FERTILIZERguide
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Hops

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Fertilizing hops improves yield and quality by supplying the crop with ample nutrition in advance of demand. Producers must combine this goal with production costs and environmental stewardship. Fertilization should be based on yield and quality response, experience, and economics. Unfortunately, limited experimental data exist linking modern cultural practices, current varieties, and hop yield in Oregon. The recommendations given in this guide are based on Oregon research, publications from other hop-producing areas, and grower experience.

This fertilizer guide provides general information for hop fertilization. Growers, with the assistance of county Extension agents and field representatives, should consider the fertilizer needs of individual hop yards. Routinely sample soil and petioles (stems) for analysis. Record soil and tissue data as well as other management practices, weather records, yield, quality, disease problems, and fertilizer rates and timing. Long-term production records then can be compared to changes in fertilization or other practices.

Fertilization is only one practice a grower must consider in hop production. The fertilizer recommendations in this guide assume adequate weed, insect, and disease control, and timely irrigation.

Soil and Tissue Sampling

Sample soil around the hill for routine analysis. Obtain a core from the soil surface to a depth of 12 inches in 15 to 20 locations throughout each hop yard. Combine individual cores into a single sample for analysis. No specific time of year is recommended for sampling. However, soil pH will vary seasonally. Lowest soil pH values usually are found in the late summer or early fall. The highest values are obtained in the late winter or early spring before fertilization. Obtain soil samples at the same time each year and in sufficient time for analysis and planning for fertilization or liming.

In addition to routine soil sampling described above, sample soil from the surface to a depth of 5 or 6 feet one time during the life of the hop yard. Ideally, this sample should be taken before the hop yard is established, but it can be obtained any time after planting. Take samples from between rows in an established hop yard. Soils with subsurface gravel or sand layers are common in some hop yards. Knowing the extent of these layers in a yard will aid in optimum fertilizer and irrigation management.

Tissue analyses can be used to monitor plant nutrient concentration or compare areas of good and poor growth. Although no tissue standards for hops are available, petiole nutrient levels, especially for nitrogen (N), can be used to evaluate the current-year fertilizer application when tissue levels are compared to previous years' analyses. Take 30 petioles from throughout the hop yard. Choose mature leaves and petioles from the main stem 5 to 6 feet from the ground.

Hop Plant Growth

A general description of hop plant growth is helpful in understanding both tissue sampling and nutrient needs. Rapid spring growth produces long shoots with little leaf area and depends on rootstock reserves. After leaf expansion, carbohydrates are produced in excess of growth requirements and accumulate in the rootstock. Accumulation of carbohydrates is most rapid during August and September when vine growth has ceased.

Seasonal accumulation in the dry weight of the aboveground portion of mature plants is illustrated in Figure 1. Rapid dry matter accumulation in the aboveground portion

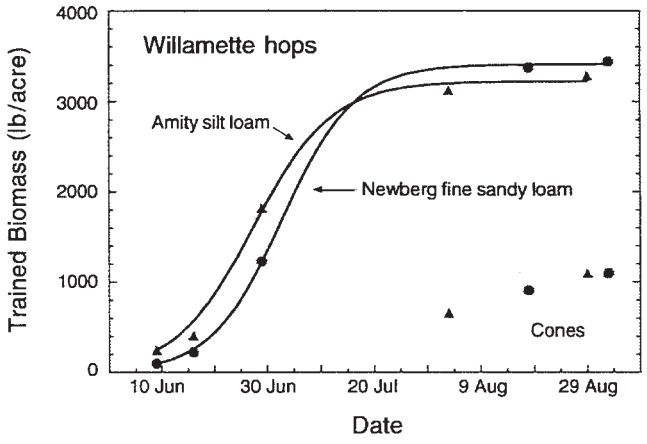

Figure 1.—Trained biomass for two yards producing 'Willamette' hops during 1992.

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begins in mid-June and is complete in mid-July as cones begin to develop. By the end of August, cone dry matter amounts to approximately 30 percent of the total aboveground growth.

Nitrogen (N)

The complex behavior of N has hindered development of a soil test for prediction of hop N fertilization in western Oregon. Consequently, an N budget will be used to estimate the N fertilizer rate. The N budget can be written as the following equation:

$$\text{hop N requirement} - \text{N from manure, vines, and cover crops} = \text{fertilizer N to apply}$$

Hop N requirement can be estimated from plant N uptake. Hop N uptake is shown in Figure 2. Nitrogen accumulation in the aboveground biomass follows a pattern similar to that for dry matter accumulation. Little N is taken up with initial growth; only 10 percent of the total is taken up by early June. N uptake occurs rapidly in June and is almost complete by early July.

Comparison of Figures 1 and 2 shows that N is taken up in advance of dry matter production, stored in the leaves, and translocated to cones. Dry matter production is complete in August; therefore, N uptake of 80 to 150 lb N/a will have occurred before this time.

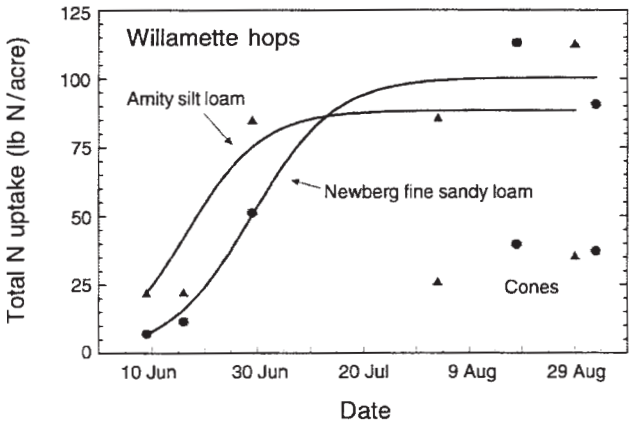

Figure 2.—Nitrogen uptake for two yards producing 'Willamette' hops during 1992.

Yield also should be considered in determining the N fertilizer rate. Since one-third to one-half of the N in hops is found in cones, a higher yield requires more N than a lower yield. Cones contain 5 to 6 lb N/bale. The N fertilizer estimates provided are based on an 8- to 10-bale/acre cone yield. Reduce N requirements when a lower yield is anticipated.

For example, Figure 2 shows a 5-bale yield containing 30 to 40 lb N/a in cones and 80 to 90 lb N/a total in the plant or 50 lb N/a in leaves and vines. An 8-bale yield in the same yard would require at least 18 lb/a more N for cones (8–5 bales = 3 x 6 lb N/bale = 18 lb N/a). In addition, vines from a 10-bale cone yield could return 100 lb N/a to the hop yard.

Hops require 100–150 lb N/a depending on cultivar, age, and yield. Apply fertilizer N by mid-June. Split N applications were equal to a single April application in Oregon trials.

Hop N requirements can be satisfied from several sources. In addition to commercial fertilizer, soil organic matter, manure, cover crops, and returned hop vines can supply substantial N for hop production. Reduce N fertilizer rates where manure is applied. The reduction in N rate or N credit should be based on an analysis of the manure or an estimate of N concentration and the rate applied. Fertilizer N can be reduced further if vines are returned to the yard or a cover crop is incorporated.

First-year plantings

Apply 75 lb N/a for first-year plantings. Reduce N application when manure or other organic materials are used.

Phosphorus (P)

The hop plant P requirement is small when compared with the plant's need for N and potassium (K). Studies in Germany and Washington indicate a 9- to 10-bale/a hop crop removes an average of only 20 to 30 lb P/a. This corresponds to other studies, which have found that hops have a low phosphorus requirement and generally do not respond to fertilizer phosphorus applications. Typically, 25 to 30 percent of the P is found in the cones, the rest in the vine and leaves. If vines and leaves are returned to the yard, there is a net removal of only 6 to 8 lb P/a with hop cone harvest.

Soil test results and a recent field survey of Willamette Valley hop yards show that soil test P values are quite high, averaging more than 80 ppm. In addition, no relationship was found between soil test P levels and leaf tissue P. The absence of a significant relationship between soil and tissue P values suggests soil P is above the critical level for hop production.

Continued fertilizer P applications to hop yards where soil test values are high have not resulted in reduced yield in the Willamette Valley. However, continued P applications where soil test P is above 30 ppm are discouraged because they may not be environmentally sound.

If soil test results indicate P is needed, incorporate it if possible. Since P is less mobile than N or K, incorporation is particularly beneficial, especially before planting a new yard. Phosphorus fertilizer recommendations for new and established yards are assumed to be the same. Apply P according to a soil test and Table 1.

Table 1.—P fertilization rates for hops.

If the soil test for P is (ppm)*	Apply this amount of phosphate (P_2O_5) (lb/a)
0–30	60–100
31–60	0–60
over 60	0

*Soil test using Bray and Kurtz P1 (ammonium fluoride) extracting solution.

Potassium (K)

Hops take up 80–150 lb K/a. Approximately one-fourth of the K is found in the cones, the remainder in vines and leaves. Potassium in vines is readily recycled when vines are returned to the yard.

Willamette Valley hop yard surface soil test K values generally are high. When soil test K values are above 200 ppm, hop tissue K levels do not increase as soil test K increases on upland soils such as Woodburn. For these soils, K fertilization is recommended when soil test K is below 200 ppm. Use column A in Table 2 to determine the K fertilization rate. Surface soil test K may need to be higher for hop yards on bottomland soils such as Newberg or Chehalis. Application rates are given in columns B and C of Table 2.

Table 2.—Potassium fertilizer recommendations for hops based on a soil test using ammonium acetate extracting solution.

If the soil test for K is (ppm)	Apply this amount of potash (K_2O) (lb/a)		
	(A)[1]	(B)[2]	(C)[3]
0–100	80–120	20	160
101–200	0–80	80–120	120–160
over 200	0	0–80	80–120

[1]Use fertilization rates in column A for silty soils such as Amity or Woodburn.

[2]Use column B for sandy soils such as Newberg without gravel layers.

[3]Use column C for Newberg or Chehalis soils with gravel layers.

Figure 3 illustrates the use of information gathered from deep soil samples in hop fertilization. Hops growing in an Amity soil where 200 ppm soil test K is present in the surface foot of soil had an August petiole K concentration of 5.2 percent. In contrast, hops growing in a Newberg soil with 375 ppm soil test K in the surface foot of soil had an August petiole K concentration of 4.53 percent.

The variation in petiole K concentration is explained by the subsoil K soil test value. In the Amity soil, soil test K values are about 200 ppm throughout the soil profile. Soil test K values in the Newberg soil are high in the surface foot but decrease to below 100 ppm at the 3-foot depth.

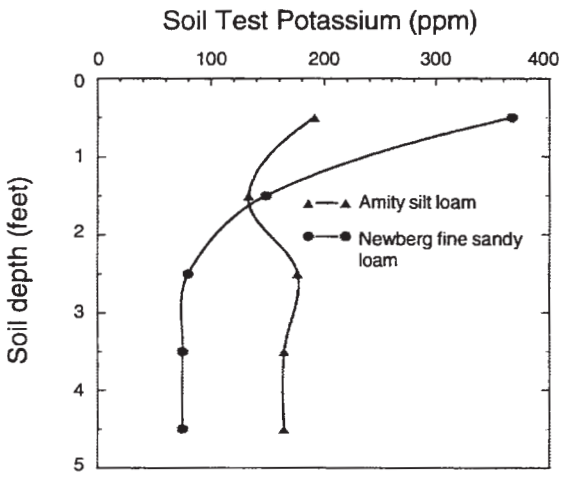

Figure 3.—Soil K with depth for two contrasting soils. August hop petiole K for the Amity silt loam soil was 5.20 percent compared to 4.53 percent for the Newberg fine sandy loam soil with a gravelly subsoil.

Subsoil K influences petiole K concentration, and soil test information from the subsoil can be used to determine K fertilization. When surface and subsoil K soil test values are above 200 ppm, no K fertilizer is recommended as shown in Table 2.

Soil pH, Calcium (Ca), Magnesium (Mg), Manganese (Mn), and Liming

The influence of surface soil pH on yields of hops, a deep-rooted crop, is unclear. Surface soil pH in Willamette Valley hop yards varies from 5.0 to 7.0. A recent survey of 20 yards showed no relation between soil pH and yield. However, a relationship between tissue manganese (Mn) and soil pH was clear. Manganese is an essential element, and like boron (B) is toxic when accumulated beyond plant needs. The hop tissue Mn levels found in the yards sampled were not considered to be toxic but increased as soil pH decreased. Decreasing tissue Mn is one reason for maintaining soil pH above 5.7 for hop production.

If the soil pH is below 5.7 or the exchangeable calcium (Ca) is below 5 meq/100 g of soil, lime is recommended. The lime requirement is determined by a second soil test, the SMP buffer or lime requirement (LR) test. Apply lime based on the SMP buffer in Table 3. Lime is most effective when mixed into the soil. This can be accomplished prior to establishment of the yard or during annual cultivation. A lime application will be effective for several years and can be made in either the spring or fall. When the SMP buffer soil test is 5.7 or below, apply lime over a 2-year period. If soil test magnesium (Mg) is below 1 meq/100 g, consider applying 1 ton dolomite/a. No lime is required if the soil pH is above 6.5.

Table 3.—Lime recommendations for hops based on the SMP (Shoemaker, McLean, and Pratt) buffer soil test for lime requirement.

If the SMP buffer test for lime is	Apply this amount of lime (t/a)
under 5.7	over 3*
5.8–6.1	2–3
6.2–6.5	1–2
over 6.5	0

*See your local Extension agent or lime dealer.

Lime rates are in 100-score lime and calibrated for western Oregon conditions by Peterson (see "For More Information" section).

Sulfur (S)

Sulfur deficiencies are noted throughout Oregon, and sulfur applications are recommended for optimum production of most crops. No reliable soil test exists for prediction of S levels in hops. Based on the response of S application on other crops and on grower experience, annual applications of 30–40 lb S/a are recommended.

Boron (B)

In western Oregon, several crops respond to boron applications when soil test levels are sufficiently low. Various broadleaf crops, including tree fruits, have shown growth and yield increases in response to applications of boron. Literature from the hop-growing areas of Washington, western Europe, and New Zealand indicate a response to the addition of boron to hop plants. In western Oregon, boron applications are recommended on hop yards where soil test values for boron are 1.5 ppm or below. Since plant damage may occur if excessive amounts or concentrations are applied, broadcast boron on the hop yard (Table 4).

Table 4.—B fertilizer recommendations for hops based on a soil test using hot water as an extractant.

If the soil test for B is (ppm)	Apply this amount of B (lb/a)
under 1.5	1–1.5
over 1.5	0

Zinc (Zn)

Hop plants require zinc for optimum growth and cone production. However, most Willamette Valley soils have adequate levels for proper plant development without zinc fertilization. Zinc deficiency symptoms were common in Yakima Valley hop yards until growers initiated Zn fertilization programs. Soil pH in the Yakima Valley is higher than in the Willamette Valley. High soil pH, above 7.5, is associated with Zn deficiencies.

No critical soil test zinc levels have been determined for hops in the Willamette Valley, and no response to applied Zn would be expected. Zinc deficiency in hops will show symptoms similar to a viral disease. Most crops show no increase in growth or yield from Zn fertilizer applications when the DTPA extractable Zn soil test level is above 1 ppm (Table 5).

Table 5.—Zinc fertilizer recommendations based on a DTPA extract.

If the soil test for Zn is (ppm)	Apply this amount of Zn (lb/a)
under 1	10–12 broadcast or 3–4 banded
over 1	0

Acknowledgment

Soil and tissue data supplied by Marvin Kauffman, agronomic consultant, were used in preparation of this fertilizer guide. Without Marvin's generosity, the guide would not contain detailed information in several sections. The authors thank Marvin for his contribution to the Oregon hop industry.

For More Information

How to Take a Soil Sample ... and Why, EC 628, by E.H. Gardner (revised 1997). No charge.

A List of Analytical Laboratories Serving Oregon, EM 8677, by J. Hart (revised 1997). No charge.

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