# GROWING CARROTS FOR MARKET AND MANUFACTURE

Extension Circular 517
(Revision of Circular 363)

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April 1948



**Federal Cooperative Extension Service**
**Oregon State College**
**Corvallis**

Cooperative Extension Work in Agriculture and Home Economics
Wm. A. Schoenfeld, Director
Oregon State College and United States Department of Agriculture Cooperating
Printed and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914

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Carrots have become an increasingly consumed article of food in recent years. The acreage of carrots as a truck crop for shipment has increased from 9,770 acres in 1923 to 43,500 acres in 1939 and 80,670 acres in 1946. Much of this change has been due to an increase in shipments of bunched carrots grown in southern states. Carlot shipments of carrots have increased from 1,773 cars in 1921 to 27,796 cars in 1945.

Statistics regarding the acreage of carrots grown for processing in the United States are not available, but the pack of canned carrots has increased from 239,930 cases in 1931 to 3,417,502 cases in 1946. The above figures do not include diced carrots mixed and canned with peas.

Oregon began canning carrots in 1919 with a pack of 2,650 cases, which had increased in 1926 and 1927 to over 100,000 cases. In 1930, 137,137 cases were canned. Then followed a period of five years of a low pack which did not in any one year exceed 86,000 cases. In 1936 the canned production reached 139,172 cases, 291,166 cases in 1937, and 789,716 cases in 1946.

Oregon packs by far the largest amount of carrots canned in the West, which packs about one-third to one-quarter of the national total.

Carrots are frozen to some extent but represent the smallest commercial frozen item in the vegetable pack. The Oregon-Washington figures of 1945 indicate 2,056,000 pounds of carrots were frozen, and peas and carrots together represented 2,874,000 pounds. The total frozen pack of carrots for the U.S. was approximately 6,051,000 pounds in 1945 and 5,322,000 pounds of peas and carrots.

Several thousand cases of carrot juice are packed each year in Oregon.

Carrots are a good source of vitamins A, B and C, as well as being fairly rich in carbohydrates. Experiments in Iowa indicate that the cortex or outer portion of the carrot is richer in sugar and food value than the core, and that the outside skin is the richest of all parts of the root in vitamin B. The vitamin A value of mature carrots has been found to be twice that of young carrots.

Climatic and Soil Conditions. The carrot prefers moderately cool conditions for its best development, although the young plants will thrive during the warm weather of the summer. By far the greatest development of the roots takes place during the months of September and October, following the occurrence of fall rains.

The normal rainfall of western Oregon is usually insufficient to induce a maximum yield of carrots without irrigation unless the crop is planted on soil that is unusually retentive of moisture. Continuous rain coupled with warm weather in the fall may cause considerable cracking of roots, especially in fields where there was no irrigation. The root is hardy to light fall frosts but must be protected when the weather shows several degrees below freezing for a continuous period. The average freezing point of topped carrots in storage is 29.6° F.

Carrots grow well on almost any kind of soil which is in reasonably good physical condition, but the heaviest yields of the smoothest roots are obtained from sandy and silt loam soils and organic lands. The roots are smoother and more symmetrical when grown in a loose soil. Organic soils are highly retentive of moisture, so it is possible to grow a large tonnage of carrots on them without irrigation. On sandy and silt loam land irrigation is desirable to provide a uniform degree of moisture for the entire growing season. It is especially important that the land be reasonably free from weeds. However, oil spraying is now counteracting the influence of weeds on the young carrot plants.

The Influence of Environment on Plant and Varietal Characteristics. In Miscellaneous Publication 361, of the U. S. Department of Agriculture, regarding "Descriptions of Types of Principal American Varieties of Orange-Fleshed Carrots," considerable data are presented regarding the influence of temperature and soil on the characteristics of the carrot plant and root.

Of particular interest is the influence of temperature upon maximum root development and growth, which probably occurs between 65 and 70° F. or several degrees lower than the optimum for foliage growth.

In addition to hereditary factors that may cause branched or forked roots, there are a number of environmental factors that have a marked influence on the shape of carrot roots. The presence of undecayed manure or plant refuse in the soil results in branching or divided roots, and soils of heavy texture produce more misshaped roots than those of a lighter or more open texture. Branched or forked roots may also be caused by an injury to the young tap root or by any impediment to its downward growth. In the case of Red-core Chantenay, low soil moisture and low soil phosphorus resulted in roots being more pointed than where optimum amounts were supplied.

The root shape of carrots seems to be affected to a considerable degree by air temperature. The typical shape of the Red-core Chantenay variety is most readily produced when the roots are grown at a constant temperature of approximately 65° F. When grown at a mean temperature of approximately 55°, the roots have been longer and more slender, and when grown at approximately 75° they were shorter and less slender. Although Nantes is a longer, more slender and nearly cylindrically shaped variety, the temperature has essentially the same effect as on Chantenay.

The smoothness of the root surface is influenced greatly by environmental conditions. Excessive moisture following a period of water shortage may frequently result in white corky outgrowths at the points of side root emergence.

There is also considerable influence of environment on the color of carrots. By means of chemical methods it is possible accurately to determine the effect of different growth conditions on the carrot root color. The total color as measured by the carotene content is in general decreased by continuous temperatures above

70° F. and below 60°. Roots grown at a mean temperature of 55° had less total color than those grown at 65° and the exterior color of the roots was much lighter. Growing the plants at a mean temperature of about 45° after the roots had started to enlarge resulted in still poorer total color. Cool nights, 45°, and warm days, 65°, resulted in a better color than continuous growth at 45°.

Carrots grown on sandy soils or soils high in organic matter seem to be of better color than those grown on a silt loam soil.

In a soil of moderate fertility, an increase in the amount of different plant food elements failed to increase appreciably the color of the roots. Varying amounts of a 4-12-4 fertilizer had no material influence on color, nor did the addition of a mixture composed of boric acid, manganese sulfate, copper sulfate, barium chloride, potassium iodide, and zinc sulfate, nor 800 pounds per acre of fertilizers varying widely in percentages of nitrogen, phosphoric acid and potash.

Development of Shape and Color of Carrot Roots. The carrot root as it increases in age and size changes in color from a yellowish-white when very young to whitish-yellow, light yellow, dark yellow, and orange, according to the variety. These changes in color are due to the accumulation of carotene which appears in varying intensities, producing the orange or orange-red color.

In fairly uniform strains the larger roots usually have a higher concentration of carotene than the smaller roots of the same age, while in mixed stocks the larger roots are liable to be lighter colored. In uniform strains the smaller, old roots usually have more carotene than younger roots which are larger.

Carotene is first laid down in the oldest cells of the cortex and then in the oldest cells of the core. The rate of increase in color depends to some extent on moisture and temperature but usually increases most rapidly during the early part of the plant growth. It is not known how long the increase in carotene will continue under optimum conditions, but records have shown that it increased up to 142 days of age in the Red-core Chantenay variety.

The increase in diameter of the carrot is most rapid at the top or crown of the root and as the plant becomes older, the lower portion of the root increases in diameter in varieties where this change is characteristic.

In tests of eating quality, sugar content and color intensity, data of the New York Experiment Station indicate superiority of "old" or fully grown carrots over young bunched carrots. Carrots delivered to processing plants are, therefore, most likely to be fully equal if not superior to bunched young roots.

Soil Fertilization and Preparation. Unless the manure is well rotted and the weed seeds are rotted out of it, it is not advisable to use barnyard manure previous to sowing carrot seed. It would be preferable to use such material for a crop the previous year. Many of the commercial soils used in growing carrots are high in organic matter, hence no added manure is necessary. In the case of sandy loam soil, the turning under of green manures would be advantageous in providing organic matter.

The crop is one which removes a considerable amount of potash from the soil. In a 20-ton crop of roots, figures indicate removal of 90 pounds of nitrogen, 50 pounds of phosphoric acid, and 200 pounds of potash. If a commercial fertilizer is used, therefore, it should be one which carries a moderately high per cent of potash

as well as a reasonable ratio of nitrogen and phosphoric acid. A fertilizer having a ratio of 1-3-3 should be suitable for this crop. Such a fertilizer might have an analysis of four per cent nitrogen, 12 per cent phosphorus, and 12 per cent potassium, of which 500 pounds and upward might be broadcasted per acre. This application would be considered as being a trial one, to indicate the effect of the fertilizer on the ensuing crop.

It seems desirable, also, to apply some commercial borax to carrot land to aid in preventing internal blackening or breakdown. A minimum of thirty pounds per acre may be mixed with the commercial fertilizer used for the crop and applied in the manner discussed below. (See also paragraph under Crop Disorders.)

There are two alternative methods of applying such a fertilizer — one, broadcasting it before planting, the other being a side dressing of the fertilizer in a band alongside the rows after the plants can be seen. The latter method would reduce the amount of fertilizer necessary by possibly 50 per cent.

Carrots are not very tolerant of an acid soil and grow best in a pH range of between 6.0 and 6.5.

A well prepared seedbed is necessary for the sowing of carrot seed for the seeds are small and the seedlings are comparatively weak. It is necessary, therefore, to have a soil that is loose and friable, which will not crust after a rain. Previous to seeding, the soil should have such plowing and disking followed by harrowing and leveling so as to be in fine mellow condition for a good seedbed. If the land is to be irrigated, it will have to be properly leveled for the passage of water from the main ditch to the ends of the rows. This will be unnecessary in the case of water being distributed by overhead sprinkling.

Varieties, Seed Strains and Seeds. The most widely grown variety of carrots for processing purposes is the Red-core Chantenay. This variety is characterized by a medium long root that tapers slowly from the neck downward, terminating abruptly at the bottom, being what is known as half long, thick and stump rooted. The roots should be deep reddish orange, 5-1/2 to 6 inches long, about 2-1/4 inches thick at the shoulder, tapering but stump rooted. The core is a reddish orange, almost the same color as the flesh, and quite inconspicuous, which is desirable in a carrot for canning or freezing.

Nantes is a variety having a cylindrically shaped root of even diameter from neck to base. Roots are 5 to 6 inches long. Core is small and inconspicuous. End of root is blunt. The flesh is of a deep orange color and of fine texture and flavor.

For the open market, long, smooth, tapering roots such as of Imperator and Morse's Bunching are preferred. Nantes is also popular, especially for a prepackaged offering.

Fresh seed is desirable for planting carrots for it does not have a long viability. The grower should know something about the germination of the seed before planting so as to adjust the number of pounds of seed sown accordingly. The amount of seed used per acre varies from 2 to 4 pounds, depending upon the size of carrots desired and the distance between rows. Planting at a distance of 20-inch rows and growing carrots for slicing or dicing purposes, three pounds of seed are desirable to make a uniform stand with no thinning necessary. The amount of seed used will

also be dependent upon the type of soil. Where the soil is loose and readily penetrated by roots, a thicker seeding can be used than when the soil is heavier, for the roots can then not shove out toward the sides of the rows. Some growers plant in rows 24 inches apart, but if the land is heavier and apt to be weedy, the distance between rows may be wider. Some plantings of market carrots are spaced 18 inches between rows.

Most of the planting for carrots grown for canning or freezing in western Oregon is done between April 20 and the first week of two in May but plantings may be made up to June 15 if there is plenty of moisture available and deliveries can be made later in the season. Market carrots are planted as early in the spring as soil and weather conditions are favorable. Storage carrots are usually planted in the late spring.

Maintenance. The work of eliminating weeds is one of the most important items in growing carrots. In recent years this has been accomplished very largely by applying oil to the carrot fields when the plants and weeds are quite small. In a survey of operations of some 31 carrot growers in 1946, it was found that the cost of weeding the carrot field was over twice as great where weeding with oil was not carried on. The cost of oil weeding in general was found to be about $6.00 per acre. The number of applications of oil varied from one to two times. About 45 gallons of oil were used at one application. According to Circular of Information No. 424, growers who oiled their fields weeded them for about one-half the cost of those not using oil.

Cultivation between the rows is done mainly for the purpose of keeping the soil in good physical condition, for weed elimination, and for possible control of moisture.

Irrigation is especially desirable for carrots in providing a uniform amount of moisture during the growing season, inducing a steady growth of the plants and roots, increasing yields, and making it possible for the roots to reach the best size for harvesting at the proper season. There is also less danger of the roots cracking in the fall when the rains begin if the roots have been irrigated. In Oregon Experiment Station Circular of Information No. 424, the total irrigation costs per acre were cited as $16.30. These costs were for sprinkler irrigation in the Willamette Valley.

Insect Pests, Diseases, and Miscellaneous Crop Troubles. Among the crop disorders of carrots are maggots, nematodes, soft rot, blackening or breakdown, as well as gophers and moles.

The carrot rust fly maggot which has spread considerably in western Oregon in recent years is one of the newest insects to affect this crop. Apparently 3 per cent DDT applied to the young carrot seedlings has given fair control. DDT applied also in the seed row has given promise of control.

Nematodes are microscopic eel-like worms that are persistent in the soil and are easily spread. The small nodule-like galls made by the nematodes are visible on the fine roots issuing from the main carrot root. Soils known to produce carrots with nematodes on them should not be planted the next year to a crop susceptible to this worm.

The cause of soft rot which induces a complete collapse of the carrot is not yet known.

There have been some outbreaks of internal blackening of carrot roots, which in certain fields has done much damage. Compared with the widespread study and knowledge of the breakdown of other kind of roots, such as beets, little is known at the present time concerning this blackening of carrot roots. However, it would seem desirable that 30 to 40 pounds of commercial borax be applied per acre in conjunction with the usual fertilizing program for the crop.

Gophers and moles are controlled in the usual manner, either by poisoning or trapping, as the case may be.

Harvesting, Yields and Costs. Bunch carrots are harvested when they have attained a desirable size. The tops are usually held together by "Twistems." The number of roots in a bunch depends on the size of the carrots. The standard pack of carrots with tops attached in a lettuce crate is 5 to 5½ dozen bunches. U. S. Standards for marketing bunch carrots or carrots with short-trimmed tops are available from the State Department of Agriculture, Salem, Oregon.

There is a trend in some areas to package carrots with the tops removed and placing the roots in a transparent semi-moistureproof container. Seemingly there are at least two benefits of such a procedure: (1) The elimination of the cost of shipping the green tops, and (2) the lengthening of the shelf life of the packaged carrots, which has been demonstrated to be longer than that of unpackaged roots with the tops attached. U. S. Standards for topped carrots are obtainable from the State Department of Agriculture, Salem, Oregon.

The harvesting of carrots for processing extends over a considerable period of time, usually beginning when the cannery or freezing plant can handle the roots, which is commonly about the first of October. The season of harvesting roots may extend well into the later portion of the year. U. S. Standards for carrots for processing are contained in a leaflet obtainable from the State Department of Agriculture, Salem, Oregon.

Yields of carrots are determined largely by the stand of plants, amount of soil fertility and moisture and freedom from crop disorders. The average planting will produce about 20 to 25 tons per acre but it is not uncommon for certain fields to produce 40 tons or more.

Costs of producing carrots, mainly for processing, are summarized in Circular of Information No. 424, Oregon Experiment Station. The data in this publication indicate a total cost per acre of $214.80 for the 31 growers interviewed, or a cost per ton of $13.30.

Growers who produced high yields per acre grew a ton of carrots much more economically than "low-yield" growers.

Considering pre-harvest and harvest costs, labor expenses accounted for 60 per cent of the total cost of growing and harvesting an acre of carrots.

## Useful References

Descriptions of Types of Principal American Varieties of Orange-Fleshed Carrots. U. S. D. A. Misc. Publ. No. 361.

Davis, G. B. and Mumford, D. C., Cost of Producing Carrots in the Willamette Valley, Oregon. Oregon Experiment Station Circular of Information No. 424, 1948.