Commercial Production and Management of Carrots

Theodore Mcavoy, Assistant Professor & Vegetable Production Extension Specialist; Emphasis: Vegetable production

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Edited by William Terry Kelley, Former Extension Horticulturist
Greg MacDonald
Sharad C. Phatak

Foreword

This publication is the result of a joint effort among the seven disciplines in the University of Georgia College of Agriculture and Environmental Sciences that serve the Georgia carrot industry. It is the most comprehensive production guide for carrots in Georgia ever assembled. The 13 topics covered in this bulletin are all integral parts of a successful carrot management program. Each topic is designed to focus on a particular aspect of production and provide the latest management technology for that phase of production. It is hoped that the information contained in this publication will assist growers in improving profitability in carrot production. Chemical pest control recommendations are subject to change from year to year and thus, only general pest control guidelines are mentioned in this publication. Growers are urged to consult the current Georgia Pest Management Handbook or check with their local county extension agent regarding the most recent chemical recommendations. Mention of trade names in this publication is not an endorsement of a particular product nor a lack of endorsement for similar products not mentioned.

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History, Uses and Botanical Classification and Development

William Terry Kelley, Darbie M. Granberry, George E. Boyhan and Sharad C. Phatak - Extension Horticulturists

Carrot production in Georgia is a relatively new industry. Commercial production was extremely sparse until the early 1990s with only a handful of acres, mostly grown for the processing market. The original areas of production centered around Macon and Colquitt Counties. Fresh market production in Georgia originated primarily in Pierce County. Production then spread to areas in Wayne, Brantley, Coffee and Jeff Davis Counties and is still active in most of these counties. Today interest in both fresh market and processing carrots extends through-out the lower two thirds of the state.

Carrot (*Daucus carota* var. *sativus*) is a member of the Umbelliferae family. Other vegetable crops and herbs in this family include celery, parsnip, parsley, dill, caraway, anise, coriander and fennel. Domestic carrots may have evolved from a wild form similar to its relative known in North America as Queen Anne's Lace. The family name comes from the flower form, which is an umbel. Characteristic of most of the family's plants, an umbel has individual flower stalks originating from the same point on the stem.

Carrots probably originated in Asia around northwest India. Cultivation of carrots for medicinal purposes began 2000 to 3000 years ago. They were used for a myriad of medicinal purposes including stomach ulcers, abscesses, bladder, liver and kidney problems, to aid in childbirth and even as aphrodisiacs. Cultivation of roots for consumption dates back to 600 A.D. when purple root types were grown in the area currently known as Afghanistan.

Yellow types were eventually selected and produced in Syria and Iran in the ninth or tenth century. Carrots were introduced to China by the thirteenth century and cultivation spread from the Middle East to Italy, Spain and throughout Europe by the fourteenth century. Eventually, white and orange types were selected. Orange types, first grown in the Netherlands during the seventeenth century, were brought to North America by early settlers. The root was popular with Native Americans and production currently exists worldwide.

One of the reasons production is so widespread is that carrots are the major single source of Vitamin A in the diets of many cultures. They are also a good source of other vitamins, minerals and fiber. Carrots are produced for a variety of uses. Fresh market production for retail sales is still an important market. Fresh packed articles include peeled baby carrots, carrot sticks, shredded carrots and salad mixes. Processing markets include baby food production, frozen and canned products. Carrots are popular as snack foods, for deli trays, in salads, cooked in casseroles, as main vegetable dishes as well as numerous other culinary creations.

Carrot varieties produced in the United States are biennial in nature, requiring two full seasons from germination to seed production. However, it is grown commercially as an annual for its large storage root produced during the first year. True annual forms of the crop also exist but are not produced in the United States. Young carrots are characterized by a tight rosette of finely serrated leaves and a slender tap root with fine fibrous side roots. As the tap root enlarges and reaches maturity, the conductive tissue is distinguished as a light-colored core (xylem) and the deeper orange cortex (phloem).

Carrot Cultural Management

William Terry Kelley, George E. Boyhan, Darbie M. Granberry and Sharad C. Phatak - Extension Horticulturists

Climatic Requirements

Small carrot seedlings up to six leaves cannot with-stand hard freezes but are somewhat frost tolerant. Optimum temperatures are in the range of 60-70 degrees F, with daytime highs of 75 degrees F and nighttime lows of 55 degrees F ideal. Although the crop can be grown outside this range with little or no effect on tops, temperatures differing drastically from the above can adversely affect root color, texture, flavor and shape. Lower temperatures from this range may induce slow growth and make roots longer, more slender and lighter in color. Carrots with a root less than one inch in diameter are more susceptible to cold injury than larger roots.

Hot, sunny days can injure or kill young plants. Long periods of hot weather may depress carrot yields, cause strong terpinoid flavor and bitter taste in roots, and result in atypically short and blunt roots. Disease pressure also increases as temperatures warm in late spring and summer. Carrots need an ample supply of moisture from rainfall and/or irrigation throughout the growing season since they are not drought tolerant. A consistent moisture supply helps keep the crop growing and reduces the incidence of splitting from growth flushes.

Although technically biennial in nature, carrots can produce seedstems prematurely in Georgia. This is commonly known as bolting. Most carrot production in Georgia occurs during the fall months, through winter and into spring. Cool winter months followed by increasing daylength in spring can result in carrots being exposed to conditions that induce flowering. Flower induction in carrots requires a period of six to eight weeks of temperatures below 50 degrees F. Increasing daylength accelerates flower induction. Once flowering is initiated, the seedstalk elongates rapidly, particularly as temperatures increase. Although fall heat at planting is not injurious if they are well watered, carrots will tend to produce a higher percentage of seed stems as spring warming turns into summer heat. Carrots that have produced seed stems are not marketable.

Planting and Spacing

Carrots are exclusively direct-seeded. Most carrots in Georgia are planted from August 15 through October 31. Carrots produced in north Georgia would require a spring planting date. Spring plantings in south Georgia have not proven to be as successful as fall plantings. However, spring dates from early January through early February in south Georgia and late February through March in north Georgia would be appropriate. Plantings in August will require frequent irrigation during periods of hot, dry weather. Ideal planting conditions are more prevalent from late August to late October. Plantings from November to mid December have been successful; however, the risk of freeze damage to later planted carrots increases as planting dates are delayed. Carrots planted in August through December will be harvested in December through May in most years.

Spatial arrangements for planting can differ, although basic spacing is the same in each scenario. Carrots can be successfully planted with vacuum, belt or plate seeders. Often a special attachment called a scatter plate or spreader shoe is added to the plate planters to scatter the seed in a narrow band. Ideal patterns are twin rows that are 2.5-3.5 inches apart. Three or four of these twin rows are situated on one bed, depending on the width of the bed. One arrangement is to plant three twin rows on beds that are on 72-inch centers. The other arrangement currently used is to plant four twin rows on a 92-inch bed (center to center). The sets of twin rows are 14 to 18 inches apart. Beds on 72-inch centers will have approximately 48 inches of formed bed. Row spacing wider than 18 inches will reduce total plant stand per acre and thus, will reduce total yield. Ideal plant populations should be in the range of 450,000 for fresh market carrots and 300,000 for processing carrots. Beds that are slightly raised are advantageous because they allow for good drainage.

Other arrangements for planting may be adapted and work equally as well. High density arrangements with rows in sets of three (instead of two) are also used. In this arrangement, carrots are seeded in six sets of triplet rows with approximately two to three inches between rows in the triplet set. There is also minimal space between the sets -- around four inches. This arrangement is planted without raised beds, and the rows are almost continuous with no distinguishable break except the width of the tractor tire. The population density of this arrangement will be considerably higher than the other arrangements described. Disadvantages of high density plantings can include producing fewer jumbo carrots and lack of airflow through the field that can increase the incidence of foliar diseases. Also, planting without slightly raised beds is only recommended on very light and extremely well-drained soils.

Carrots should be spaced 1.5 to 2 inches apart within the row. Carrot seed should be planted no deeper than 1/4-1/2 inch. A final stand of 14 to 18 plants per foot of twin row is ideal. Beds should be firmed and not freshly tilled before planting, and soil should be firmed over the seed at planting. A basket or roller attachment is often used to firm the soil over the seed as they are planted. Seeds should be planted one-quarter to one-half inch deep. Light irrigation will be required frequently during warm, dry periods for adequate germination.

Windbreaks are almost essential in areas with primarily sandy soils. Sand particles moved by wind can sever young carrot plants, severely reducing stand. Small grain strips planted between beds or at least planted between every few beds can help reduce this sandblasting injury.

Variety Selection

William Terry Kelley and Sharad C. Phatak - Extension Horticulturists

There are four basic types of carrot cultivars that are generally distinguished by the shape of the root. Within each type there are many different varieties to select from. The carrot root consists of the phloem (or cortex) and the xylem (or core). More desirable varieties have a thicker phloem and a minimum of xylem. The phloem is deeper orange and flavorful. The xylem tends to be paler, tasteless and woody.

Taper-Rooted or Pointed

These roots decrease gradually in diameter from crown to tip and taper to a point. The Danvers and Imperator types of carrots fall into this category.

Danvers varieties are classified as half long and taper slightly in a conical shape from 2 to 2.5 inches in diameter at the crown to a length of 6 to 7 inches at maturity. Danvers carrots are deep orange with a light center. They have excellent quality early but can become fibrous with age.

Imperator varieties are probably the most widely grown fresh market type. They have a long tapered tip from a shoulder diameter of 1.5 to 2 inches to a length of 7 to 12 inches. Imperator types have deep orange phloem and light orange xylem and can become woody at full maturity. Young roots have excellent quality, however.

Stump-Rooted or Blunt

As in the taper rooted types this root type also tapers from crown to tip but the tip is blunt instead of pointed. The Chantenay types belong to this group.

Chantenay carrots are 2 to 2.5 inches in diameter at the crown and have a short, conical shape. These roots are shorter than Imperator or Danvers types, growing to a length of 4.5 to 5.5 inches with a medium to large neck. Chantenay types have medium to light orange phloem with a light to red core. Since they have coarse texture in raw form and produce a relatively small amount of waste they are popular as processing carrots and are the most widely grown.

Cylindrical

This type vary little from crown to tip and are somewhat blunt at the tip. Nantes type carrots are defined by this group. Most home garden cultivars are of this type. As per the name of the type these carrots are virtually cylindrical in shape. They have a blunt end with a shoulder diameter of 1.5 inches and a length of 6 to 7 inches. The thick phloem is bright orange and the xylem is often hardly noticeable. They have little top growth but excellent quality.

Ball-Shaped

Among this type of carrots are both round and stump-rooted varieties. The Amsterdam types have roots 0.5 to 0.75 inches in diameter and 2.5 to 3 inches long. Many are used for baby carrots, mixed vegetables and freezing. The more round shaped varieties, which are about 1.5 inches in diameter and length, perform well in heavy soils. They are best when harvested before full maturity and must be hilled to prevent green shoulders.

Variety Selection Criteria

Commercially grown carrot varieties in Georgia are generally of the Imperator type. Numerous commercial varieties exist, however, there are vast differences in performance of varieties over varying environmental conditions. Qualities that are important for commercial carrot production include yield, color, top growth, core diameter, length and uniformity. Top growth and low bolting are critical for carrots grown during fall and winter in Georgia.

Although yield is an important criteria, it should not be the only selection criteria. Good top growth is essential since most mechanical harvesters utilize the tops to extract carrots from the soil. Rich orange color and a small diameter core are essential fresh market characteristics. Acceptable length, uniformity and maturity are also important for packing efficiency and maximum yield. Certainly good flavor and high sugar content are desirable characteristics and are a marketing point with Georgia carrots. However, flavor is not always the most important factor in variety selection as visual appearance, yield and harvesting and packing factors often take priority. Basically a variety must be adaptable to the area, produce a competitive yield and be acceptable to buyers. Although disease resistance is not a major factor in carrot varieties, as resistant varieties are developed, this should be considered as well. Listed below are several varieties that have been tried in Georgia and have proven to be acceptable regarding these characteristics.

Commercial Carrot Varieties for Georgia					
Variety	**Source**	**Maturity**	**Use**	**Length**	**Tops**
Varieties for full-season production					
Apache	SunSeeds	Medium	Fresh	10"	mod strong
Choctaw	SunSeeds	Medium	Fresh/Proc	10"	strong
Navajo	SunSeeds	Medium	Fresh	9"	strong
Cheyenne	SunSeeds	Medium	Fresh	8-10"	strong
Varieties for production only through mid-March					
Indiana	Bejo	Med-Late	Fresh/Proc	10"	mod strong

Commercial Carrot Varieties for Georgia					
Six Pak	Harris Moran	Early-Med	Fresh	7-8"	strong
Topnotch (XPH 3918)	Asgrow	Medium	Fresh	8-10"	mod strong
Vita Sweet 691	Abbot & Cobb	Early	Fresh	9-10"	strong

Soil and Nutrition Management

William Terry Kelley, Sharad C. Phatak, Darbie M. Granberry and George E. Boyhan - Extension Horticulturists

Soil Requirements

Muck soils or loose, friable sandy loam soils are ideal for carrot production. Although heavier soils are not ideal, carrots can successfully be grown on heavy-textured soils under irrigated conditions. Short, blunt types are often grown on heavier soils. Sandy loam soils allow proper growth and development of a long, smooth, straight root. Soils cannot have excessive stones, pebbles and debris since this can cause forked or misshapen roots. Soils should also be well drained as carrots will not perform well under water-logged conditions. Sites should be selected that have loose, friable soils to a depth of 12-14 inches without pebbles. Deep sandy soils can also be used although they may require more frequent irrigation. Drain tiles should be installed on flatwood type soils that are subject to water-logged conditions. Preparing high beds to avoid wet conditions in these soils is not recommended since under drier circumstances these beds will dry out and cause damage to carrot tops and shoulders.

Land Preparation

Proper land preparation should begin by deep turning soils to bury any litter and debris and breaking soils to a depth of 12-14 inches. Compacted soils or those with tillage pans can benefit from subsoiling to break the compacted areas. If uncorrected, compact soil or tillage pans can result in restriction of root expansion. It is best to apply lime after deep turning to prevent turning up acid soil after lime application. After turning, mark beds using tractor tracks. Prepare a good seedbed using bed-shaping equipment. Do not use disks or rototiller to avoid soil compaction. Carrots in Georgia should be planted on a slightly raised bed (2-3 inches) to improve drainage. After beds are tilled and prepared for seeding, it is best to allow the beds to settle slightly before planting. Avoid other tillage practices that can increase soil compaction.

Following in the same tracks for all field operations will help reduce compaction in planting areas.

Fertilization and Nutrition Management

Carrot fertilization is one of the most critical components of successful production. Carrots have a medium requirement for nitrogen, however, timing of applications is just as critical as amount of fertilizer used. Carrots require a pH of between 6.0 and 6.5 for optimum growth. Acquire soil test recommendations several months prior to planting in order to make needed lime applications two to three months in advance of planting. If soil tests indicate magnesium is required use dolomitic lime.

Apply potassium and phosphorous according to soil test results. Recommendations for potassium and phosphorous based on various soil test indices are shown in Table 1. Apply one-third to one-half of potassium and all phosphorous banded in the width of the bed and incorporated prior to planting. The remaining potassium should be applied in two to three sidedress applications. Apply 1 pound of boron and 10 pounds of sulfur per acre. If soil test zinc is low, apply 5 pounds of actual zinc per acre.

Nitrogen requirements for carrots will be from 90 to 120 pounds per acre. **It is imperative that nitrogen be applied in small quantities.** These spoon fed applications allow the crop to better utilize nitrogen and helps to prevent splitting from growth spurts. Incorporate one-sixth to one-fourth of the recommended nitrogen into the bed prior to planting. Apply remaining nitrogen in four to six sidedress applications. Never apply more than 15 pounds of nitrogen per acre at any one time. Additional applications may be necessary if leaching rains occur. Since carrots may remain in the field from 110 to 130 days, nitrogen applications should be spread out over the length of the growing season by making applications every two to three weeks, depending on rainfall. Applications through pivot irrigation can be used when wet conditions prevent tractor operations. This can also reduce field traffic and thus compaction.

Calcium, boron and magnesium should be applied according to soil test recommendations. However, the use of foliar applications of these nutrients may be beneficial to maintain proper growth. Two to four applications of two quarts of CAB (or similar material) beginning with the first sidedressing and 3-5 pounds of $MgSO_4$ along with the first sidedressing can be beneficial.

Although plant tissue analysis is a good tool to use in all vegetable crops, in carrots it is almost essential. Since winter weather conditions often make scheduled fertilizer applications difficult, the use of tissue analysis to keep track of nutritional status can help avoid problems before they become yield limiting. Proper levels of various nutrients at different stages of growth are shown in **Table 2**. See your county agent or crop consultant regarding proper techniques for tissue sampling and availability of laboratories that provide routine tissue analysis.

Table 1. Recommended rates of Phosphorus and Potassium in pounds per acre for carrots based on soil test ratings.

Phosphorus Rating	**PotassiumRating**			
	Low	**Medium**	**High**	**Very High**
	(Pounds of N-P_2O_5-K_2O per acre)			
Low	*-150-150	*-150-120	*-150-60	*-150-30
Medium	*-100-150	*-100-120	*-100-60	*-100-30
High	*-50-150	*-50-120	*-50-60	*-50-30

Table 1. Recommended rates of Phosphorus and Potassium in pounds per acre for carrots based on soil test ratings.				
Very High	*-0-150	*-0-120	*-0-60	*-0-30
* Recommendations for nitrogen: Coastal Plain - 9-120 pounds per acre Piedmont, Mountain and Limestone Valley - 80-100 pounds per acre				

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Table 2. Plant tissue analysis standards by nutrient for carrots based on stage of growth.											
Status	**N**	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**B**	**Cu**
	%						**ppm**				
0-60 days after seeding											
Deficient	2.5	0.4	4.0	3.5	0.5	0.4	60	100	60	40	10
> 60 days after seeding											
Deficient	2.5	0.4	4.0	1.5	0.5	na	60	100	60	40	10
Adapted from *Carrot Production in Florida*. Publication HS 722, a chapter of the *Vegetable Production Guide for Florida,* SP 170. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. July, 1995.											

Disease Management

David B. Langston, Jr. - Extension Plant Pathologist

Disease management in carrot production is necessary to produce high yields of high quality carrots. The major concern is the production of a disease-free and cosmetically clean carrot root. The main problems associated with carrot production are root-knot nematodes and diseases caused by fungi and bacteria. Carrots should be planted in well-drained, litter-free, deep turned soils. Certain crops like tobacco should be avoided because of the slow decomposition of the crop stubble. Also, nematode control in tobacco stubble is difficult to achieve because nematodes can withstand treatment as they are embedded in the root system and may not be exposed to the fumigant. Several root diseases will be discussed in this section.

Also, certain foliage diseases can affect carrots. In most cases, these never require any type of fungicide or bactericide application. However, under certain weather conditions, fungicide applications may be necessary. Basically, adequate fungicides and bactericides for managing the above ground diseases are available.

Root-Knot Nematode

Figure 1. Root-knot galling.

By far, the most destructive problem is root-knot nematodes caused by *Meloidogne* sp. Root-knot nematodes are small eel-like worms that live in the soil and feed on plant roots. Since the root of the carrot is the harvested portion of the plant, no root-knot damage can be allowed. Root-knot causes poor growth and distorted or deformed root systems, which results in a non marketable root. Root-knot damage also allows entry for other diseases such as *Fusarium, Pythium,* and *Erwinia*. (Figure 1)

Soil assay is the best way to determine the numbers and kinds of nematodes to be dealt with in carrot production. A nematode assay should be made during the months of July, August, or September, depending on the current crop. Nematode populations are usually at a peak at about crop maturity. Thus, the most accurate numbers can be obtained during this period. If any root-knot nematodes are found, treatment is recommended. Good success has been obtained using field soil fumigation to eradicate root-knot nematodes in the root zone of carrots.

Soil-Borne Root Diseases

Depending on the cropping history of the field, *Pythium, Southern Blight* and *Sclerotinia* may cause problems. It is advisable to avoid fields where these diseases have been identified in the previous crop. Deep turning is also necessary to help prevent root diseases.

Pythium Blight

Pythium Blight is usually characterized by flagging foliage indicating some root damage is occurring. Under wet conditions, *Pythium* may cause serious problems to the root causing a white mycelium mat to grow on the infected area that rapidly turns to a watery soft rot. Forking of the root system is also a common symptom associated with *Pythium* infection. Pythium is probably the most isolated disease associated with carrot production in Georgia. Rotation is considered a major factor in reducing *Pythium* along with the use of fungicides. (Figures 2, 3)

Figure 2. Root forking caused by *Pythium*. Photo courtesy of J.O. Strandberg, Univ. Fla.

Figure 3. Stumping caused by *Pythium*. Photo courtesy of J.O. Sandberg, Univ. Fla.

Southern Blight

Southern blight is caused by the fungus *Sclerotium rolfsii* and can cause serious damage to carrots. This disease is usually associated with carrots remaining in the field after the soil begins to warm in the spring. This disease causes a yellow top to develop with a cottony white fungal growth associated with the upper part of the carrot root. The top of the root and the surrounding soil may be covered with a white mycelium with tan sclerotia developing as the disease progresses. Southern Blight is best controlled by using rotation and deep turning. (Figures 4, 5)

Figure 4. Above ground symptoms and signs of infection caused by *Schlerotium rolfsii*. Photo courtesy of J.O. Strandberg, Univ. Fla.

Figure 5. White mycelium of *Schlerotium rolfsii* on carrots. Photo courtesy of J.O. Strandberg,

Univ. Fla.

Sclerotinia Blight

Sclerotinia blight is caused by the fungus *Sclerotinia sclerotiorum* and can cause serious damage to the roots of carrots. This disease is usually worse under wet soil conditions. This is the same disease that causes the familiar raisin head in cabbage. White mycelium forms around the infected area and, later, dark sclerotia develop on the white mycelium, which is a good indicator of *Sclerotinia* rot. This disease causes a progressive watery soft rot of the carrot root tissue and is considered a potential problem in the production of carrots. Rotation and deep turning of the soil are recommended to reduce losses to this disease.

Rhizoctonia

This disease is caused by *Rhizoctonia* species and is associated with the carrot root. It causes brown to black lesions to develop on the sides of the carrot root. The disease is much worse under cool, wet conditions. Saturated soil conditions often enhance all soil-borne diseases, which are potential problems in carrot production. Rhizoctonia damage can be minimized by using rotation and good cultural practices. Soil fumigation will prevent damage with any of the soil inhabiting fungi, however soil fumigation is expensive and cultural practices may be used to reduce the injury without the expense of fumigation. (Figure 6)

Figure 6. Symptoms caused by Rhizoctonia. Photo courtesy of J.O. Strandberg, Univ. Fla.

Foiliar Diseases

Bacterial Blight

Bacterial Blight caused by the bacterium *Xanthomonas carotae* causes irregular brown spots on the leaves and dark brown streaks on the petioles and stems. The lesions on the foliage begin as small yellow areas with the centers becoming dry and brittle, with an irregular halo. The bacterium affects the leaflets, stems and petioles as the disease progresses. Some of these lesions may crack open and ooze the bacteria. These bacteria may be washed down to the crown of the plant causing brown lesions on the top of the root. The earlier the infection the more damage to the root. The bacterium is spread by splashing water and takes about 10-12 days before symptoms appear after inoculation. The bacterium progresses rapidly between 77 degrees and 86 degrees F. Rotation is a major factor in controlling Bacterial Blight. (Figures 7, 8)

Figure 7. Foliar symptoms caused by *Xanthomonas carota*. Photo courtesy of J.O. Strandberg, Univ. Fla.

Figure 8. A comparison of symptoms caused by *Alternaria dauci* (right) and *Xanthomonas carota* (left). Photo courtesy of J.O. Strandberg, Univ. Fla.

Alternaria Blight

Alternaria blight is caused by the fungus *Alternaria dauci.* This disease causes small dark brown to black spots with yellow edges forming mostly on the leaf margins. The spot increases as the disease progresses and in some cases entire leaflets may be killed. In moist weather, the disease can move so rapidly it resembles frost injury. Such conditions can reduce the efficiency of mechanical harvesters which require strong healthy tops to remove the carrot from the soil. *Alternaria* may also cause damping off of seedlings and a black decay of roots. The spores and mycelium are spread by splashing rains, contaminated soil, or on cultivation tools. The disease can manifest itself in about 10 days after infection. The optimum temperature for *Alternaria* blight is 82 degrees F. (Figure 9)

Figure 9. *Alternaria dauci* on seedling carrots. Photo courtesy of J.O. Sandberg, Univ. Fla.

Cercospora Leaf Blight

Cercospora blight is caused by the fungus *Cercosproa carotae*. This disease causes lesions to form on the leaves, petioles and stems of the carrot plant. The symptoms appear to mimic that of *Alternaria* blight but can be separated using a compound microscope. *Cercosproa* blight progresses in warm, wet weather and spots appear in about 10 days after infection. The youngest leaves are usually more susceptible to *Cercosproa* infection.

Insects

David B. Adams - Extension Entomologist

Carrots are subject to attack by numerous insect pests. Fortunately, in Georgia, many pest populations are not present or do not develop to economically damaging levels during the major production window from fall to spring. Soil insects, if present, may damage the roots and should be controlled with cultural practices and incorporation of soil insecticide. Some fumigants may provide some control of soil insects. Other pests that primarily attack the foliage can be monitored and treated as needed with foliar insecticides.

Soil Insects

Wireworms, mostly *Conoderus* spp., white grubs, *Phyllophagus* spp., and the granulate cutworm, Feltia subterranea, may be partially controlled with good cultural practices. Soil should be deep turned in sufficient time prior to planting to allow destruction of previous crop residue that may harbor soil insects. When possible, avoid planting just after crops slow to decompose, such as tobacco and corn. Avoid planting behind peanuts and root crops such as sweet potatoes and turnips. If a field has a history of soil insect problems, either avoid these or broadcast incorporate a soil insecticide prior to planting. Plantings in fields recently in permanent pasture should be avoided as should fields recently planted to sod/turf, although these are not as critical. Fields with a history of whitefringed beetle larvae, *Graphognathus* spp., should not be planted to carrots because there are no currently registered insecticides effective on this pest. (Figures 10, 11, 12, 13)

Figure 10.

Figure 11.

Figure 12.

Figure 13.

Flea beetle larvae, *Systena* spp., can damage roots by feeding on the surface too the cortex. The damage will take on the appearance of narrow s-shaped canals on the surface. Flea beetle larvae can be prevented easily with soil insecticides.

The seedcorn maggot, *Hylemya platura,* is an opportunistic pest that takes advantage of crops that are under stress or where there is decaying organic matter. Plants may be considered under stress for several reasons such as freeze damage, nutritional deficiencies, herbicide injury, drought, wind and sand injury and diseases to mention a few. At-planting soil insecticides will prevent the development of maggot infestations for several weeks after planting, however, as residues decrease late season infestations may develop, especially from late January through April. Seedcorn maggots cannot be effectively controlled after the infestation begins. If plants become stressed during the period of high root maggot potential, preventive applications of insecticides should be sprayed every seven days until the stress is minimized. (Figure 14)

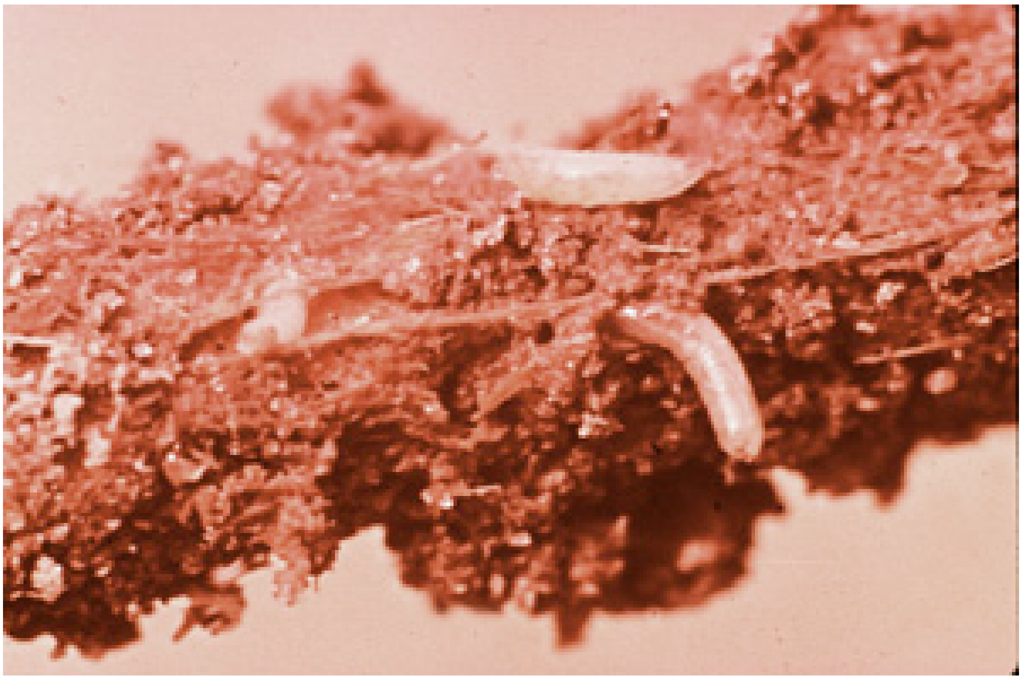

Figure 14.

Foliar Insects

Foliar insect pests may be monitored and insecticides applied as needed. Very often carrots may be grown without the addition of any foliar insecticides. Carrots should be scouted at least once per week for developing populations of foliage pests.

Aphids

Several species of aphids may develop on carrots. The most common aphids to inhabit carrots in Georgia are the green peach aphid, *Myzus persicae* and the cotton or melon aphid, *Aphis gossypii*. Both of these aphids may infest carrots in the fall after other cultivated hosts, such as cotton and vegetables, are harvested. There are no treatment thresholds for making control decisions. Often parasitic wasps and fungal diseases will control these aphids. If populations persist and colonize plants rapidly over several weeks and honeydew or sooty mold is observed readily, then foliar insecticides are justified.

Flea Beetles

Fleas beetle adults, *Systena* spp., may cause severe damage to the foliage on occasion. If carrots are attacked during the seedling stage and infestations persist over time, an insecticide application may be necessary. Minor feeding is no cause for alarm. If plants are in the cotyledon to first true leaf stage, treatments should be made if damage or flea beetles are observed on more than 5 per-cent of the plants. After plants are well established, flea beetles should be controlled only if foliage losses are projected to be moderate to high, e.g., 15 percent or more.

Vegetable Weevil

The adult and larvae of the vegetable weevil, *Listroderes difficilis,* may attack carrots from late December through April. They are most prevalent from late January through early April. The adult and larvae feed on the foliage. Vegetable weevil larvae often will feed near the crown of plants and, if shoulders are exposed at the soil surface, larvae will feed on tender carrots. Treatments are justified if adults or larvae and damage are easily found in several locations. [Figures 15 (larvae),16 (adult)]

Figure 15.

Figure 16.

Armyworms

The armyworm, *Pseudaletia unipuncta,* can cause damage from late winter through spring. Armyworms may move from grain crops or weeds into carrots or adults may lay eggs directly on carrot plants. Armyworms are easily controlled with foliar insecticides. There are no action thresholds but, if foliage is excessive, an insecticide application may not be justified. (Fig. 17)

Figure 17.

Beet Armyworm

The beet armyworm, *Spodoptera exigua,* infests carrots in the late spring. Usually natural predators and especially parasites regulate beet armyworm populations below economically damaging levels.

Whiteflies

The silverleaf whitefly, *Bemesia argentifolii,* may be a problem from August through October during the early seedling stage of fall plantings. Silverleaf whitefly migrate from agronomic crops and other vegetables during the late summer. Infestation may become severe on carrots grown in these production areas. Often whiteflies may be controlled by several natural enemies and diseases by early fall so, treatments may not be justified. However, if whiteflies develop generally heavy populations, treatment on young plantings is justified. (Fig. 18)

Figure 18.

Managing Weeds in Carrots

Greg MacDonald - Extension Weed Scientist

Weed control in carrots is an essential component of producing a high-yielding and high-quality crop. Weeds compete with carrots for light, water, nutrients, and physical space. In addition, many weeds may impair the harvesting process, either through improper digging or contamination of the harvested crop. Weeds can also harbor deleterious insects and diseases. The presence of plant residue from weeds or other plants during fumigation can also decrease the effectiveness of most soil fumigation materials, thus increasing the problems associated with nematodes.

Most of the fumigants used in carrots grown in Georgia will not provide adequate weed control, therefore additional weed control measures must be employed. Carrot growers face a multitude of weed problems including both summer and winter annual broadleaf weeds and grasses. These may include sicklepod *(Cassia obtusifolia),* crabgrass *(Digitaria* spp.), pigweeds *(Amaranthus* spp.), carpetweed *(Mollugo verticillata),* lambsquarters *(Chenopodium album),* wild radish *(Raphanus raphinistrum),* cut-leaf evening primrose *(Oenthera lanceolata),* and several others.

Prevention is the first step in managing weeds in carrots. **Avoid areas that contain heavy infestations of perennial weeds such as bermudagrass and nutsedge.** Proper tillage, insect and disease control and fertility will help to ensure a healthy crop. Planting density will also allow the carrots to out-compete many weeds. Mechanical cultivation is generally not used in carrot production due to the tight row spacing (several rows on a bed). However, mechanical cultivations will help control weeds between rows particularly during early fall planting.

Chemical weed control is often used in carrot production and recommendations may be found in the most current *Georgia Pest Management Handbook.* Chemical weed control in carrots relies heavily on the herbicide linuron (Lorox, others). Linuron provides excellent control of most weeds found in carrots and is used postemergence over-the-top. Although good control of large weeds can be achieved with this product, it is critical to eliminate the weeds at an early stage to reduce the deleterious effects of competition. The lower rate should be used on smaller carrots (tops

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