NUTRIENT MANAGEMENT guide

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Hybrid Seed Carrot

(Central Oregon)

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Central Oregon is the primary U.S. hybrid carrot seed production area, supplying seed to the domestic fresh market carrot industry. Approximately 85 percent of the hybrid carrot seed planted in the United States is grown in Jefferson and adjoining counties. The Madras and Culver areas support most of the carrot seed production. The production area is situated at an elevation of 2,000 to 2,500 feet on the east side of the Cascade Mountain Range.

The environment created by this setting—low rainfall and humidity, cool nights, and moderate summer temperature—is favorable for carrot and other seed production. An additional benefit to carrot seed production is the absence of wild carrot, which can contaminate seed crops through cross-pollination.

Production of hybrid Nantes-type seed carrots predominates, with limited acreage of hybrid Imperator-type grown. About 20 percent of the seed production is from open-pollinated varieties.

Seed carrots are grown in relatively shallow, well-drained, light to moderate soil, generally clay loam, loam, silt loam, and some sandy loam textural classes. Slightly more than half the acreage is irrigated by sprinkler, the rest by furrow or drip systems. Production on rolling topography was limited until the introduction of drip irrigation. Drip irrigation allows adequate water to be provided without runoff and erosion.

Recommendations in this guide apply to stands established from seed or steckling (transplanted roots). Most fields are established by seeding in August with 10 to 12 live seeds/ft row, with rows on 30-inch centers. The stand is thinned to two to three plants/ft.

Management practices from seedbed preparation to harvest must be performed in an appropriate and timely manner for optimum carrot seed yield. Fertilizer is not a substitute for failure to promptly diagnose and treat root rots, overirrigation, poor stand establishment, mechanical damage from cultivation, inadequate weed control, or reduced stand density from winter-kill. These problems can be significant limiting factors to obtaining high seed yields. Increasing fertilizer rates or adding nutrients already in adequate supply will not correct or overcome these limiting factors and may decrease seed yield.

Nutrient management can be addressed by answering the following questions.

- How much fertilizer should be applied?
- When should the material be applied?
- How should the material be applied?
- What material should be used?

This guide answers questions about nitrogen rate and timing based on research from 1999 to 2003. Other nutrient uptake was also measured, but application rates of other nutrients were not part of the research.

This publication is not designed to answer all questions about nutrient application. It assembles current information so growers and field representatives can consider nutrient application in terms of why a nutrient should be applied and what will be gained from the application. Use the information along with knowledge of site characteristics such as soil, microclimate, and variety being grown, to create a site- and year-specific nutrient management plan for carrot seed production in central Oregon.

Yield, growth, and nutrient accumulation

Hybrid carrot seed yield is low, typically less than 500 lb/a (Table 1), but it is worth $8 to $15/lb to the grower. Small changes in yield substantially change income.

Table 1.—Average carrot seed yields for central Oregon.

Year	Hybrid (lb/a)	Open pollinated (lb/a)
1997	405	974
1998	274	652
1999	388	799
2000	328	833
2001	322	450

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Higher seed yields do not require greater amounts of nutrients than recommended in this guide. For example, Table 2 shows that increasing seed yield above 500 lb/a produces very little increase in the amount of nutrients in the seed. The carrot plant contains sufficient nutrients to produce a seed yield higher than 500 lb/a without additional nutrients. Most likely, some factor other than nutrient supply limits yield to the 500 to 600 lb/a range.

Table 2.—Nutrient content of carrot seed.

	Amount of nutrients in seed (lb/a)	
Nutrient	**500 lb seed**	**100 additional lb seed**
Nitrogen	17.5	3.5
Phosphorus	3.5	0.7
Potassium	10	2
Sulfur	1	0.2
Calcium	7	1.4
Magnesium	3	0.6
Boron	0.02	0.004
Zinc	0.03	0.006
Manganese	0.05	0.01

Nutrient uptake presented in this publication was measured on commercial Nantes-type seed carrot fields near Madras, Oregon, during 2001 and 2002. The research on the influence of nitrogen rate on seed yield was performed in a commercial Nantes-type carrot seed field in 2003.

Figures 1–4 show time of plant use or demand for a nutrient. For each nutrient, three graphs are stacked on a common horizontal axis. Biomass accumulation, or growth, is shown in the upper graph; seasonal uptake, or accumulation, of nitrogen (N), phosphorus (P), potassium (K), or sulfur (S) is presented in the middle graph; and daily uptake is found in the lower graph.

Look closely at differences. Graphs for various elements may look the same since the growth, or biomass, is always on the upper graph. However, the numbers on the vertical axis, which show the amount of material in the aboveground portion of the carrot seed crop, vary significantly from one element to another.

Dates are the same on all graphs. The most useful information for nutrient management is the time of peak, or maximum, uptake and the date when accumulation of a nutrient slows or is nearly complete.

Seed carrots grow slowly in the fall and spring, producing only 500 to 1,000 lb biomass/a by late April or early May (Figure 1, top graph). From early to mid-June through mid- to late July, growth is rapid and linear, accounting for two-thirds to three-fourths of the total biomass. Peak biomass production of 150 to 200 lb/a/day occurs in the last week of June or first week of July. Growth of carrots for seed production slows in July after seed set. Less than 20 percent of the biomass is produced after late July.

Nitrogen

The amount of nitrogen (N) taken up by carrots grown for seed depends on variety and primarily is a function of biomass produced. Total N uptake was approximately 175 lb N/a during the 2000–2001 growing season and about 225 lb/a in the 2001–2002 growing season. The difference in nitrogen accumulation can be attributed to a varietal difference between years and production of more biomass, or plant material, in 2001–2002.

N accumulation is rapid during May and June and is essentially complete by early August, 5 to 6 weeks before harvest (Figure 1, middle graph).

Peak N uptake of 2.5 to 3.5 lb/a/day occurred in mid- to late June in both years. The peak N uptake rate occurs as bloom is beginning and before bees are placed in the field, usually during the third week of June, when day length is longest (Figure 1, bottom graph). The maximum biomass production was estimated to occur 1 to 2 weeks after the maximum rate of N accumulation was achieved.

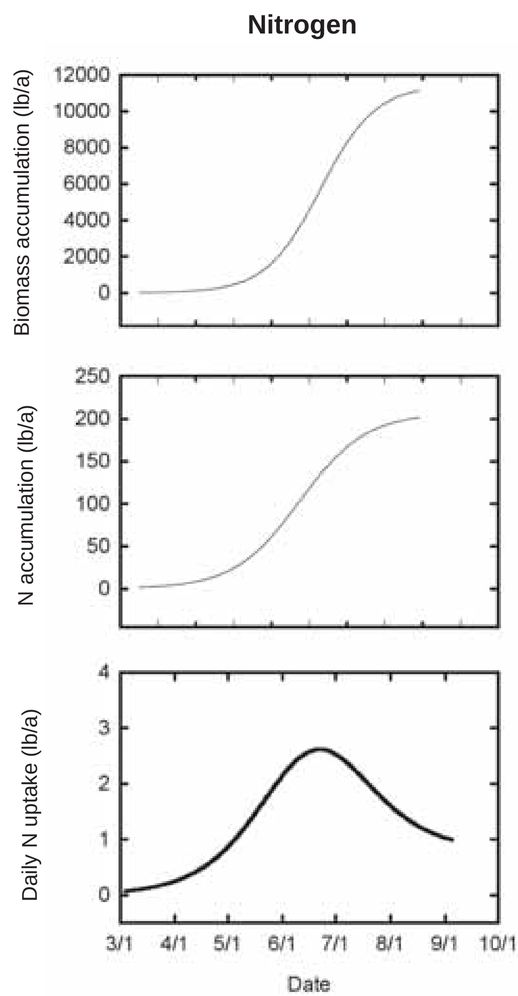

Figure 1.—Biomass accumulation (top), seasonal nitrogen accumulation (middle), and daily nitrogen uptake (bottom).

Management

Nitrogen is needed for carrot seed production and has been credited with both increasing and decreasing seed yield. The seed yield increase from a nitrogen application resulted after a nitrogen deficiency was corrected. When nitrogen supply is adequate and additional nitrogen is supplied, carrot seed yield will decrease, as shown in Table 3.

Table 3.—Influence of nitrogen fertilizer rates on Nantes-type hybrid carrot seed yield in a commercial field near Madras, Oregon, 2003.

N rate (lb/a)	Seed yield (lb/a)
0	223
50	331
90	242

Seed size and umbel position

Production of a uniform product is a challenge for fresh market carrot growers. Carrots typically produce variable root sizes and weights. This variation is associated with plant size and vigor at germination. Plant vigor at germination is linked in turn to seed characteristics, including seed size and maturity at harvest. The umbel from which seed was produced determines many seed characteristics. The primary, or king, umbel produces seeds that generally are larger than seed produced by secondary or tertiary umbels.

Primary umbel seed production should be maximized in order to obtain seed that germinates rapidly and uniformly and minimizes variation in harvestable root size. Increasing planting density from 0.5 to 1 plant/sq ft increases the proportion of seed produced on primary umbels. Low seeding rates or plant density increases seed production on secondary umbels.

A small nonreplicated sample in 2003 indicated that nitrogen rate influenced the 1,000-seed weight in the primary umbel. As N rate increased from 0 to 50 to 75 lb/a, 1000-seed weight of primary umbel seed also increased. Primary umbel seed weight declined with the addition of nitrogen above 75 lb/a, the same pattern seen with total seed yield. No change was measured for 1,000-seed weight from secondary and tertiary umbels.

The measurements made in 2003 generated speculation that excess fertilizer nitrogen stimulates seed carrots to increase secondary and tertiary umbels. As more umbels are produced and fill, 1,000-seed weight, or seed size, for primary umbel seeds decreases as competition for resources, probably carbohydrates, increases.

Apply some N in mid- to late April to support early growth. The bulk of the N is accumulated during June. Nitrogen should be supplied well in advance of need, early to mid-May at the latest.

If sufficient nutrients are supplied during the early growing season, late-season applications are not efficient or effective. Nitrogen uptake decreases rapidly in late June. After seed set occurs in July, the crop enters a phase of growth marked by redistribution of nutrients rather than nutrient accumulation.

Table 4 provides a ledger approach to crop N needs and soil supply. A combination of available soil and fertilizer N totaling 175 to 225 lb/a should be adequate.

Table 4.—A ledger approach to carrot seed N supply in 2003.

System component	Amount of N (lb/a)	Range (lb/a)
Crop use	175	175 to 225
In crop on May 1	-25	25 to 50
Amount needed for rest of season	150	150 to 175
Amount available in soil on May 1	-50	50 to 100
Amount needed for rest of season	100	50 to 125
From spring fertilizer application	-50	50 to 75
Balance needed—supplied by decomposing crop residue	50	50 to 100

Seed carrots grown in central Oregon often are planted in fields following grass seed production. Decomposition of perennial grass sod provides substantial N to a following crop. Crops following perennial grass typically receive 50 to 100 lb N/a from the decomposing grass roots. Although a carrot seed crop uses 200 lb N/a or more, it may require application of half that amount, or even less, when following grass seed production.

Apply 50 to 75 lb N/a when carrots grown for seed follow rough or Kentucky bluegrass. Adjust the N rate for variation in biomass of the seed carrot crop. Varieties producing low biomass amount should need only 50 lb N/a. Varieties producing high amounts of biomass can benefit from 75 lb N/a. Check with the seed contractor for characteristics of the specific variety to be grown.

The “Balance needed” by the carrot crop in Table 4 should easily be supplied by decomposing grass roots. However, the amount of N supplied by the previous crop is difficult to estimate. A site- and year-specific test to predict the amount of N needed for a spring application for carrot seed production is desirable.

To support the data in Table 4, measurements of aboveground N accumulation and soil test measurements were used. Based on samples from 2001 and 2002, between 175 and 225 lb/a nitrogen are found in mature carrot plants. The carrots grown in 2003 were similar to the type accumulating only 175 lb N/a.

The surface foot of soil was sampled in early May. Data from nutrient accumulation measurements were used to estimate the amount of N in the crop when the soil was sampled. The previous crop was roughstalk bluegrass.

In 2003, a replicated farm-scale nitrogen rate trial was performed. Application of 50 lb N/a produced significantly more carrot seed than application of 0 or 90 lb N/a (Table 3). For most crops, 50 lb N/a is a low application rate and would not be sufficient for optimum yield.

Table 3 demonstrates the need for a low rate of N and the detrimental impact from overapplication of N. The addition of only 15 to 40 lb N/a above the amount needed for maximum yield reduced yield by 89 lb/a, which would have cost the producer approximately $800/a.

Verification that a low rate of N is appropriate was found in the remainder of the commercial field. Approximately 15 acres received 75 lb N/a and produced a seed yield of 328 lb/a, similar to the 50 lb N/a application.

Using ammonium-N and nitrate-N soil tests

Many approaches are used to estimate soil test inorganic nitrogen, nitrate-N (NO_3-N) and ammonium-N (NH_4-N). Time and depth of sampling are considered as well as recent fertilizer additions. For the ledger example in Table 4, a soil sample was taken from the surface foot in early May and analyzed for ammonium and nitrate-N, the crop-available forms of nitrogen.

After possible winter movement and before spring fertilizer application, soil test nitrate-N is unlikely to change as a result of factors other than crop uptake. The key assumptions are that the field will not lose nitrate-N and that all nitrate-N will be used by the crop. Another assumption is that irrigation is adequate but not excessive, so leaching loss of nitrate-N does not occur.

Soil test nitrate-N from the plot area in the nitrogen rate study was 10 ppm. To convert this expression to pounds of nitrogen per acre, a soil density of 1.32 g/cc was assumed (weight of 1 acre-foot of soil was assumed to be approximately 3,600,000 pounds). To estimate the amount of nitrate-N available for the crop in pounds per acre, multiply ppm nitrate-N from the soil test by 3.6:

Soil test nitrate-N x 3.6 = lb/a plant-available N
10 x 3.6 = 36 lb N/a

One different assumption is used for calculating the ammonium-N contribution. Crops don't use all of the ammonium-N measured in a soil test. A small amount, 4 to 5 ppm, is not available for crop use. The ammonium-N soil test for the field in which the nitrogen rate plots were located was 9 ppm.

(Soil test ammonium-N - amount crops unable to use) x 3.6 = lb/a plant-available N
(9 - 5 = 4) x 3.6 = 14 lb/a plant-available N

The combination of available nitrogen from nitrate and ammonium forms is (36 + 14 = 50 lb/a), the amount used in line 4 of the nitrogen ledger (Table 4).

Phosphorus

The amount of phosphorus in mature carrot plants is less than one-quarter the amount of nitrogen or potassium, 25 to 30 lb/a (60 to 70 lb P_2O_5). Phosphorus uptake follows biomass production. Peak or maximum uptake occurs about the third week in June (Figure 2, bottom graph).

Olsen extractable phosphorus soil test values in seed carrot fields usually are between 25 and 50 ppm. A typical P soil test would be 35 ppm and is double the amount normally considered adequate. Phosphorus fertilizer is not recommended for alfalfa and peppermint grown in the same geographic area when the soil test is above 15 ppm. For carrot seed production, broadcast and incorporate P before planting (50 to 100 lb P_2O_5/a) if the P soil test is below 20 ppm.

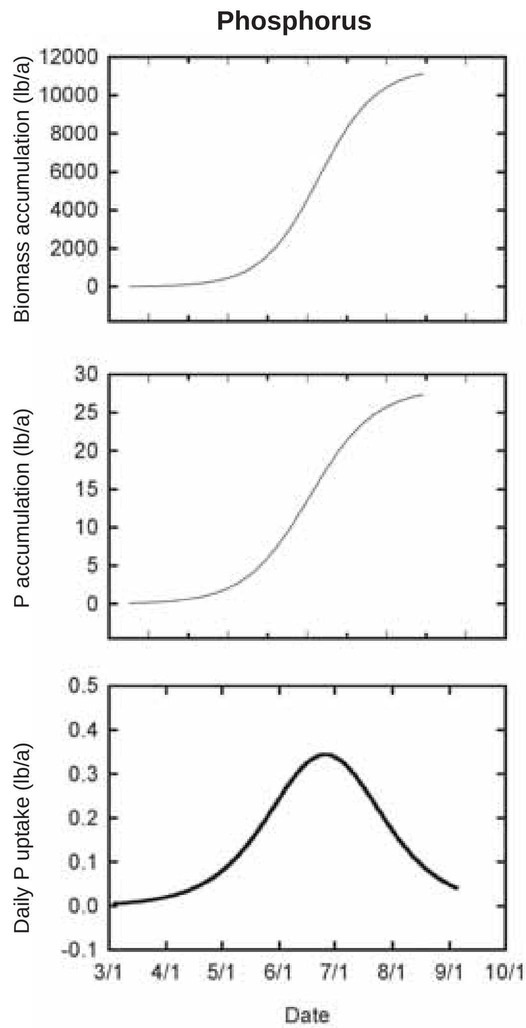

Figure 2.—Biomass accumulation (top), seasonal phosphorus accumulation (middle), and daily phosphorus uptake (bottom).

Potassium

Total potassium uptake for seed carrots is 150 to 200 lb/a, and the maximum uptake rate is 3 lb K/a/day, slightly higher than the maximum N uptake rate. Potassium uptake is rapid during May and June, reaching a maximum in early June, and is essentially complete by mid-July, 200 days after January 1 (Figure 3, bottom graph).

Potassium uptake precedes growth and slightly precedes N accumulation. Little potassium is removed in seed—10 lb in 500 lb seed, about half as much as the amount of nitrogen removed. Although the crop uses substantial K (150 to 200 lb/a), most of the K is recycled and readily available to the next crop.

Potassium soil test level needed for carrot seed production in central Oregon has not been studied. Ammonium acetate extractable potassium soil test levels usually are between 150 and 300 ppm. A soil test K level of 200 ppm is sufficient for peppermint, a crop using similar amounts of potassium and grown in the same area.

Potassium fertilizer rates for peppermint are suggested for use in carrot seed production (Table 5). Shallow soil (12 to 24 inches deep) increases nutrient demand, but should not require more potassium than that recommended for peppermint.

You can incorporate potassium during seedbed preparation or sidedress it in the spring. Banded K rates typically are 20 to 40 lb K_2O/a. If the K soil test is low and more than 40 lb K_2O/a is desired, apply most of the material before planting.

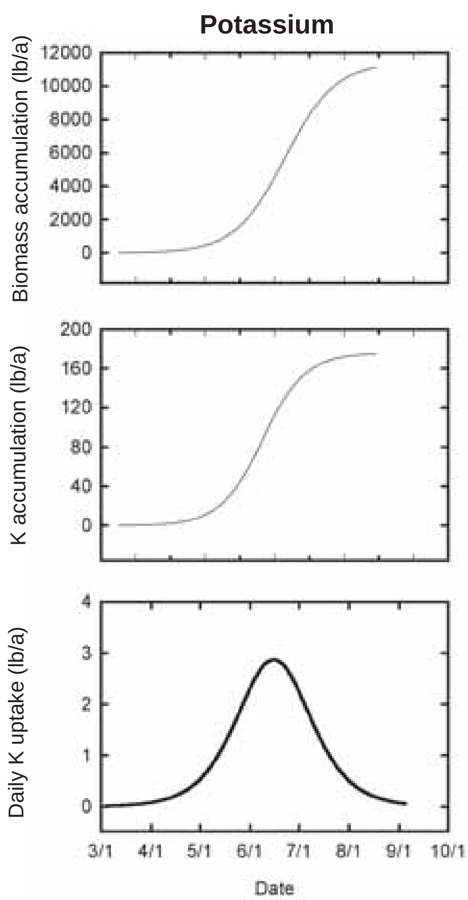

Figure 3.—Biomass accumulation (top), seasonal potassium accumulation (middle), and daily potassium uptake (bottom).

Table 5.—Fertilizer potassium rates for peppermint and carrot in central Oregon using the ammonium acetate extractable soil test.

Potassium soil test (ppm)	Amount to apply (lb K_2O/a)
0 to 100	120 to 200
101 to 200	60 to 120
Above 200	0

Sulfur

The amount of sulfur in the aboveground portion of a mature carrot seed crop is similar to the amount of phosphorus (25 to 35 lb/a). Sulfur accumulation parallels biomass production. The maximum uptake rate occurs during the third week in June (Figure 4, bottom graph).

Annual sulfur application may not be necessary. For many crops, application in 3 of 4 years or every other year is sufficient. Application of 15 to 25 lb/a sulfur in the sulfate form meets the needs of most crops. Sulfur can be applied in the spring.

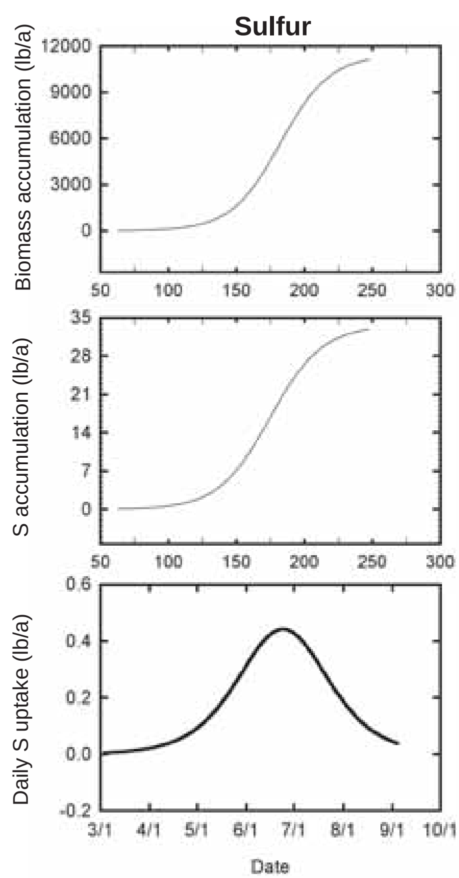

Figure 4.—Biomass accumulation (top), seasonal sulfur accumulation (middle), and daily sulfur uptake (bottom).

Carrot Seed Nutrient Management Calendar

AUGUST	Preplant soil test for pH, P, K, and S and application of nutrients as indicated by soil test.
APRIL	Ensure adequate nitrogen is available for early growth. Nitrogen uptake accelerates in early May.
JUNE	Peak nitrogen uptake occurs during June, as 2 to 3 lb/a/day is used for the month. The highest uptake rate is in mid-June. N uptake decreases after flowering/seed set. No nitrogen application is necessary after early June.

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