, after some N has become plant-available but before the crop's time of greatest need. The test will accurately predict how much plant-available N will be released from spring-applied manure or spring-incorporated cover crop. The PSNT can also be used, however, to determine N application rates on unmanured fields.

To perform the PSNT, measure nitrate-N between the rows to a depth of 12 inches when corn has five or six leaves (approximately 12 inches high at the center of the whorl). See sidebar at right for sampling instructions.

If midseason PSNT values are greater than 25 ppm, more than enough N probably will be available. If the PSNT is below 25 ppm, N is **not** sufficient to produce economically optimum silage corn. Approximate N fertilizer rates required to meet crop N need at PSNT values less than 25 ppm are shown in Table 9.

Manure testing

Manure nutrient content varies with amount and type of bedding, feed source, handling, and addition of materials such as footbath solutions. Test manure periodically to determine nutrient supply for crops. See *Which Test Is Best? Customizing Dairy Manure Nutrient Testing* (PNW 505) and *Fertilizing with Manure* (PNW 533).

Directions for PSNT

Sample soil when the corn has five collared leaves or at least a week before planned sidedressing (Figure 10). This usually coincides with a plant height of about 12 inches at the center of the whorl.

- Collect the soil sample between rows, away from fertilizer bands. Avoid irregular areas, such as low areas or places where manure accumulates.
- Collect a composite sample of 15 to 20 cores. The more cores you collect, the better your chance of getting an accurate measurement.
- 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 mixed soil.
- Send the sample to a soil testing lab to be analyzed for nitrate-N (NO_3-N).The sample should be delivered to the lab immediately. To avoid shipping delays over the weekend, do not mail samples on Thursday or Friday. Changes in N occur when the soil is warmed.
- Request results in ppm or mg/kg, **not** lb/a.

If soil nitrate-N is above 25 ppm, no additional nitrogen is needed. If soil nitrate-N is below 25 ppm, apply N at the rate shown in Table 9.

Figure 10.—A pre-sidedress soil nitrate test (PSNT) should be taken when corn has six leaves with collars or is about 12 inches tall.

Table 9.—Nitrogen rate recommendations for western Oregon using the PSNT.*

PSNT value NO_3-N (ppm)	Apply this amount of N (lb/a)	Amount of manure to apply: If manure supplies 4 lb N/1,000 gal (gal/a)	If manure supplies 4 lb N/1,000 gal (acre-inches)	If manure supplies 6 lb N/1,000 gal (gal/a)	If manure supplies 6 lb N/1,000 gal (acre-inches)
0–10	100–175	25,000–44,000	1.0–1.5	17,000–30,000	0.6–1.1
11–20	50–100	12,500–25,000	0.5–1.0	8,000–17,000	0.3–0.6
21–25	0–50	0–12,500	0–0.5	0–8,000	0–0.3
Above 25	0	0	0	0	0

*Use as a guide. To refine N rates for your cropping system, monitor yield, silage crude protein, and stalk nitrate-N, or use a postharvest soil nitrate test (see pages 10–12).

Supplying N with lagoon water usually requires multiple applications (Figure 11). Make the last, and probably smallest, N application at or before silk emergence, since N uptake is two-thirds complete by silk emergence. An adequately fertilized silage corn crop will not produce additional yield if fertilized with N after silk emergence. In addition, late-season N fertilization increases the risk of N loss to the environment.

Even if you are not able or willing to alter fertilization practices for the present growing season, the PSNT can provide useful information for adjusting N application rates the following season.

Applying N without using the PSNT usually provides more N than needed by a silage corn crop. Therefore, we do not recommend using crop uptake or other approaches to estimate a growing-season N application rate.

Figure 11.— Dairy lagoon water application to forage grass with a "big gun" style irrigator.

Separated solids

Separated solids are frequently applied to corn fields (rather than to established grass or alfalfa) on dairies, because they can smother perennial grasses and reduce forage palatability. Relatively high rates of separated solids can be applied without danger of providing excess plant-available N.

Separated solids have a lower N content than other manure sources (Table 10). They do, however, supply considerable P and K to a crop.

Unlike other manures, separated solids temporarily remove or immobilize soil N during the growing season (Figure 12). The period of N immobilization typically lasts 30 days when soil temperatures are close to 70°F. Because of the potential detrimental effects of N immobilization on early-season growth, apply separated solids 4 weeks or more before seeding.

Only a small amount (about 5 to 10 percent) of the N in spring-applied separated solids becomes plant-available by the end of summer. Most of the N from separated solids remains in the organic form in soil, enhancing soil tilth but providing only small amounts of plant-available N. In subsequent growing seasons, approximately 5 percent of the total N applied as separated solids is released to plant-available forms by microbial activity.

When separated solids are applied preplant in the spring, the pre-sidedress soil nitrate test will indicate the effect of solids application on sidedress fertilizer N needs.

Table 10.—Nutrient analysis of mechanically separated dairy solids.*

	lb/dry ton (no moisture)	lb/"as-is" ton (22% dry matter)
Carbon (C)	807	178
Nitrogen (N)	36	8
C:N ratio	23	23
Ammonium-N	2.4	0.5
Nitrate-N	0.06	0.01
Phosphate (P_2O_5)	21	5
Potash (K_2O)	34	8
Sulfur (S)	7	1
Calcium (Ca)	54	12
Magnesium (Mg)	12	3
Manganese (Mn)	0.5	0.1
Copper (Cu)	0.6	0.1
Boron (B)	0.1	0.02
Zinc (Zn)	0.4	0.1

*Values are the average of five samples collected 2002–2003. Figures for lb/dry ton were calculated based on Gale, E., 2004.

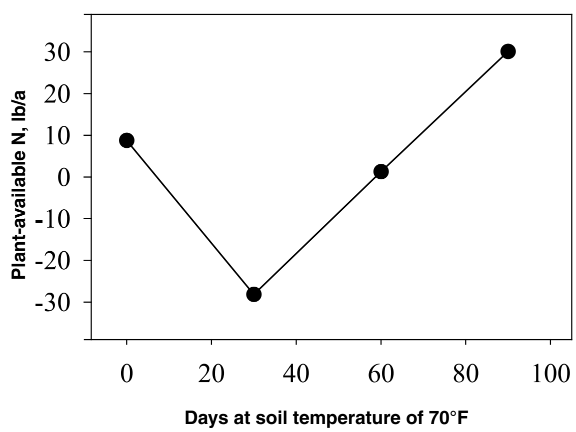

Figure 12.—Effect of a first-year high-rate dairy solids application (15 dry ton/a at Day 0) on plant-available nitrogen (lb/a N). The dairy solids application supplied about 500 lb/a total N, but it temporarily immobilized (in microbial biomass) about 40 lb/a plant-available N. Graph created from data in Kusonwiriyawong, C., 2005.

Figure 13.—Obtain a 6- to 8-inch section of stalk from the lower part of the corn plant for determination of nitrate-N. The stalk nitrate-N test is used to evaluate adequacy of N application.

Postharvest measurements and evaluation of N application rate

Various methods can be used after harvest to evaluate the adequacy of the N fertilizer program. Results of these measurements can help growers adjust N application rates during the following growing season.

- If silage corn yield is less than expected, producers wonder whether sufficient nutrients have been supplied. Measuring nitrate-N (NO_3-N) in the lower stalk at harvest can help answer this question. Crude protein can also be used to assess whether N supply was sufficient, as it is related to stalk nitrate-N.
- Growers who have reduced manure rates or made other adjustments to the fertilizer program want to know whether N application was adequate. The stalk nitrate test or crude protein evaluation can help with this assessment.
- Another concern is the amount of nitrate-N remaining in the soil at harvest. This nitrate-N is vulnerable to leaching loss. Analyses of soil after harvest (postharvest nitrate test) is the most reliable method to determine whether residual soil nitrate-N after harvest is high.

Stalk nitrate test

The corn stalk nitrate-N test is performed at harvest and can be a valuable diagnostic tool for **future** corn silage crops, rather than the current crop. Growers who are reducing their manure application rate or using new N management practices are most likely to benefit. If the stalk nitrate-N test indicates N was not limiting following a reduction in the manure application rate, further reductions can be considered.

The stalk nitrate-N test also can be very useful for determining whether low yield was caused by inadequate N supply. If silage yield was low, but the stalk nitrate-N test is adequate, N was not the cause of reduced yield.

Directions for collecting a sample for a stalk nitrate-N test

- At harvest, cut a 6- to 8-inch-long section of stalk from the lower part of the corn plant. Make the lower cut about 6 inches above the soil surface (Figure 13).
- Remove leaves from the stalk.
- Take 15 to 20 samples from a field.
- Immediately submit samples to a lab for nitrate-N analysis.
- Interpret laboratory results using Table 11.

One drawback of the stalk nitrate-N test is the inconvenience of collecting the sample. Lower sections of corn stalk need to be collected at harvest, a busy time of year. The sample can be collected a few days before harvest to a few days after harvest as long as no rain falls between harvest and stalk sampling.

If a stalk nitrate-N test is not possible, the PSNT (pre-sidedress soil nitrate test; see pages 8–9), a growing-season soil test, is an excellent predictor of high stalk nitrate-N (Figure 14). You can assume that N supply is high and that stalk nitrate-N at harvest will be high if the PSNT is above 35 ppm.

Table 11.—Postharvest corn stalk nitrate-N test interpretation.

Stalk nitrate-N	Interpretation (ppm)
Below 3,500	**Low**. N supply may have been inadequate or late; root limitation may have reduced N uptake.
3,500–5,500	**Expected range**. Adequate N supply and expected yield.
Above 5,500	**High**. N supply excessive, late, or both.

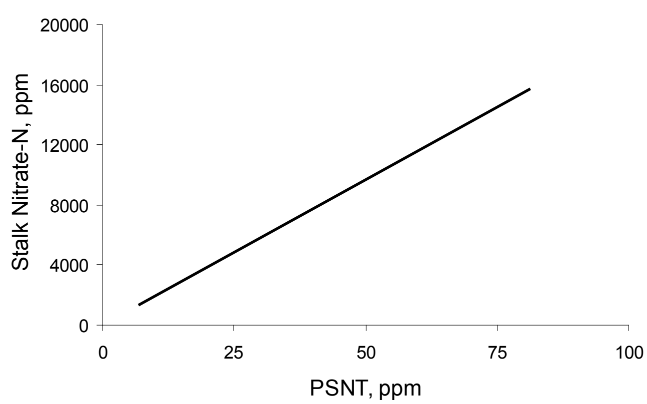

Figure 14.—The relationship between stalk nitrate-N and PSNT from 26 locations in western Oregon. Created from data in Marx, E.S., 1995.

Using crude protein to evaluate N sufficiency

An alternative to the stalk nitrate-N test is an assessment of crude protein in silage corn. Dairy producers often analyze silage corn for feed value, including crude protein. Crude protein can be used to assess N supply to the corn crop, as it is related to yield and stalk nitrate-N.

As shown in Table 11 (page 10), N is sufficient when the stalk nitrate-N concentration is above 3,500 ppm. Silage corn that contains 3,500 ppm will have about 6.5 percent crude protein on a dry-weight basis. Thus, if crude protein is below 6.5 percent, N may have limited silage corn yield. In this case, review your manure and fertilizer application rate and timing.

Crude protein in silage will not indicate whether excessive N was supplied. Use the postharvest nitrate test to measure available N remaining in the soil after harvest.

Postharvest nitrate test

The postharvest nitrate test (PHNT) measures soil nitrate-N not used by the crop. The PHNT looks backward in time and evaluates the balance between N supply and crop N uptake. Nitrate-N accumulates in the soil when the total of applied N plus plant-available N mineralized from soil organic matter exceeds corn N uptake.

Use the postharvest test to:

- Evaluate the balance between N supply from manure and other sources and crop N demand
- Identify imbalances in N supply among fields on a farm
- Identify fields that may respond to changes in timing or amount of manure application or other agronomic practices

If fall soil nitrate-N is high, consider ways to reduce the N surplus in the future. Evaluate the overall N supply, including:

- Timing and amount of current-season application(s) of N fertilizer, manure, or lagoon water
- Plant-available N mineralized from a previous cover crop or perennial grass crop

Note that a low PHNT does not indicate that too little N was applied. Continual mineralization of N can provide enough plant-available N for a crop without accumulation of nitrate-N in the soil. Also, the PHNT does not predict the amount of plant-available N that will be mineralized from soil organic matter or crop residues in the fall.

Directions for a PHNT

Collect a soil sample to a 12-inch depth. The amount of nitrate-N in the upper 12 inches is a good predictor of nitrate-N in the rest of the soil profile, provided that nitrate-N was not moved below 12 inches by irrigation or fall rains.

Collect soil samples (15 to 30 cores per field) as soon as possible after harvest (Figure 15). Do not sample fields that received a manure application (including lagoon water) within the past 30 days. Take samples before heavy fall rains move nitrate-N below the sampling depth. On medium- to fine-texture soils (loam or clay), sample before 5 inches of cumulative rainfall (after September 1). Coarse soils (sand or sandy loam) have low water-holding capacities; sample them before 3 inches of cumulative rainfall after September 1. Sampling Willamette Valley locations before October 15 is acceptable in most years. At sites near the Oregon coast, take PHNT samples before October 1.Use Table 12 to interpret PHNT analyses.

Figure 15.—Obtain a soil sample immediately after harvest, to evaluate adequacy of the N application rate.

Table 12.—Postharvest nitrate-N test interpretation following silage corn.

Nitrate-N	Interpretation (ppm)
0–20	**Acceptable**. PHNT test value can be as low as 5 to 10 ppm without compromising yield.
21–45	**High***
above 45	**Excess***

*See EM 8832-E, *Post-harvest Soil Nitrate Testing for Manured Cropping Systems West of the Cascades*, for ways to reduce post-harvest test values for fields treated with dairy manure.

Field research in northwest Washington (Lynden area) and western Oregon demonstrated that the pre-sidedress soil nitrate test is correlated with the postharvest nitrate test (Figure 16, page 12). A PSNT test greater than 25 or 30 ppm indicated a high probability of excess N remaining in the soil profile after harvest. In Washington, PSNT values above 40 ppm usually produced PHNT values of more than 150 lb/a nitrate-N (0- to 24-inch depth).

Because of the correlation between PSNT and PHNT values, you may prefer to make dual use of the PSNT: (1) as an indicator of whether sidedress N fertilizer is needed and (2) as an indicator of postharvest soil nitrate-N.

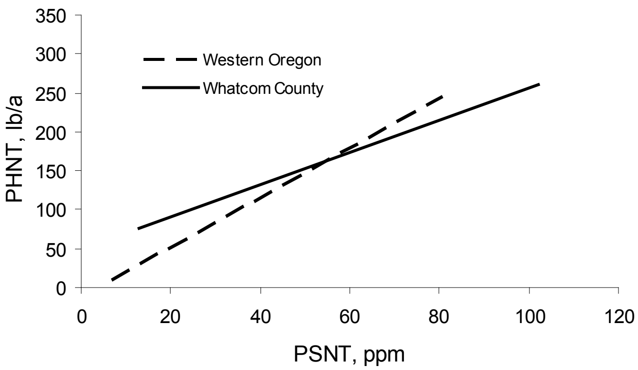

Figure 16.—The relationship between soil nitrate-N measured in midsummer (PSNT) and soil nitrate-N measured in fall (PHNT). Data represent 26 western Oregon fields and 27 sites in Whatcom County, Washington. Sampling depth for the PHNT was 12 inches in western Oregon and 24 inches in Whatcom County. At all sites, lagoon water was not applied after the midsummer (PSNT) test.

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Acknowledgments

We thank the following reviewers for their thoughtful advice and assistance during preparation of this publication.

Robert G. Stevens	Washington State University Irrigated Agriculture Research and Extension Center
Craig C. Cogger	Washington State University Puyallup Research and Extension Center
Bradford Brown	University of Idaho Southwest Idaho Research and Extension Center
Joseph H. Harrison	Washington State University Department of Animal Sciences
T.J. Hafner	Wilbur-Ellis Company
Ernie Claassen	Wilco Farmers

Robert Flynn, New Mexico State University, provided information used on page 6 in the section on “Footbath solutions and soil Zn and Cu.”

Published June 2009.