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Carrot Production and Processing in Georgia

Coastal Plains Experiment Station
Tifton, Georgia

Georgia Experiment Station
Griffin, Georgia

Cooperative Extension Service

The University of Georgia
Athens, Georgia

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Georgia Sweet Carrot, Inc.
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Carrot Production and Processing in Georgia

A. Estes Reynolds, Editor

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List of Future Research Needs, etc.

Prussia et al.:

Several actions are needed to ensure that carrot marketing next year builds on the successes from this year. Expansion of the brand name and enhancement of the reputation of the cooperative depends on the delivery of shipments with consistent quality. Obtaining consistency depends on the development and following of procedures, especially for actions that do not show any results for several days. Thus, written procedures and records verifying completion of tasks are very important. Actions needed include:

1. Assign a person with responsibility for Quality Control.
2. Develop written procedures for operations as done this year with changes based on experience.
3. Develop a Quality Control Manual with sections in addition to operating procedures.
4. Obtain feed-back on marketing from the broker, customers, and consumers.
5. Improve measurement methods for quality attributes.

James Reid:

Having adequate wind breaks in the fields. Better fertility and water management to improve the production problems. Improving knowledge and experience with the planter.

Phatak et al.:

Information on **Total Carrot Production System,** including planting dates, varieties, planting densities, row spacing, rotations, and pest management will be needed. Information on marketing, packaging, developing value-added products will increase a market share of Georgia carrots.

Research needs to develop **Total Carrot Production System**

Tillage: to develop minimum-till systems
Fertility: to develop fertility program which minimizes root cracking
Planting Dates: Problems associated with planting dates will be identified and addressed. Will help to provide information on maintaining continuity of supply of carrots.
Planting Densities: Proper spacing will reduce culls and thereby increase growers margin of profits.
Row Spacing: Optimum spacing will be determined for the specific harvest equipment used by growers; this will help increase marketable yield.
Crop Rotations: Rotations are important in reducing diseases, nematodes, weeds, and insect problems; it is also important in fertility management.
Soilborne Diseases: To control the diseases.
Nematodes: alternative method of control to reduce production costs.
Variety Trials: evaluate various seeds for their adaptability.

Maw, Dales, Phatak:

It would be beneficial to determine the mass of seed that is most likely to produce a viable plant.

Carrot Production and Processing in Georgia

Executive Summary

A. Estes Reynolds
Department of Food Science and Technology
Athens, Georgia

Carrots have been successfully produced and marketed in Georgia for the past five or six years. Both fresh carrots for the retail market and processing carrots for baby food and other processed products have been produced with significant yields of over 25,000 lb per acre. Success has varied due to a variety of production and marketing problems. Information on planting dates, varieties, planting densities, row spacing, and pest management have been needed to maximize production and reduce input cost.

One essential part of carrot production and marketing is the need to define the quality standards necessary for consumer acceptance. Product physical defects can be readily measured, but the flavor and sweetness characteristics must be defined and the parameters affecting these important factors understood.

Georgia Sweet Carrots, Inc.

In the 1996-1997 production year the Georgia Sweet Carrot, Inc. formed a cooperative to produce carrots in Georgia. Approximately 400 acres were planted, and over 360 acres were harvested. The company was able to pack out about 60% of the production with returns that yielded a profit. They are planning for 800 acres for 1997-1998 and 1000 acres for 1998-1999. This production had an economic impact of $1,000,000 in 1996-1997, but should increase to $4,800,000 in 1997-1998.

The potential for producing carrots for the fresh market may be significantly influenced by actions taken in Florida to return 18,000 acres of muck land to wildlife. This area currently is used for carrot production and represents 8% of the U.S. carrots produced. The 1997-1998 production year will be the last year this land is available for carrot production. The total U.S. carrot production is valued at $311 million. Georgia farmers can capture 10% of this market over the next 10 years, with potential yearly increases of $1,000,000. This was demonstrated by the present Georgia Sweet Carrot Cooperative's success in the first year, marketing over $500,000 in carrots. The current study's results indicate that the Georgia carrots were preferred by consumers over Florida carrots in all areas of acceptability, sweetness, flavor, and texture; this puts the Georgia carrot industry in a very competitive position.

Value Added Carrot Products

Value-added carrot products also have the potential for providing stability to the production of fresh market carrots. Presently 150 to 200 acres of carrots are produced in Georgia for cooked carrot products such as baby food. Carrot segments were successfully marketed by the Georgia Sweet Carrot Cooperative, Inc. in their first year of packing. Frozen processed carrots in the form of diced carrots, coins, or bits have considerable market potential in the processed vegetable market. Fresh shredded carrots, carrot sticks, small peeled carrots, segments, and match sticks are presently purchased by Georgia firms for retail sales and use in salads and fast food entrees. Processing provides a stability outlet for downgrades and physical appearance of defective products that cannot be marketed as fresh whole carrots. These product outlets provide income to increase the value of the total production, thereby making carrot production profitable.

Georgia vs Florida: Consumer Preference

Consumer preferences for carrots were studied on the Georgia varieties selected from the variety field trials and compared to market samples of Florida and California carrots. Consumers preferred the California carrots in flavor and sweetness, but two Georgia carrot varieties were comparable in flavor and quality. Georgia carrots were preferred in all measured traits over the Florida carrots, especially in flavor and sweetness. Among the Georgia carrots, 'XPH 3973' and 'VitaSweet 711' were most preferred. The 'XPH 3973' can compete with the California carrots on overall acceptability. Defining the factors that affect the flavor and sweetness of Georgia carrots is important in determining the quality standards necessary to compete in the market.

Variety Trials and Production Management Practices

The first year's variety trials provided considerable experience with carrot diseases, weed control, planting practices, germination and land preparation. Significant progress was made in understanding the optimum production practices needed for Georgia carrot production. Much additional information is needed, however, on tillage, fertility, planting dates, planting densities, row spacing, crop rotation, nematodes, and plant diseases. Several varieties are presently used, while new varieties show promise, especially in the area of yield and consumer acceptance.

Additional research is needed on a **Total Carrot Production System** to ensure that the development and production of quality carrots will be available to compete with other states in the production of this commodity. Quality control, mechanization, marketing and product development lie ahead as areas of needed research.

Carrot Production Research
And Potential for Carrot Production in Georgia

Sharad C. Phatak, Jimmy M. Hornbuckle[1] and Anthony G. Bateman
Department of Horticulture, University of Georgia Coastal Plain Experiment Station, Tifton, GA 31793-0748

Background:

In the late sixties and early seventies, extensive research on carrot production was conducted by Campbell's Soup Company at its farm in Cairo, Georgia. The objective of the research was to grow carrots for processing. Campbell's factories needed carrots during the spring, from April through June. This research information was not distributed outside of the Campbell's establishment. Thus, findings of that research were not available to others. Campbell's never produced carrots in Georgia commercially.

In October 1975, carrots were planted at the Coastal Plain Experiment Station. All cultivars planted were baby carrots. These carrot cultivars produced high quality carrots during the winter months. Due to the small size of the carrots, however, yields were less than eight tons per acre. After two to three years of research on baby carrots, it was determined that baby carrot production in Georgia was uneconomical due to lower yields. After a period of two years, Southern Frozen Food indicated an interest in processing carrots. We were able to produce carrots that met their quality requirements. However, Southern Frozen Foods decided to continue bringing carrots from Texas.

During the early nineties there was renewed interest in carrot production in Georgia. This time interest was in fresh markets as well as in processing carrots. We conducted fresh market and processing cultivar trials for three years. The carrot variety 'Choctaw' used by the Georgia growers was one of the best in our trial three years in row. It has sufficient top growth for machine harvesting, excellent internal and external color, and essentially no bolting in spring. We also conducted fertility and plant population trials, as well as many other trials, in order to develop production practices that are currently being used by the Georgia growers. These production practices need fine tuning.

Potential for Carrot Production:

Georgia is one of the five leading fresh market vegetable states. In 1994, Georgia ranked fourth in area harvested and fifth in production and value. Georgia ranks high in the production of watermelons, cabbage, onions, cantaloupes, cucumbers, etc. In 1994, California continued to lead all states in fresh market vegetables.

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[1] Carrot Research was successful because of the hard work and dedicated participation of the late Jimmy M. Hornbuckle.

In 1994, total U.S. production of carrots was $274.9 million ($274,927,000) for fresh market and $35.5 million ($35,534,000) for processing. California lead the nation in fresh market, accounting for over 66% of the value, while Washington lead the nation with over 40% of the value for processing carrots.

Soil and climatic conditions in South Georgia are ideal for the production of quality carrots. South Georgia's sandy soils are better for uniform carrot growth than heavy clay soils. During fall and winter, daytime temperatures are warmer and nights are cooler. These conditions promote sugar storage in carrots, making carrots produced in south Georgia sweeter and having better color than others grown anywhere else in the continental United States. Carrots grown in Georgia do not have a bitter taste or strong aroma. Thus, on the basis of quality we can compete with carrots from Arizona, Florida, Texas or California. Production time in other leading states, such as Michigan, Colorado, Washington, and most other states will not coincide with Georgia production. Thus, there will be no direct competition.

We have the potential for producing and marketing Georgia carrots all over the eastern United States and Canada. At present, carrots are produced in 8 to 10 Georgia counties, and the total carrot crop production in Georgia is valued at $2.5 million. Presently, Georgia growers have markets for all they are able to produce. Within the next ten years, with appropriate production and marketing strategies, Georgia can easily capture 10% of the total market, which is currently worth $311 million. According to many conservative estimates, there is a potential for $1,000,000 yearly increases in the farm value of carrots for the next 10 years. Success, however, will depend on producing and marketing quality carrots.

Georgia growers produce 150 to 200 acres of carrots for Gerber Foods. Campbell's Soup and Heinz USA are also interested in carrots from Georgia, and their representatives are watching developments in Georgia closely.

The short-term goal should be to market the best quality Georgia Carrots from mid-December through mid-June. In the future it should be possible to produce, store, and market Georgia carrots throughout the year.

Research:

To achieve these goals, information on a **Total Carrot Production System,** including planting dates, varieties, planting densities, row spacing, rotations, and pest management will be needed. At present this information has been provided by extrapolating some of the small-scale research which has been conducted at the Coastal Plain Experiment Station *off-and-on* during the past 20 years. Presently many fresh market and processing varieties suitable for Georgia climates are available. Breeders from seed companies are releasing new varieties on a regular basis. Seed companies will develop varieties for Georgia when acreage increases. Information on marketing, packaging, and research on developing value-added products will increase a market share of Georgia carrots.

Research on a limited scale may be continued with present support. Carrots are a specialty-crop and require special equipment. Research may be expanded with the financial support to purchase new equipment for planting, tillage, and harvesting. Equipment needed is available on the market and, thus, there is no need to design new equipment.

Problems for Carrot Production in Georgia

1. Lack of uniform stands.
2. Loss of stands due to seedling diseases in carrots planted during August and September.
3. Loss of stands due to sandblasting.
4. Root knot nematodes.
5. Maintaining uniform size and length.
6. Cracking of roots.
7. Southern blight (white mold) in May-June.
8. Maintaining high marketable tonnage (need 10-12 tons per acre to break even).
9. Maintaining continuity of supply from mid-December to mid-June (potential through July-end).
10. New varieties are introduced by seed companies regularly. Information of performance of these varieties under Georgia conditions is needed.
11. Losses during harvest.
12. Weed control.

An ultimate goal should be to market best quality Georgia Carrots from mid-December through mid-June (potential through July-end).

Research Needs to Develop: Total Carrot Production System

Tillage: Research will be conducted to develop minimum-till systems for carrot production. This research will help reduce stand reduction from sandblasting and cracking of roots caused by excess nitrogen and fertility imbalance. This research will increase marketable yields and increase growers' profits.

Fertility: We have a general idea of the fertility requirement of carrots. However, root cracking appears to be related to excess nitrogen and nutrient imbalance. Objectives of this research include developing a fertility program which helps minimize root cracking, probably with reduced fertilizer input. Grower profits will benefit from this research with increase in marketable yields.

Planting Dates: Carrots will be planted every two weeks beginning August 15 to determine the feasibility of maintaining continuity of supply of quality carrots from December 15 through June 15 (maybe July 15). Problems associated with planting dates will be identified, and research to solve those problems will be conducted. This research will provide information on maintaining continuity of supply of carrots from December 15 through June 15.

Planting Densities: Various spacing between rows and within rows to maximize marketable yield will be evaluated. Spacing will be adjusted according to the carrot size requirements of the market. Proper spacing will reduce culls and thereby increase growers margin of profits.

Row Spacing: Harvesting equipment varies greatly and influences row spacing. Optimum row spacing will be determined for the harvest equipment used by the growers. This research will help increase marketable yield.

Crop Rotations: Rotations are important in reducing soilborne diseases, nematodes, weeds, and insect problems. Rotations are also important in fertility management. Various crop rotations will be studied, with objectives to reduce pest-disease complex.

Soilborne Diseases: Seedling diseases (pythium, rhizoctonia) reduce stands of carrots planted during August-September. Research will be conducted to control these diseases with fungicides and rotations. Similarly, southern blight (white mold, *Sclerotium rolfsii*) causes root-rots in carrots harvested during May-June. Crop rotations and fungicides will be studied to reduce this problem.

Nematodes: Carrots are very susceptible to root-knot nematodes. Thus, management of nematodes is important for profitable carrot production. Telone is used by growers to control nematodes but it increases cost of production substantially. We plan to study crop rotations to reduce nematodes and reduce production costs.

Variety Trials: Varieties developed by seed companies and public institutions will be evaluated for their adaptability.

Georgia Sweet Carrot Project

Rick Reed, County Extension Coordinator, Coffee County

In the fall of 1995, Bill Elliott (SunTrust Bank, Vice-president and a board member of the Georgia Ag. Business Council) asked me if there were any projects or areas of growth that area growers needed assistance in pursuing. Tommy Irvin (Georgia Commissioner of Agriculture) had said this would be a good time to develop support for such an effort. Working with vegetable growers in the Coffee County area for the past 10 years, I already knew that growers were looking for a crop that could be grown during the winter growing season on irrigated land. After much work and discussion, carrots were identified as being that crop. It had already been proven that carrots could be successfully grown in south Georgia. The growers, however, had not been totally satisfied with the marketing effort.

On the evening of December 7,1995, a group of growers and agricultural leaders met in the conference room of the Coffee County Ag Center to discuss the feasibility of growing and marketing carrots in the southern region of Georgia.

After a number of grower meetings and much discussion, a group of growers from Coffee, Jeff Davis, Wayne, Tift, and, later, Bacon counties, was invited by then State Representative Van Street and then Senator Walter Ray in February of 1996 to meet with their elected state officials in the Georgia General Assembly. The proposed grower co-op was very well received, and the growers were invited to present these ideas again the next week to the House and Senate leadership and with the House Agriculture and Consumer Affairs Committee to discuss the details on funding proposals to help foster this new commercial venture to fruition.

The state, through the Ag Committee's New Crop Budget, funded the carrot harvesting and processing equipment. This money went to the University of Georgia School of Agricultural and Environmental Sciences to purchase the needed equipment. This equipment was in turn leased to the growers to help establish the Georgia Sweet Carrot Growers Cooperative. In the fall of 1996, the growers in the co-op planted their first 350-plus acres of carrots.

To aid these producers, a research team was formed to support the growers' efforts. This team was composed of University of Georgia research scientists, Cooperative Extension Service specialists, and Georgia Department of Agriculture Vegetable Marketing Division representatives. Their mission was to help growers produce, harvest, and market their carrots; to evaluate their production, harvesting, and marketing practices; and to identify areas where additional research and support were needed.

Effect of Land Preparation on Carrot Production

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Materials and Methods:

Carrots were planted September 10, 1996, on five raised beds 250 ft long using a Monosem planter with three twin-row planters set 18 in. apart with 0.54 in. (22 seed/ft) seed spacing. Three beds were tilled and allowed to sit 14 days before planting; and two beds were tilled the day of planting. The variety Choctaw was used. Following planting 10-10-10 (150 lbs/A), CAB (gallon/A), and Epson salt (magnesium sulfate, 3 lbs/A) were applied four times at two-week intervals when needed. Also, 1.5 in. irrigation was applied to maintain moisture levels during dry periods. Weeds were controlled using two applications of Lorox (1.5 lbs/A).

Samples were taken from four of the five beds from 18 ft^2 plots (6 ft wide by 3 ft long) based on a completely randomized block design with two replications. All carrots within the sampling area were used. In the lab, samples were rinsed, green tops removed, and excess water drained. They were then graded, counted, and weighed. The grades were: (marketable fruit) regular, large, and small; (unmarketable fruit) split, rot, and other. These grades were based on external appearance and size using local supermarket carrots as a standard.

The standard carrot was 9 to 10 in. long, 1 in. in diameter, orange in color, and fairly smooth. Regular carrots were equal to or exceeded the standard in length by 1 in. or diameter by 0.25 in. Large carrots were greater than the standard in length (> 1 in. but ≤ 3 in.) or diameter (≥ 0.5 in. but ≤ 1 in.). Small carrots were 2 in. less than the standard in length or 0.25 in. less in diameter. Split and rot carrots were based on physical damage. Other carrots were either too small or large, poor in color, rough, or deformed.

Refractometer readings were used to measure soluble solids. Three carrots of marketable grade from each bed, one per double row, were used in each sampling. These carrots were topped, rinsed, peeled, and 1 in. discarded from either end. The samples were then blended to a mulch and juiced using a kitchen sieve and pestle. The juice was filtered using doubled coffee filters. All sampling was done on three different dates with one week intervals between dates.

Results and Discussion:

The two methods of land preparation were chosen to decide which provided the best growth for carrots. Land tilled 14 days before planting provided a firm and compact planting surface whereas land tilled the day of planting had a fluffy unsettled surface. Analysis of data (Table 1) showed significant differences between the two methods. The number (#/A) of marketable, unmarketable, regular, small, and other carrots was significantly higher for carrots planted on land tilled 14 days before planting. The yield (lbs/A) of small,

other, and unmarketable carrots was also significantly higher for carrots planted on land tilled 14 days before planting.

There were no significant differences between the two methods for total marketable yield and soluble solids. However, land tilled 14 days before planting may be the best method for growing carrots because of the greater numbers of regular, small, and total marketable carrots.

Table 1. Yield and soluble solids in carrots produced on land tilled 14 days before planting and land tilled the day of planting.

Parameters	Land Preparation	
	Tilled 14 days before planting	**Tilled 0 days before planting**
(#/Acre)		
Regular	41140*	19763
Large	88733	76633
Small	10487*	1613
Split	403	0
Rot	0	0
Other	32670*	10890
Total marketable	60500*	29040
Total unmarketable	33073*	10890
(Lbs/A)		
Regular	14399	8611
Large	5163	5606
Small	1315*	182
Split	242	0
Rot	0	0
Other	7684*	2843
Total marketable	20877	14399
Total unmarketable	7925*	2843
(Brix)		
Percent solids	9.75	9.67

* Significantly different according to Duncan's Multiple Range Test (p=0.05).

Effect of Early Planting On Carrot Production

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Materials and Methods:

The planting, samples, standard carrot, and refractometer reading procedures and methods followed in this study were identical to those followed as stated in the study by Phatak et al., *Effect of Land Preparation on Carrot Production,* except that the carrots were planted August 20, 1996, samples were taken from two of the five beds with four replications, and for refractometer readings, three carrots of marketable grade from four of the five beds were used in each sampling.

Results and Discussion:

Three harvest dates were chosen to decide the best time to harvest. The dates were approximately one week apart except the third date, which was later due to the holidays. Data analysis (Table 1) shows significant differences among grade number (#/A) and yields (lb/A) on different dates. Soluble solids were not significantly different. The number of carrots for each grade did vary with each harvest, but the total number of marketable and unmarketable carrots was not significantly different. By grade, there were no significant differences in the number of regular, split, and other carrots; however, the number of large carrots was significantly different on the third harvest, smalls on the first and third harvest, and rots on the third harvest. The yield of regular, small, split, rot, and other carrots was not significantly different, but the yield of large carrots was on the third harvest. The total yield of marketable carrots was significantly different on the third harvest, and the total yield of unmarketable carrots was significantly different on the first and third harvest. The first harvest date seems acceptable if a greater number of smaller carrots is desired. However, if a greater number of larger carrots is desired, then the third harvest date would be more acceptable.

Table 1. Yield and soluble solids in carrots planted August 20, 1996, and harvested on three different dates.

Parameters	Harvest Dates		
	December 11, 1996	**December 17, 1996**	**January 3, 1997**
(#/Acre)			
Regular	111,925.0	102,245.0	107,690.0
Large	3,933.0	6,353.0	12,402.0*
Small	40,611.0*	34,258.0	23,595.0*
Split	3,630.0	2,117.0	3,328.0
Rot	0.0	0.0	907.5*
Other	43,182.0	41,669.0	41,443.0
Total marketable	156,468.0	142,856.0	143,687.0
Total unmarketable	46,812.0	43,787.0	45,677.0
(Lbs/A)			
Regular	25,879.0	25,349.0	29,418.0
Large	1,724.2	3,115.7	6,609.6*
Small	2,659.4	2,457.7	1,714.1
Split	741.1	620.1	1,421.7
Rot	0.0	0.0	175.5
Other	5,841.0	7,313.0	8,783.0
Total marketable	30,262.0	30,923.0	37,742.0*
Total unmarketable	6,582.0*	7,933.0	10,380.0*
(Brix)			
Percent solids	9.0	9.5	9.5

* Significantly different according to Duncan's Multiple Range Test (p=0.05).

Germination of Carrot Seed According to the Mass of the Seed

Bryan Maw and Dewayne Dales
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Sharad C. Phatak, Department of Horticulture
University of Georgia Coastal Plains Experiment Station, Tifton, GA,
and Wayne Guerke, Georgia Department of Agriculture Seed Lab

Introduction:

Approximately 350 acres of carrots, *Daucus carota* subspecies *sativus,* were harvested during the spring of 1997 under a co-operative program introducing to Georgia a crop of potential economic merit. The carrots are being marketed as sweet carrots to be grown and harvested at a time of the year when carrots of this type are needed on the U.S. market. Drilled directly into a seed-bed during the fall of 1996 and grown during the winter of 1996, the carrots were harvested during March, April, and May of 1997.

Growers experienced several different hindrances to full production. One hindrance was the lack of a uniform stand of carrots as the seed germinated and the plants grew on the bed. Carrot seed has, by nature, an extended term of germination such that different seed in the same batch can germinate over a period of days rather than on the same day. The minimum germination standard required for sale of seed in Georgia is only 55% (Georgia Seed Law, 1997). Seed merchants are likely to give the germination for the seed they are supplying, but this can vary from one batch to the next. It would be helpful if the window of germination could be narrowed and the percentage of viable seed in a sample could be increased as a contribution toward an improved stand. Carrot seed is often sold as sized seed, based upon the physical dimensions of the seed. However, size may not completely signify the viability of the seed.

As well as by size, seed may be sorted by density. One method of sorting by density is to aspirate the seed and use the buoyancy of the seed in an airstream to determine which seed are carried by the airstream and which remain (Gamiely et al., 1990; Smittle et al., 1976; Smittle and Williamson, 1977 and 1978; and Smittle, 1982). Radish, cucumber, snap bean, and onion seed were sorted by these authors. Further work (unpublished) has been conducted by Phatak on turnip seed. In each case, even though having the same size, seed of different densities once sown showed a variation in germination, growth, yield and sometimes a varying response to nitrogen and seed bed compaction. Even when removing as little as 20% of the seed by aspiration, the mean thickness and weight of the remaining seed was increased and beneficial effects realized once the seed was sown.

Objectives:

To establish how the density of carrot seed is influential in the germination of the seed and thus the uniformity of stand after drilling the seed.

Materials and Methods:

Carrot seed was sorted by means of a vacuum seed separator designed and built at the Biological and Agricultural Engineering Department, Coastal Plain Experiment Station, Tifton, Georgia. It works on the principle of extracting seed of a required density by creating an airstream through the seed mass and carrying those seed of critical buoyancy from the mass.

The squirrel cage fan was 320 mm (13.0 in.) in diameter and 140 mm (5.5 in.) in width. The speed of the fan was consistently held at 2083 rpm (Extech Instrument Stroboscope tachometer, Digital Instrument PI21205, Davis Instrumentation, 1-800-368-2516), being driven by a 1.12 kW (1.5 hp), 1725 rpm single phase electric motor. Airflow for seed separation was generated by leaving the exhaust of the fan open to the atmosphere and providing air to the inlet of the fan through a 101 mm (4 in.) diameter flexible duct. This duct was attached to a cyclone mounted 2.5 m (8 ft) above the ground. Leading into the cyclone from below was a vertical composite aluminum and plexiglass straight tube 101 mm (4 in.) in diameter and 2.1 m (7 ft) high, feeding into the base of the cyclone. Seed was placed on a fine mesh drawer and slid horizontally into a space through the wall of the plexiglass tube. Air to the inlet of the fan was drawn up through the seed, into the cyclone, and on into the fan. Seed that was lifted from the mesh by virtue of its buoyancy in the airstream entered the cyclone and separated from the airstream only to fall down a 0.9 m (3 ft) long tube 50 mm (2 in) diameter, into a collecting cup attached by a screw thread onto the base of the tube. The speed of the air passing through the seed was regulated by controlling the area of the orifice at the base of the aluminum tube below the mesh of seed. Depending upon the area of the orifice, less dense seed could be separated from the entire seed mass present upon the mesh. A variable shutter was used to control the area of the orifice.

The seed was of three varieties: 'Choctaw' (Sun Seed), 'Prelude' (Peto Seed)and 'Six Pak F1' (Harris Moran). All seed passed through a number 10 mesh (2 mm) sieve and the 'Six Pak F1' was specified as a size 3 (through a 1.39 mm (7/128 in.) and held on a 1.19 mm (3/64 in.) screen. The 'Choctaw' and 'Prelude' were coated with a thin film of inert material in order to increase the size of the seed for ease of seed separation during drilling. The 'Six Pak F1' was raw, noncoated seed.

For each variety, 32 g of seed as supplied from the seed merchant were place upon the mesh in the drawer. During pre-testing, positions on the shutter were marked when no seed would be drawn off and then when all the seed would be drawn off the mesh. Multiple positions between those two marks were chosen to provide the required levels of seed separation. At each level of airflow, the fan was run for 3 minutes, during which time a percentage of the seed was observed to be withdrawn from the parent mass and transferred over to the collecting cup. Beginning with the minimum orifice size for seed separation, the size was increased for each treatment until all seed had been withdrawn. After each treatment, the seed that was removed was weighed (Electronic analytical balance, Denver Instrument Company, 6542 Fig Street, Arvada, Colorado, 80004-1042) in order to calculate by weight the percentage of seed removed. The remaining seed was also weighed. Of those seed collected at each treatment, 500 were counted, weighed, and later shipped to the Georgia Department of Agriculture seed laboratory at Tifton, Georgia, for testing according to the (Association of Official Seed Analysts, 1993). The remaining seed were kept separate by variety and treatment, and were stored in a cold room at 34 degrees F.

Once at the seed laboratory, the seed was divided into lots of 25 seed per replication, with 16 replications per treatment. The seed was maintained in a dark growth chamber at conditions specified by the rules for testing seed (Association of Official Seed Analysts, 1993), at a temperature of 20 degrees C for 16 h and 30 degrees C for 8 h each day, the seed resting in a petri dish on blotting paper moistened with

water. The first count of germination was taken after 6 days and the final count after 14 days, from which a percentage of germination was calculated.

Results and Discussion:

Germination of the seed according to treatment is given in Table 1. In general, heavier seed germinated earlier (Table 2).

Future Research:

As many as 36 varieties of carrot seed are under surveillance as to their suitability for the soil conditions, climate, and market being considered. For each of the varieties of promise, it would be beneficial to determine the mass of seed that is most likely to produce a viable plant. Seed needs to be tested not just for germination, but for vigor of growth after germination, which requires greenhouse tests and field tests.

Acknowledgments:

Appreciation is expressed to Denne Bertrand for laboratory assistance during the seed germination tests and to Benjamin Mullinix for additional statistical analysis.

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Table 1. Germination of the carrot seed according to the mass of the seed.

Variety	Treatment Number	Total seed mass for Treatment (%)	Cumulative seed mass Extracted (%)	Seed Mass	Germination (%) for 500 seeds (g)>6 days; >14 days
Choctaw	1		original sample	-	1.49125
	2		12		121.25955
	3		25		371.40350
	4		26		631.53548
	5		19		821.65536
	6		7		891.78213
Prelude	1		original sample	-	0.78899
	2		3		30.50533
	3		15		180.64512
	4		31		490.74422
	5		28		770.89151
	6		15		921.02825
Six Pac F1	1		original sample	-	0.51442
	2		5		50.42673
	3		32		370.47078
	4		30		670.52171
	5		21		880.58352
	6		7		950.62189

Values having the same letter are not significantly different at P<.05 level, within the same variety.

Table 2. Carrot percent germination.

Variety	Treatment	Early[1] Normal	Normal	Final[2] Abnormal	Dead
Choctaw	1	44.50	88.25	2.50	9.25
	2	33.91	82.67	3.22	14.10
	3	41.44	84.12	4.22	11.66
	4	55.03	91.96	3.02	5.03
	5	55.10	90.37	2.72	6.91
	6	58.81	93.05	1.49	5.46
Prelude	1	75.06	88.26	0.73	11.00
	2	78.43	87.50	0.98	11.52
	3	79.25	90.75	0.25	9.00
	4	82.89	88.26	0.98	10.76
	5	72.75	88.75	0.50	10.75
	6	76.00	85.75	1.00	13.25
Six Pack II	1	73.75	89.50	1.75	8.75
	2	62.00	91.50	1.50	7.00
	3	63.50	91.75	2.50	5.75
	4	70.25	93.50	0.75	5.75
	5	66.00	88.75	1.00	10.25
	6	61.00	84.00	2.25	13.75

[1]Early count at 6 days.
[2]Final count at 14 days.

Effect of Plant Spacing On Carrot Production

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Materials and Methods:

The planting, samples, standard carrot, and refractometer reading procedures and methods followed in this study were identical to those followed as stated in the study by Phatak et al., *Effect of Land Preparation on Carrot Production,* except the fact that the carrots were planted December 10, 1996, on eight raised beds with eight different seed spacings. Samples were taken from 18 ft^2 plots (6 ft wide by 3 ft long) based on a randomized block design with three replications.

Results and Discussion:

Eight plant spacings were chosen to determine which spacing is best for carrot growth. There were significant differences (Table 1) between spacings. The number (#/A) of regular carrots for spacings C4, C5, C6, B5, and B6 was significantly more than for C2, and C6 was also more than for C1 and C3. The number of large carrots for spacings C1, C2, C3, and B6 was significantly more than for C4, C5, C6, and B5. The number of small carrots for spacings C5 and C6 were more than for C1, C2, C3, B5, and B6; the number for C4 was significantly more than for C2 and C3. For the number of carrots of the unmarketable grade, C2 and C3 were significantly more than C6 and C5 for splits; for rots, C1 was more than C4; and for other, there were no significant differences. No significant differences were found for the total number of unmarketable carrots, but spacings C4, C5, and C6 were significantly more than C1, C2, and C3 for the total number of marketable carrots.

Regular carrot yields for spacing B5 were significantly more than for C1, C2, and C3; yields for C4, C6, and B6 were more than for C2. Large yields for C2 and C3 were significantly more than C4, C5, C6, and B5; and small yields for C4, C5, and C6 were more than C2 and C3. For carrot yields of the unmarketable grade, spacings C2 and C3 splits were greater than C5, C6, B5, and B6; for rots, C1 was greater than C4; and for other, there were no significant differences. Total marketable yield for C4, C6, B5, and B6 was significantly greater than for C2, whereas total unmarketable yield for C1 was significantly greater than for C6 and B5. Based on statistical findings, C6 may be the best spacing for carrots and C2 the worst.

Table 1. Yield in carrots produced at different plant spacings.

	Plant Spacings *							
Parameters	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**B5**	**B6**
(#/Acre)								
Regular	79053 ^{BC}	67760 ^{C}	79860 ^{BC}	116967 ^{AB}	112127 ^{AB}	121000 ^{A}	118580 ^{AB}	112933 ^{AB}
Large	4033 ^{AB}	10487 ^{A}	12100 ^{A}	807 ^{B}	0 ^{B}	0 ^{B}	0 ^{B}	4840 ^{AB}
Small	25007 ^{BC}	10487 ^{C}	12907 ^{C}	45980 ^{AB}	66953 ^{A}	58080 ^{A}	28233 ^{BC}	32267 ^{BC}
Split	9680 ^{AB}	14520 ^{A}	12907 ^{A}	8067 ^{AB}	7260 ^{AB}	3227 ^{B}	3227 ^{B}	5647 ^{AB}
Rot	12100 ^{A}	4840 ^{AB}	6453 ^{AB}	0 ^{B}	4840 ^{AB}	1613 ^{AB}	4033 ^{AB}	6453 ^{AB}
Other	35493 ^{A}	31460 ^{A}	25813 ^{A}	44367 ^{A}	60500 ^{A}	54853 ^{A}	25813 ^{A}	34687 ^{A}
Total marketable	108093 ^{BC}	88733 ^{C}	104867 ^{BC}	163753 ^{A}	179080 ^{A}	179080 ^{A}	146813 ^{AB}	150040 ^{AB}
Total unmarketable	57273 ^{A}	50820 ^{A}	45173 ^{A}	52433 ^{A}	72600 ^{A}	59693 ^{A}	33073 ^{A}	46787 ^{A}
(Lb/A)								
Regular	23635 ^{BC}	19199 ^{C}	23716 ^{BC}	30774 ^{AB}	26741 ^{ABC}	30250 ^{AB}	35251 ^{A}	32146 ^{AB}
Large	2501 ^{AB}	5848 ^{A}	6413 ^{A}	484 ^{B}	0 ^{B}	0 ^{B}	0 ^{B}	2944 ^{AB}
Small	3751 ^{BC}	1331 ^{C}	1775 ^{C}	6332 ^{AB}	8309 ^{A}	6897 ^{AB}	3832 ^{BC}	4074 ^{BC}
Split	3428 ^{ABC}	5808 ^{A}	4719 ^{AB}	2420 ^{BC}	1613 ^{C}	887 ^{C}	1452 ^{C}	1008 ^{C}
Rot	3227 ^{A}	1654 ^{AB}	2581 ^{AB}	0 ^{B}	766 ^{AB}	403 ^{AB}	645 ^{AB}	1855 ^{AB}
Other	7502 ^{A}	6050 ^{A}	4598 ^{A}	6171 ^{A}	4880 ^{A}	5082 ^{A}	4517 ^{A}	7583 ^{A}
Total marketable	29887 ^{AB}	26378 ^{B}	31904 ^{AB}	37591 ^{A}	35050 ^{AB}	37147 ^{A}	39083 ^{A}	39164 ^{A}
Total unmarketable	14157 ^{A}	13512 ^{AB}	11898 ^{AB}	8591 ^{AB}	7260 ^{AB}	6373 ^{B}	6615 ^{B}	10446 ^{AB}

*Means within a row with the same letter are not significantly different, according to Duncan's Multiple Range Test (p=0.05).

Managing Weeds in Carrots

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Weed control in carrots (*Daucus carota* var. *sativus* L.) is an essential component of producing a high-yield, 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*), cutleaf evening primrose (*Oenthera lanceolata*), and several others.

Prevention is the first step in managing weeds in carrot cultivars. Avoiding areas that contain heavy infestations of perennial weeds such as bermudagrass and nutsedge is an important first step. Proper tillage, insect and disease control, and fertility will help to ensure a healthy crop. Proper 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).

Chemical weed control is often used in carrot production and relies heavily on the herbicide linuron (Lorox, others). Linuron provides excellent control of most weeds found in carrots and is used post-emergence 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 rates of linuron range from 0.75 to 1.5 lbs-ai/A. The lower rate should be used on smaller carrots (< 2-4 inches) and during warmer weather. A crop oil (1 qt/A) may be added to improve control of larger weeds, although this may increase the chance of crop injury. The best rule of thumb is to avoid the use of crop oil on smaller carrots.

Sencor (metribuzin) can also be used for post-emergence weed control, but certain carrot varieties may be injured by this herbicide. Due to the limited use of this herbicide in Georgia, a list of sensitive carrot varieties has not been developed to date. The rate for metribuzin is 0.25 lbs-ai/A. Trifluralin (Treflan) at 0.5 lbs-ai/A can also be used as a pre-plant incorporated treatment for the control of most annual grasses and several small-seeded broadleaf weeds. This herbicide should be applied before planting and soil incorporated to a depth of 2-3 inches. Trifluralin may provide early season weed suppression, allowing the carrots to emerge and begin seedling growth in the absence of heavy weed competition. Fluazifop-methyl (Fusilade) can be used for post-emergence weed control at 0.19 lbs-ai/A, and it provides good control of most annual and perennial grasses.

One of the worst weeds in carrots and most other crops is nutsedge. Most infestations are limited to yellow nutsedge (*Cyperus esculentus*), which is found throughout Georgia. Linuron and metribuzin may provide some temporary suppression, while trifluralin and fluazifop have no effect. Nutsedge causes the greatest problem in the early fall, during carrot emergence and seedling growth. The small carrot size during the fall limits the use of higher rates of linuron for suppression of nutsedge. Unfortunately, the lower rates give no control. The stale seed-bed technique may provide some control and can be effectively used in carrots for nutsedge, because nutsedge will emerge before the carrots. A non-selective material such as Roundup (1-2 lbs-ai/A) or Gramoxone Extra (0.25-0.5 lbs-ai/A) is commonly used. As with most weed management strategies, proper weed identification, site selection, and timing are the critical issues in controlling weeds in carrots.

Seedling Diseases of Carrots In South Georgia, 1996-1997

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Materials and Methods:

Carrot was seeded with a Monosem planter at various time intervals from August 23 to December 17, 1996. Fungi were isolated from root and hypocotyl tissues in plantings August 23, September 10, and December 17. Tissues were washed in running tap water for 0.5 to 1 hour, blotted dry on sterile filter paper, incubated on water agar, and hyphal tips were transferred to potato dextrose agar and identified. Selected isolates of fungi were tested for pathogenicity to the carrot grown in a greenhouse.

In the last planting, a seed treatment experiment was run with the variety Pak More F-1. A randomized complete block design with four replications was used. Treatments were nontreated seed or seed treated with Actinovate Plus (*Streptomyces* WYEC 108), 4 g mixed with 1 lb of seed in a plastic bag before seed was placed into the planter. Each plot was 3 rows 18 in. apart on a raised bed 50 ft long. In a laboratory test at planting, germination of treated and nontreated seed was 63% and 64%, respectively. Soil samples were collected at each planting and assayed on selective media for *Rhizoctonia* spp., and *Pythium* spp. were assayed in the December planting.

Stand counts were taken on 30-cm sections of the middle row 3, 6, 9, and 12 m into each plot January 6, 13, 22, and 27; and February 8, 1997. Seedlings were collected at random January 6 and 14, and evaluated for root and hypocotyl discoloration and decay. Fungi were isolated and identified. Carrots from a 3-ft section of all three rows (18 ft^2) were harvested and graded May 2, 1997.

Results and Discussion:

Numerous fungi were associated with roots of seedlings in the August and September plantings. *Alternaria* spp., *Curvularia* spp., *Fusarium* spp., *Phoma* spp., *F. solani*, *Macrophomina phaseolina*, and *Nigrospora* spp., in order, were isolated most frequently from seedlings. Most of the fungi were probably saprophytes living in the rhizosphere or on the surface of the roots. In the December planting, *Pythium* spp.(primarily *P. irregulare*), *Phoma* spp., *Alternaria* spp., and *Fusarium* spp. were isolated most frequently from seedlings. *Rhizoctonia* spp. were not detected in any of the soil samples, and populations of *Pythium* spp. were low or nondetectable in soil in December. In the greenhouse experiment, *Rhizoctonia solani* anastomosis group (AG)-4, *Pythium irregulare*, and *Rhizoctonia* spp. caused severe pre-emergence damping-off and reduction in final stand. In contrast, *F. solani* and *Phoma* spp. were not pathogenic on carrot seedlings.

Carrots grown from seed treated with Actinovate Plus and nontreated seed were similar (Table 1). Data were analyzed statistically, and there were no significant differences (P = 0.05). No differences were

observed in plant stand, and there was no moderate or severe root and hypocotyl discoloration and decay on seedlings 20 or 28 days after seeding. However, there was approximately 13% post-emergence damping-off in both treated and nontreated plots. No phytotoxicity was observed in plots treated with Actinovate Plus.

Carrot yield and quality were similar in treated and nontreated plots (Table 1). Average yields of regular carrots from treated and nontreated plots were 22,140 lb/A and 25,860 lb/A, respectively. Because carrot is a cool season crop, and soil temperatures were cool at planting, seedling diseases were probably not as severe as would be expected in late-summer plantings. According to Coastal Plain Experiment Station records, soil temperatures 2 inches deep ranged from 41 degrees to 66 degrees F December 17-31, 1996. In contrast, soil temperatures at the same depth August 23 to 31, 1996, ranged from 75 degrees to 93 degrees F. Soil temperatures 0.5 inches deep in dry soil may exceed 100 degrees F in southern Georgia in late summer.

Table 1. Emergence, plant stands, root disease, and yield in carrot treated with Actinovate Plus at seeding December 17, 1996.

	Seed Treatments	
Parameters	**Actinovate Plus**	**None**
Emergence, 20 days[x]	43	46
Plant stand, 36 days	40	42
Plant stand, 53 days	38	40
Plants with slight root discoloration, 20 days (%)[y]	37	50
Plants with slight root discoloration, 28 days (%)	55	55
Marketable carrots, regular, number[z]	45	49
Marketable carrots, regular, weight (lb)	9.15	10.68
Marketable carrots, small, number	31.2	20.5
Marketable carrots, small, weight (lb)	3.08	2.20
Nonmarketable, split, number	0.5	1.0
Nonmarketable, split, weight (lb)	0.06	0.20
Nonmarketable, decayed, number	6.0	5.5
Nonmarketable, decayed, weight (lb)	0.91	1.11
Nonmarketable, other, number	21.5	19.2
Nonmarketable, other, weight (lb)	1.46	1.92

[x] Plant counts are for 1.2 m of row.
[y] Plants with 1-10% root discoloration and decay. No plants had moderate (10-15%) or severe (>50%) discoloration and decay.
[z] All plants in the rows 3 ft long (18 ft^2, 0.0004 acre) were harvested and graded.

Disease Management in Carrots

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Disease management in carrots is necessary to produce high yields of high quality carrots. The major concern is the production of a disease-free, cosmetically clean carrot root. The main problems associated with the carrot root are root-knot nematodes and diseases caused by fungi, primarily *Pythium* and Southern Blight. *Pythium* root rot can usually be controlled by rotation and incorporation of Ridomil 2E. Southern Blight is best controlled by deep turning and following a rotational program that decreases the amount of southern blight in the soil. Rotation is a key factor in preventing these diseases as well as timely soil assays for nematodes. The root-knot nematode can be very destructive to carrots, causing stunting as well as root distortion. The root-knot nematode must be controlled for successful carrot production.

Carrot foliage is susceptible to a number of diseases, primarily *Alternaria* and *Cercospora*. In most cases, these diseases never require any type of fungicide application. Under certain weather conditions, however, fungicide application may be necessary. We have adequate fungicides for managing the above-ground diseases.

	Broadcast	**Row**
NEMATODES:		
Telone II *	9 to 18 gal/Acre	52 to 106 fl. ozs/1,000 ft
Telone C-17	10.3 to 17.1 gal/Acre	30.3 to 50.2 fl. ozs/1,000 ft
Vapam	75 to 100 gal/Acre	
SOIL DISEASES:		
Ridomil 2E *	4 to 8 pts incorporated top 2 inches	
FOLIAGE DISEASES:		
Chlorothalonil	**Example:** *Bravo 720 @ 1 1/2 to 2 pts/Acre (Alternaria, Cercospora)	
Rovral	1 to 2 lbs/Acre (Alternaria)	
Ridomil-Copper 70W *	2 lbs/Acre (Alternaria, Cercospora)	

*** Recommended Treatments**

Tift County Carrot Variety Trials

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Materials and Methods:

The planting, samples, and standard carrot procedures and methods followed in this study were identical to those followed as stated in the study by Phatak et al., *Effect of Land Preparation on Carrot Production,* except the fact that the carrots were planted December 10, 1996, on 22 raised beds, 22 carrot varieties were planted, and samples were taken May 28, 1997, from 18 ft^2 plots (6 ft wide by 3 ft long) based on a randomized block design with two replications.

Samples were taken again on June 17, 1997. Soluble solids, pH, and core color of these carrots were compared using the variety Choctaw as the standard. A Fisherbrand hand-held refractometer was used to measure soluble solids; an Orion portable pH/mV temperature meter was used to measure pH, and an investigator was assigned to visually rate core color. Two to three carrots of marketable grade from each sample were sampled depending on carrot size. These carrots were rinsed, towel dried, and approximately 1 to 2 in. discarded from each end.

The carrots were first rated for core color (0 to 10 rating, with 0 being very poor and 10 excellent) by making a cross sectional cut mid-length of the carrot. The samples were then juiced using a Waring commercial juice extractor. The juice was filtered using a single filter sheet in the strainer basket of the extractor and a single coffee filter over the recovery container, a 9 oz plastic cup. Refractometer readings were taken from the juiced sample, followed by pH measurements. The pH electrode was triple rinsed between samples using distilled water, 70% ethanol, and distilled water again. The 70% ethanol was used to prevent a film from forming on the electrode bulb.

Results and Discussion:

Data were analyzed statistically, and each variety was rated using 'Choctaw' as the standard (Tables 1, 2, and 3). The results of several varieties were affected by poor weed control in sample plots, but these varieties are noted with special emphasis in this discussion. As for the number of marketable fruit per acre (Table 1), regular carrots from varieties 'Cheyenne,' 'Sugarsnax 54,' and 'Navajo' were significantly higher than 'Choctaw,' and the varieties from weedy plots were significantly lower. 'Tripleplay 58' large carrots were significantly higher, while all others were not significantly different. There were no varieties with significant differences in the number of smalls and splits. However, 'Choctaw' rots were significantly higher than all but six varieties. 'Cheyenne,' 'Sugarsnax 54,' and 'Prelude' other carrots were significantly higher than 'Choctaw,' while all others were not significantly different. Overall, only the 'Cheyenne' total number of unmarketable carrots was significantly higher than 'Choctaw,' while six varieties grown in weedy plots were significantly lower. 'Sugarsnax 54' and 'Cheyenne' total number of marketable carrots was significantly higher than 'Choctaw,' and most varieties from weedy plots were significantly lower.

For fruit yield, lb/A (Table 2), 'Cheyenne' regular carrots were greater than 'Choctaw,' while weedy varieties were less. There were no significant differences for large, split, and other carrots among the

varieties, but ‘Sugarsnax 54’ small carrots were greater than ‘Choctaw.’ Also, ‘Choctaw’ rots were only significantly greater than a few weedy varieties. Finally, only the weedy varieties showed significant differences in total marketable yield. There were no significant differences in total unmarketable yield.

When rated for color, there were no varieties superior to ‘Choctaw,’ but 10 varieties were similar to ‘Choctaw’ in core color (Table 3). Four varieties’ (Cheyenne, XPH 3916, Navajo, and Dawn Dee) overall internal color rating was equal to that of ‘Choctaw.’ Also, there were greater differences in soluble solids among the varieties, but readings were good for all varieties. Varieties with soluble solid readings 0.5 or higher than ‘Choctaw’ were rated greater than ‘Choctaw,’ while readings equal to or no more than 0.5 below ‘Choctaw’ were rated equal to ‘Choctaw.’ Five varieties (Vita Sweet #781, Navajo, XPH 3918, Pacific Gold, and Six Pak) were superior to ‘Choctaw,’ while 12 varieties equaled ‘Choctaw.’ Only ‘Primecut 59,’ ‘Vita Sweet #691,’ ‘XPH 3916,’ and ‘Vita Sweet #711’ were rated lower than ‘Choctaw.’

Also, pH varied greatly among the varieties. Varieties with pH measurements 0.06 or greater than ‘Choctaw’ were rated superior while varieties with measurements equal to or +/- 0.05 than ‘Choctaw’ were rated equal to ‘Choctaw.’ There were no varieties rated superior to ‘Choctaw,’ but 3 varieties (Cheyenne, Tripleplay 58, and Dawn Dee) equaled ‘Choctaw.’ Eighteen varieties rated inferior to ‘Choctaw’ with one, ‘Primecut 59,’ having a pH reading below 6.00.

Table 1. Yield (#/A) of 22 carrot varieties grown in Tift County.

	Parameters *							
Variety	**Regular**	**Large**	**Small**	**Split**	**Rot**	**Other**	**Total Unmarketable**	**Total Marketable**
Choctaw	**81070** C	**13310** ABC	**31460** ABC	**3630** AB	**22990** A	**29040** CD	**55660** BCD	**125840** BC
Cheyenne	128260 A	0 C	64130 AB	4840 AB	4840 AB	77440 A	87120 A	192390 A
XPH 3916	71390 C	13310 ABC	15730 BC	12100 AB	12100 AB	25410 CD	49610 BCDE	100430 CDEF
Navajo	116160 AB	3630 BC	49610 ABC	6050 AB	13310 AB	30250 CD	49610 BCDE	169400 AB
Apache	55660 CD	4840 BC	49610 ABC	12100 AB	3630 B	36300 BC	52030 BCDE	110110 CDE
Sugarsnax 54	117370 AB	0 C	78650 A	6050 AB	7260 AB	64130 A	77440 AB	196020 A
Tripleplay 58	78650 C	21780 A	8470 C	8470 AB	0 B	26620 CD	35090 DEFG	108900 CDE
Primecut 59	85910 BC	18150 AB	10890 BC	10890 AB	8470 AB	21780 CD	41140 CDEFG	114950 BCD
XPH 3973	59290 CD	6050 ABC	18150 BC	9680 AB	8470 AB	30250 CD	48400 BCDE	83490 CDEFG
Pacific Gold [w]	31460 DE	0 C	16940 BC	14520 A	2420 B	29040 CD	45980 CDEF	48400 EFGH
XPH 3918 [w]	33880 DE	18150 AB	9680 C	8470 AB	0 B	27830 CD	36300 DEFG	61710 EFGH
Prelude [w]	53240 CD	7260 ABC	36300 ABC	9680 AB	1210 B	58080 AB	68970 ABC	96800 CDEF
Six Pence [w]	13310 E	8470 ABC	8470 C	3630 AB	1210 B	36300 BC	41140 CDEFG	30250 GH
24 Karat [w]	26620 DE	0 C	18150 BC	2420 AB	2420 B	32670 C	37510 DEFG	44770 FGH
Vita Sweet #781 [w]	18150 E	7260 ABC	4840 C	8470 AB	2420 B	10890 CD	21780 EFG	30250 GH
Canada Super X [w]	3630 E	0 C	10890 BC	0 B	0 B	16940 CD	16940 FG	14520 H
Vita Sweet #691 [w]	12100 E	1210 C	4840 C	6050 AB	0 B	18150 CD	24200 EFG	18150 H
Six Pak [w]	9680 E	0 C	15730 BC	2420 AB	1210 B	31460 CD	35090 DEFG	25410 GH
Dawn Dee [w]	10890 E	6050 ABC	1210 C	6050 AB	1210 B	6050 D	13310 G	18150 H
Pak Mor [w]	4840 E	9680 ABC	1210 C	2420 AB	1210 B	18150 CD	21780 EFG	15730 H
Six Pak II [w]	1210 E	0 C	0 C	3630 AB	0 B	18150 CD	21780 EFG	1210 H
Vita Sweet #711 [w]	13310 E	2420 BC	9680 C	4840 AB	3630 B	25410 CD	33880 DEFG	25410 GH

* Means with the same letter within a column are not significantly different, according to Duncan's Multiple Range Test (p=0.05).
[w] These varieties planted in weeds.

Table 2. Yield (Lbs/A) of 22 carrot varieties grown in Tift County.

	Parameters *							
Variety	**Regular**	**Large**	**Small**	**Split**	**Rot**	**Other**	**Total Unmarketable**	**Total Marketable**
Choctaw	**23474** BCD	**7018** ABC	**3811** BC	**968** AB	**4658** A	**3630** ABC	**9256** ABCD	**34303** ABC
Cheyenne	34364 A	0 C	6776 AB	1633 AB	1512 AB	7683 ABC	10829 ABCD	41140 A
XPH 3916	22627 BCD	7260 ABC	2480 BC	6413 A	3811 AB	5747 ABC	15972 AB	32367 ABC
Navajo	32670 AB	2299 BC	7018 AB	2057 AB	4174 AB	4658 ABC	10890 ABCD	41987 A
Apache	17847 CDEF	3206 ABC	6171 ABC	4416 AB	786 AB	6836 ABC	12039 ABCD	27225 BCD
Sugarsnax 54	31520 AB	0 C	10285 A	1633 AB	1270 AB	8349 ABC	11253 ABCD	41805 A
Tripleplay 58	26075 ABC	11434 A	1149 BC	3448 AB	0 B	7381 ABC	10829 ABCD	38659 A
Primecut 59	25349 ABCD	9498 AB	1573 BC	3872 AB	2964 AB	4658 ABC	11495 ABCD	36421 AB
XPH 3973	18573 CDE	3327 ABC	2662 BC	4235 AB	2722 AB	9982 AB	16940 A	24563 DC
Pacific Gold [w]	8227 EFG	0 C	2420 BC	5445 AB	786 AB	4416 ABC	10648 ABCD	11192 EF
XPH 3918 [w]	10043 EFG	9014 AB	1210 BC	5021 AB	0 B	6231 ABC	11253 ABCD	20267 DE
Prelude [w]	15669 DEF	3085 ABC	4961 ABC	3085 AB	302 AB	8228 ABC	11616 ABCD	23716 DC
Six Pence [w]	4174 G	4537 ABC	1270 BC	2359 AB	181 AB	9801 AB	12342 ABC	9982 EF
24 Karat [w]	7986 FG	0 C	2359 BC	605 B	605 AB	6836 ABC	8046 ABCD	10345 EF
Vita Sweet #781 [w]	4598 G	3146 ABC	665 BC	3146 AB	1270 AB	2964 BC	7381 ABCD	8409 F
Canada Super X [w]	1149 G	0 C	1512 BC	0 B	0 B	2541 C	2541 D	2662 F
Vita Sweet #691 [w]	2964 G	968 BC	847 BC	2117 AB	0 B	4719 ABC	6836 BCD	4779 F
Six Pak [w]	1936 G	0 C	1875 BC	665 B	605 AB	4840 ABC	6110 CD	3811 F
Dawn Dee [w]	4356 G	3993 ABC	181 C	4053 AB	847 AB	1936 C	6836 BCD	8530 F
Pak Mor [w]	1391 G	5324 ABC	181 C	1694 AB	484 AB	6413 ABC	8591 ABCD	6897 F
Six Pak II [w]	605 G	0 C	0 C	2843 AB	0 B	10466 A	13310 ABC	605 F
Vita Sweet #711 [w]	3811 G	1452 BC	1331 BC	1694 AB	1391 AB	5626 ABC	8712 ABCD	6594 F

* Means with the same letter within a column are not significantly different, according to Duncan's Multiple Range Test (p=0.05).[w] These varieties planted in weeds.

Table 3. Tift County Carrot Variety Trials.

#	Variety	Core Color	Overall Internal Color	% Solids	pH
1	**Choctaw**	**8**	**8**	**8.7**	**6.25**
2	Cheyenne	8	8	9.0	6.21
3	XPH 3916	8	8	8.0	6.09
4	Navajo	8	8	9.6	6.14
5	Apache	6	6	9.0	6.14
6	Sugarsnax 54	8	7	9.1	6.15
7	Tripleplay 58	8	7	9.0	6.21
8	Primecut 59	8	7	8.1	5.97
9	XPH 3973	7	7	9.0	6.03
10	Pacific Gold*	7	7	9.5	6.10
11	XPH 3918*	8	7	9.5	6.03
12	Prelude*	7	7	8.5	6.14
13	Six Pence*	8	7	9.0	6.05
14	24 Karat*	6	6	8.5	6.00
15	Vita Sweet #781*	7	6	9.6	6.12
16	Canada Super X*	6	6	8.7	6.09
17	Vita Sweet #691*	8	7	8.0	6.12
18	Six Pak*	7	6	9.4	6.11
19	Dawn Dee*	8	8	9.0	6.20
20	Pak Mor*	7	6	8.5	6.14
21	Six Pak II*	7	7	9.0	6.19
22	Vita Sweet #711*	7	7	8.0	6.12

* These varieties planted in weeds.

Jeff Davis and Wayne County Carrot Variety Trials

Terry Kelley, Sharad Phatak, Rick Reed, James Reid
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Introduction:

Carrot variety trial studies were conducted in three different locations at various times during the 1996-1997 growing season. Seed for the trials was supplied by 10 different seed companies. Approximately 80 acres of carrots were planted, with approximately 70 acres being harvested. Although a number of varieties of carrots are available for commercial planting in Georgia, the adaptability of most of these varieties to the Georgia farm land has not been tested locally.

As an initial test, 23 varieties were planted at the Tate Farm in Jeff Davis County on October 1, 1996. A second planting of 16 varieties was conducted on November 4, 1996, at the Burch Farm in Wayne County. A third planting of 36 varieties was at the Tate Farm again on November 24, 1996.

Most of the planting was later than desired because of the late arrival of the planter. Reduced stand and low pack out per acre was caused by lack of knowledge and experience with the planter, inadequate windbreaks, inclement weather following planting or during the germination period, and poor fertility and water management. Tip rot and splitting at the soil line were also major factors in the low pack out per acre. As these problems are addressed, pack out per acre numbers will increase.

Variety Trials

Methodology:

The ‘Choctaw’ variety was used as the standard to compare the quality characteristics (visual attractiveness) of the other carrot varieties. Approximately 50 carrots from each variety were harvested and laid out on the ground in their respective groups. University of Georgia extension, research personnel, and growers, using ‘Choctaw’ as the standard, rated each variety visually on a scale from 1 to 10, with 10 being the most desirable rating. Each variety was rated for external color, growth of the top, smoothness of the carrot, length of the carrot, and overall marketability of the carrot. Growth of the top was rated on the sufficiency of the top growth for machine harvesting of the carrot. Overall marketability was rated on the percent of usable, visually attractive carrots in the group. All other quality characteristics were rated by comparison to the ‘Choctaw’ standard carrot. Unless otherwise noted, two representative plots from each variety were evaluated and their scores averaged. Some carrots were further analyzed in a lab to rate their internal color, core color, % soluble solids, pH, and sugar content.

Results:

The October 1 planting at the Tate Farm resulted in reduced stands because of inclement weather the day after planting and difficulty in the utilization of the planting equipment. As a result of these problems, the only data collected from this planting were quality characteristics. However, carrots from this test plot were used in taste/sweetness trials.

Evaluations of this stand took place on March 27, 1997. Visual ratings of two representative plots were obtained in the field for external color, growth of the top, smoothness, length, and marketability; these results are shown in Tables 1a and 1b. The top 11 varieties were further evaluated for sugar content and used in taste tests.

The November 4 planting at the Burch Farm was evaluated on May 8, 1997. Only 16 varieties were planted at this location due to the lack of seed for some varieties. However, this test proved to have the most favorable conditions for evaluation. Visual ratings for two representative plots were obtained in the field for external color, growth of the top, smoothness, length, and marketability; these results are shown in Table 2.

The November 24 planting at the Tate Farm was evaluated on May 30, 1997. Thirty-six varieties had been planted, but below freezing temperatures during the germination period resulted in a poor stand. Visual ratings were obtained for external color, growth of the top, smoothness, length, and marketability. However, only one representative plot was evaluated; these results are shown in Table 3.

Lab Analysis:

Further analysis of the 36 varieties planted on November 24 was conducted in a lab. The Core color, overall internal color, % soluble solids and pH were all evaluated. These results are shown in Table 4.

Materials and Methods:

Thirty-six varieties of carrots were obtained from the Tate Farm in Jeff-Davis county on May 30, 1997. These carrots were placed in cold storage at 40 degrees F for five days before testing and between testing dates. Soluble solids, pH, and core color of these carrots were compared using the Choctaw variety as the standard. A Fisher® hand-held refractometer was used to measure soluble solids; an Orion portable pH/mV temperature meter was used to measure pH, and an investigator was assigned to rate the core color visually.

Two to three carrots from each variety were sampled, depending on carrot size. These carrots were rinsed and towel dried. Approximately 1 to 2 inches from each end of the carrots was discarded. The carrots were first rated for core color (0 to 10 rating, with 0 being very poor and 10 excellent) by making a cross sectional cut of the carrot and then visually rating the color. The samples were then juiced using a Waring commercial juice extractor. The juice was filtered using a single filter sheet in the strainer basket of the extractor and a single coffee filter over the 9 oz plastic recovery container.

Refractometer readings were taken from the juiced sample followed by pH measurements. The pH electrode was rinsed three times between samples using distilled water, 70% ethanol and distilled water again. The 70% ethanol was used to prevent a film from forming on the electrode bulb.

Results and Discussion:

Thirty-six carrot varieties were sampled, including 'Choctaw' (the standard). The sample's core color and overall internal color as judged through a cross sectional view were rated for color quality. Three varieties, 'Indiana,' 'KXPC 037,' and 'Canada Super X,' were superior to 'Choctaw' in core color (Table 1), while 17 varieties were equal to 'Choctaw,' and 15 varieties inferior. Varieties 'Six Pak 316,' 'Zanahoria,' and 'Sugarsnax 54's' core colors were notably different. For overall internal color, only 'Canada Super X' exceeded 'Choctaw,' while 16 varieties equaled 'Choctaw,' and 18 varieties were inferior. 'Vita Sweet 781,' 'Six Pak EZ,' 'Sugarsnax 54,' 'Zanahoria,' and 'Six Pak 316's' overall internal colors were notably different from 'Choctaw.'

There were greater differences among the varieties in soluble solids readings, but readings were good for all varieties. Varieties with soluble solid readings higher than 'Choctaw' by 0.5 or more were rated greater than 'Choctaw,' while readings +/- 0.5 that of 'Choctaw' were rated equal to 'Choctaw.' Based on this rating scheme, there were no varieties with readings greater than 'Choctaw.' However, There were 7 varieties ('Terminator,' 'XPH 3918,' 'Six Pak 316,' 'Carrotte Hybrid,' 'Six Pence,' 'Zanahoria,' and 'XPH 397') equal to 'Choctaw.' Also, there were 28 varieties that, although good, rated below 'Choctaw.' 'KXPC 037' and '24 Karat' had the lowest soluble solids readings.

Varieties also varied greatly in pH measurements. High pH measurements often correlated to high soluble solid readings. Varieties with pH measurements greater than 'Choctaw' by 0.06 or more were rated superior, while varieties with measurements +/- 0.05 than 'Choctaw' were rated equal to 'Choctaw.' Carrotte Hybrid was rated superior, while varieties (10 in all) 'Ivanhoe,' 'Vita Sweet 691,' 'Prelude,' 'KXP 022,' 'Zanahoria,' 'XPH 3916,' 'Vita Sweet 711,' 'XPH 3918,' 'Navajo,' and 'Canada Super X' were equal to 'Choctaw.' There were 24 varieties with pH measurements less than 'Choctaw,' and 8 of that 24 had measurements less than 6.00.

This data should only be interpreted using yield and grade information to select favorable varieties.

Jeff Davis County Carrot Variety Trials
TABLE 1
Results of the quality evaluation of the Tate Farm cultivar

Variety	Rep I					Rep II					Average
	Smooth	Top	Color	Length	Market	Smooth	Top	Color	Length	Market	of Reps
Sixpack	10	6	10	5	8	9	10	10	10	9	8.7
Pakmor	10	6	10	8	8	5	8	10	10	7	8.2
XPH3916	10	5	10	8	8	10	5	10	7	7	8.5
Navajo	9	8	10	8	6	9	7	10+	9	8	8.4
VitaSW691	8	8	10	7	6	10	7	7	9	9	8.4
Sixpence	8	7	10	8	9	10	7	10	7	6	7.9
Australia	9	6	10	9	8	9	8	10	10	9	8.7
Prelude	9	6	10	6	8	10	8	10	8	8	8.3
XPH3918	9	7	7	8	9	7	7	10	9	5	7.8
Nashville	9	7	10	5	7	8	9	10	10	7	8.2
VitaSW781	9	7	10	8	8	10	6	10	7	8	8.3
XPH3973	9	8	9	8	8	8	8	10	9	8	8.5
Sixpack 11	10	7	10	7	8	10	6	10	6	7	8.0
Zanahoria	10	8	9	7	6	10	6	10	6	7	7.9
Choctaw	9	8	10	8	7	--	--	--	--	--	8.4
Cheyenne	9	9	10	10	7	10	8	10	9	9	9.1
VitaSW711	9	9	10	9	9	9	10	10	10	8	9.3
Apache	10	8	10+	8	9	8	9	10	10	8	9.0
Pacific Gold	10	7	10	10	8	8	8	10	8	7	8.5
Can SuperX	10	5	10	8	7	8	6	10	7	5	7.5
Ireland	9	10	10	9	9	8	7	10	8	7	8.7
Ivanhoe	7	9	10	9	6	9	9	10	8	8	8.5
Indiana	9	8	10	9	7	8	9	10	9	8	8.6

Planted October 1, 1996
Evaluated March 27, 1997
Smooth=Smoothness; Market=Marketability
Top=Sufficiency of top for machine harvest
Ratings on 1-10 scale with 10=most desirable

Wayne County Carrot Variety Trials
TABLE 2
Results of quality evaluation of the Burch Farm cultivar

Variety	Rep I					Rep II					Average
	Smooth	Top	Color	Length	Market	Smooth	Top	Color	Length	Market	of Reps
XPH 3973	7	8	10	7	7	6	8	9	6	5	7.3
First Class	9	7	10	7	7	7	6	10	6	7	7.6
Canada Super X	8	5	9	6	7	9	4	9	6	8	7.1
Vita Sweet 711	9	8	10	8	9	7	7	10	8	8	8.4
XPH 3918	9	8	10	7	9	8	8	10	8	8	8.5
Vita Sweet 781	7	7	10	8	8	9	7	10	8	9	8.2
Prelude	7	10	10	7	8	7	9	10	7	6	8.2
XPH 3916	9	8	10	9	8	6	7	10	7	7	8.1
Navaho	6	9	10	8	6	8	9	10	7	9	8.2
Premium	6	6	10	7	7	8	4	10	7	7	7.2
Dawn Doe	9	7	10	9	8	8	7	10+	7	8	8.2
Cheyenne	10	8	10	8	6	10	9	10	8	8	8.7
Pak Mor	8	10	10	8	6	9	9	9	9	8	8.6
Apache	8	6	10+	7	7	7	8	9	7	6	7.5
Vita Sweet 681	6	8	10	4	6	7	9	10	7	7	7.4
Choctaw	10	10	10	8	8	10	10	10	9	10	9.5

Planted November 4, 1996
Evaluated May 8, 1997
Smooth=Smoothness; Market=Marketability
Top=Sufficiency of top for machine harvest
Ratings on 1-10 scale with 10=most desirable

Jeff Davis County Carrot Variety Trials
TABLE 3

Results of the quality evaluation of the Tate Farm cultivar

Variety	Only 1 Rep					Average
	Smooth	Top	Color	Length	Market	
Apache	5	7	9	10	5	7.2
VitaSW711	7	10	10	10	8	9.0
Choctaw	9	10	10	10	9	9.6
VitaSw781	8	5	7	5	5	6.0
VitaSW691	10	10	10	9	8	9.4
Sixpence F1	9	8	8	9	8	8.4
24 Karat	8	6	8	7	5	6.8
Crusader	8	10	10	10	7	9.0
Terminator	8	5	10	10	8	8.2
Cheyenne	8	6	9	8	6	7.4
Carrotte Hybrid	9	8	9	9	8	8.6
Zanahoria	9	4	10	10	9	8.4
XPH 3916	8	8	9	9	7	8.2
Navajo	9	9	9	9	8	8.8
Prelude	8	8	10	7	7	8.0
Gladiator	7	5	7	9	5	6.6
Ivanhoe	8	8	10	7	6	7.8
Nashville	8	9	10	6	6	7.8
Dawn Doe	6	6	10	9	6	7.4
Canada SuperX	8	6	8	8	6	7.2
XPH 3973	6	8	9	7	5	7.0
Tripleplay 58	8	9	10	7	6	8.0
Primecut 59	9	8	10	8	8	8.6
Sugarsnak 54	7	9	8	10	8	8.4
Ireland	7	9	8	8	5	9.4
Indiana	8	9	10	10	7	8.8
KXPC-030	8	10	10	9	7	8.8
XPH 3918	7	7	10	7	7	7.6
Pak Mor 1303	9	10	8	10	8	9.0
Sixpack 316	8	8	8	7	7	7.6
Sixpack 11	9	9	8	6	5	7.4
Pacific Gold	7	9	8	7	6	7.4
Sixpack EZ	9	6	9	8	8	8.0
KXPC 020	5	10	9	8	4	7.2
KXP-022	7	10	10	4	8	7.8
KXPC-037	7	8	9	10	7	8.2

Planted November 24, 1996; Evaluated May 30, 1997

Smooth=Smoothness; Market=Marketability; Top=Sufficiency of top for machine harvest

Ratings on 1-10 scale with 10=most desirable

Jeff Davis County Carrot Variety Trials Lab Analysis
TABLE 4

Results of the lab analysis of the Tate Farm cultivar

Variety	Core Color	Internal Color	% Solids	pH
Terminator	7	8	12.5	6.06
Choctaw	8	8	12.4	6.16
XPH 3918	7	7	12.3	6.14
Carrotte Hybrid	8	7	12.0	6.23
Zanahoria	6	6	12.0	6.17
Six Pack 316	6	5	12.0	6.04
Six Pence	7	7	12.0	6.03
XPH 397	8	7	11.9	6.10
KXP - 022	7	7	11.8	6.19
Pak Mor 1303	8	7	11.8	6.07
Apache	8	8	11.7	5.93
Six Pack II 1317	8	7	11.6	5.93
Vita SW 711	7	8	11.5	6.14
Indiana	9	8	11.5	6.06
Navajo	8	8	11.5	6.13
Canada Super X	9	9	11.4	6.13
XPH 3916	7	7	11.4	6.15
Six Pack EZ	7	6	11.2	5.93
Nashville	8	8	11.2	5.92
Vita SW 781	7	6	11.1	6.02
Pacific Gold	8	8	11.0	5.93
Crusader	8	8	11.0	5.91
Primecut	8	8	11.0	6.09
Prelude	7	7	10.9	6.19
Dawn Doe	8	8	10.8	6.06
Vita SW 691	8	8	10.6	6.19
Ireland	8	8	10.6	6.06
Sugarsnax 54	6	6	10.5	5.83
Ivanhoe	8	8	10.5	6.19
KXPC - 030	8	8	10.5	6.01
Tripleplay 58	8	8	10.2	5.89
Cheyenne	8	7	10.0	6.05
Gladiator	7	7	10.0	6.09
KXFC - 020	7	7	10.0	6.04
KXPC - 037	9	8	9.7	6.08
24 Karat	7	7	9.5	6.03

Post-Harvest Handling of Carrots

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Introduction:

Fresh Georgia carrots were harvested before reaching full maturity. These carrots averaged 7 to 9 inches in length, 1.5 inches in diameter, had a mild, sweet flavor and a bright external color. All Georgia carrots are machine harvested.

Harvesting and Packaging:

Machine harvested carrots are loosened under the row by pull-like devices and elevated out of the soil onto belts that grasp the carrot tops. These tops are cut mechanically and allowed to fall back into the field while the trimmed roots are elevated to trucks for bulk transport to the packing house. At the packing house, carrots are off-loaded into a dry dump tank, conveyed through a cylindrical revolving cleaner to remove dirt and sand, and then enter a revolving drum washer with spray nozzles. Washed carrots then proceed through a series of sizing belts, where they are sorted by length and diameter. Diverging rollers are used to separate roots for diameter, and an inclined, vibrating platform with graduated hole sizes separates roots according to length. Sized carrots drop onto conveyor belts for hand grading to remove culls and are then hand packed into one, two, three and five pound polyethylene bags, which are subsequently palletized into 50 pound, heavy polyethylene master bags.

Mechanical damage to the roots can be minimized by the proper operation of all harvesting, sizing, and grading equipment. Excessive speed or overloading of equipment will result in an increase of mechanical damage to the carrots. Such bruising or cutting will open up avenues for greater water loss and the invasion of decay microorganisms.

Precooling and Chlorination:

Carrots have a high rate of respiration, which means field heat must be removed before dense packaging and storage. Precooling is accomplished by using cold water in the revolving drum washer. Temperatures should be kept at 40 degrees F. Water used in cleaning and cooling should be chlorinated at a concentration of 75 to 100 ppm of free chlorine. Chlorination can be accomplished using a gas injection system, adding bleach, or using calcium hypochlorate tablets. Chlorination levels in the water should be monitored frequently during operation through the use of chlorine litmus paper, or more accurately with a chlorine test kit.

Storage Requirements:

Topped fresh market carrots are very perishable and rapidly transpire moisture from even trimmed roots. Wilting symptoms become evident with as little as a 3% weight loss. Therefore, high humidity (95-100%) is imperative in storage. Free moisture, if allowed to condense on carrots, will promote decay; therefore, good air movement is necessary to prevent decay during storage. Topped carrots should be held at 32 degrees F. If the above conditions are met, the shelf life of immature, topped carrots is four to six weeks.

Quality Defects:

One of the most common signs of visual quality loss is a lack of firmness: Carrots become limp and soft, flabby, and/or shriveled. Other quality defects causing carrots to be downgraded by the buyer or due to a USDA inspection include the following: Non-uniform shape, growth cracks, insect damage, poor color, roughness, green core, sunburn injury, poor trimming, evidence of freeze damage, and decay.

Mixed Load/Storage Compatibility:

Carrots have the same storage requirements as beets, broccoli, brussel sprouts, cabbage, cauliflower, celery, collards, sweet corn, endive, greens, lettuce, green onions, parsley, parsnips, peas, radishes, snow peas, spinach, and watercress. Therefore, these crops can be stored together without deleterious effects. However, carrots should not be stored with ethylene-producing crops such as cantaloupes, apples, etc. Carrots are sensitive to as little as 0.5 ppm ethylene. This will impart a perceptible bitter flavor to the carrots.

Postharvest Decay:

Postharvest decay organisms are obligate parasites and therefore, do not normally enter the product through healthy, exterior tissue. These organisms require mechanical damage or weakening of tissue before they can enter. Spoilage losses can be minimized if the following precautions are observed: Use new or disinfected storage containers, handle carrots carefully to prevent injuries, precool roots properly, and maintain carrots at a constant temperature slightly above 32 degrees F.

The most important decays of carrots in storage are gray mold rot (*Botrytis*), watery soft rot (*Sclerotinia*), crater rot (*Rhizoctonia*), fusarium rot, rhizopus soft rot, bacterial soft rot, black rot (*Stemphylium*), and sour rot (*Geotrichuim*).

Carrot Packinghouse Quality Control System

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Quality control procedures were developed for a new carrot packinghouse. Special efforts were made to establish a good reputation for the brand label, *Georgia Sweet Carrot.* To support the brand name development and to assure the economic sustainability of the venture written, quality management procedures and specialized forms for record keeping were prepared.

The objective of this work is to ensure that the carrots shipped from the packinghouse are consistently high in quality. This objective is met by developing applicable yet essential quality control policy and procedures based on International Standard ISO 9004 and the U.S. Department of Agriculture standards for fresh carrot grades. The quality management procedures include those directly related to the handling of fresh carrots. The need to meet quality standards requires the development of a record keeping system.

Results from a survey of Atlanta area consumers are shown in tables 1, 2, and 3. It is evident that consumers pay moderate attention to the country of origin when buying fresh vegetables, because consumers believe origin influences quality (Table 1.) Consumer preference for vegetables of USA origin ranked high (36 first, 60 second, 2 third, and 1 fourth in table 2). The ranking for Georgia origin was even higher (69 first, 28 second, 3 third, and 0 fourth). Table 3 shows consumers purchase carrots because they like the taste and believe they are good.

During the past season, we focused on the: (1) procurement and receiving inspection of carrots; (2) packingline inspection; (3) cooler inventory recording; and (4) packinghouse sanitation and personal hygiene.

Procurement and Receiving Inspection of Raw Carrots

The policy and procedures for carrot receiving was developed. The written policy and procedures detail the responsibilities and duties of co-op members, the packinghouse manager, assigned assistant, and packingline employees upon receiving carrots from the fields.

A form entitled “Carrot Receiving and Packing Report” was developed and used in the past harvest season. This form records: (1) arrival time, farmer name or number, and the lot number of the carrots received; (2) labor used and cost for grading and packing; (3) categorized final products; and (4) location of carrot sample storage for the lot. Detailed instructions for completing the form were provided to the packinghouse manager. A sample of the form and the instructions for completing it are shown in Appendix A.

Packingline Inspection

The quality of carrots coming off the line was measured and recorded on the *Packingline Inspection Record* form that was developed. Detailed procedures for packingline inspection were written. These procedures included five parts: (1) sample selection; (2) recording of basic sample information; (3) inspection of packing and labeling; (4) test of sweetness and bitterness; and (5) inspection of carrot appearance based on USDA standards.

Each grade had a separate form entitled *Packingline Inspection Record* for U.S. No. 1, U.S. No. 1 Jumbo, and U.S. No. 2, which were developed and used in the past harvest season. USDA standards and sample tolerance information were incorporated into the form based on the standards for each grade. Allowable tolerances were provided for each attribute and for the total sample. Procedures for measuring sweetness and other attributes were provided. Detailed instructions for inspection and form preparation were provided.

Cooler Inventory Recording

A form titled *Cooler Inventory* was developed and used in the past season. The form recorded volume, bag size, and date of final carrots received in the cooler; volume and date of carrots shipped to customers; and the balance of cooler inventory for each grade and bag size. Instructions for preparing the form were provided.

Packinghouse Sanitation and Personal Hygiene

Policy and requirements for packinghouse sanitation and personal hygiene were written. Responsibilities and the role of employer and employees were specified. Packinghouse sanitation included plant and grounds, carrot handling and storage upon arrival, final carrot handling and storage, waste disposal, and pest control. Personal hygiene guidelines included facilities and employee hygiene. The preliminary guidelines and instructions are shown in Appendix B.

Preparing for Next Year

Several actions will be needed to make sure that carrot marketing next year builds on successes from this year. Expansion of the brand name and enhancement of the reputation of the cooperative depends on delivery of shipments with consistent quality. Obtaining consistency depends on developing and following procedures, especially for actions that do not show any results for several days. Thus, written procedures and records verifying the completion of a task are very important. Actions needed include:

(1) Assign a person responsible for Quality Control.
(2) Develop written procedures for operations (as done this year, with changes based on experience)
(3) Develop a Quality Control Manual with sections in addition to operating procedures.
(4) Obtain feed back on marketing from the broker, customers, and consumers.
(5) Improve measurement methods for quality attributes.

Plans have been made to expand the number of written procedures relating to quality management. The foreword in Appendix C and the proposed preface in Appendix D give an overall description of the approach suggested for developing a Quality System. The Table of Contents in Appendix E indicates some of the materials that have been prepared in anticipation of expansion of the materials described above. The complete *Quality Control Manual* will demonstrate the determination of the growers and the packinghouse to adhere to the highest standards recognized on the U.S. and international fresh vegetable market.

The reputation of Georgia Sweet Carrots will continue to grow as consistent quality carrots are shipped. The written procedures, forms, and records will help to ensure quality remains consistently high. The commitment to quality by the Georgia carrot growers enhances opportunities for increasing revenues in the future.

APPENDIX A

Georgia Sweet Carrot Cooperative
Carrot Receiving and Packing Report

Arrival date		Farmer	
Arrival time		Variety/Lot #	

Start time for grading	
End time for grading	

Task	# of workers	Hours	# of workers	Hours	# of workers	Hours	Total work hours
Grading							
Packing							
Other							
Total labor cost							

Final product (masters)	1 lb	2 lb	3 lb	5 lb	25 lb	50 lb	Total
U.S. No. 1							
U.S. No. 1 Jumbo							
U.S. No. 2							
Increment							
Dehydrated							
Other							
Weight of culls							

Sample location	
Inspector	
Date	

Notes:

Instructions for Completing *Carrot Receiving and Packing Report*

Arrival date:	Record the date that carrots are received.
Arrival time:	Record the time that carrots are received.
Farmer:	Write down the name of the farmer whose carrots are received.
Variety/Lot#:	Record the variety of the carrots or the lot number where received carrots were planted.
Start time for grading:	Record the time that grading starts.
End time for grading:	Record the time that grading is completed.
# of workers and Hours:	Record the number of workers for grading, packing, and other tasks and hours they work, respectively.
Total work hours:	Calculate and record the total number of hours for grading, packing and other tasks.
Total labor cost:	Calculate and record the labor cost for grading, packing and other tasks.
Final product:	Report the number of the master bags (1 Master = 50 lbs) of final products from the delivery of carrots in this report separately according to bag size and grade.
Increment:	Record the amount of increment.
Dehydrated:	Record the amount of dehydrated carrots.
Weight of culls:	Record the amount of culls.
Sample location:	Record the cooler location where samples representing this lot are located.
Inspector:	The inspector who completed this report signs.
Date:	Write the date this report is completed and signed.

APPENDIX B

Packinghouse Sanitation and Personal Hygiene

Packinghouse sanitation and personal hygiene are important to prevent and avoid contamination of the product by pests, microorganism, dust and other foreign materials.

Packinghouse Sanitation

Employees Will Create and Maintain a Sanitary Packinghouse.

Plant and Grounds

- Keep the grounds surrounding the facility free of standing water, rodent harborage, debris, excessive dust, weeds, and insect-breeding materials.
- Clean floors, walls, and ceilings periodically and keep them free of debris.
- Sanitize floors, walls, and ceilings regularly.

Raw Carrot Handling and Storage

- Clean and, if necessary, sanitize raw carrot handling equipments before use.
- Clean raw carrot storage areas periodically, and keep them free of debris, rodents, insects or other pests.

Finished Carrot Handling and Storage

- Clean/sanitize carrot processing and packing equipment before use.
- Avoid cross-contamination between raw and processed carrots.
- Keep packaging materials in a clean location.
- Store finished carrots in clean and properly maintained areas.
- Never store raw carrots and processed carrots together.

Waste Disposal

- Pick up dropped carrots immediately and place them in the appropriate container.
- Put rejected carrots in waste bins, and discard them away from the packinghouse when bins are full or at the end of the day.

Pest Control

- Plant should be well equipped to keep vermin out.
- Frequently clean and properly maintain working, storage, and rest areas so pests do not have food, water, and shelter.
- Promptly destroy pests if found.
- The assigned employee must keep chemicals and other hazardous substances in a safe area.

Personal Hygiene

Proper Personal Hygiene Is Required of all Employees

Facilities

- Restroom and break room must not open directly into processing areas.
- The assigned employee must clean rest room and break room regularly and keep them in an orderly manner.

Employee Hygiene

- Packingline personnel must be healthy, showing no evidence of a communicable disease.
- All employees on packingline must be clean and report to work in a sanitary condition.
- All employees must not smoke, eat or drink except in designated areas.
- All employees on packingline must wash their hands with soap and water before leaving the rest room.

APPENDIX C

Proposed Foreword

This QUALITY ASSURANCE MANUAL FOR SWEET CARROT PACKINGHOUSE was prepared as a proposed model program for a sweet carrot packinghouse. The overall approach and the contents are based on International Standard ISO 9004.

Changes to this proposed model will be made according to input received from the packinghouse manager and co-op members. The resulting manual will then be published with the intention that changes will be made as needed.

The proposed model manual was made realistic by writing it as though the authors were the actual owner and manager of a sweet carrot packinghouse.

A management program is a tool for helping to ensure that the quality of the carrots is consistently at the level selected. Writing out the plans and procedures unique to your packinghouse will help clarify and communicate your expectations.

It is also critical that this manual include only the statements and activities that you fully intend to complete. Omit any activity you are not convinced should be implemented.

Format of the Manual:

The Table of Contents includes a revision number for each section. The revision number at the bottom of the Table of Contents page indicates the current revision for the complete manual. Each manual should be numbered and a record kept of its location, so all copies can be updated when a section is revised.

At the bottom of the first page for each section in the manual is a signature block for management to show their approval of the section. Any future revisions will be signed in the same way.

Benefits:

- A consistent and progressively improved level of quality.
- A recognized unique product, and improved marketing ability.
- Well-defined procedures, responsibilities, and authorities.

APPENDIX D

Proposed Preface

As the packinghouse manager of Georgia Sweet Carrot Cooperative, I believe that long term success depends on the quality of the carrots we ship. We are confident the management program described in this manual provides the tools necessary for consistently delivering to our customers quality sweet carrots at competitive prices.

We realize this packinghouse is one link in the chain for delivering sweet carrots to the tables of consumers. Thus, we are especially committed to the extra management effort needed to ensure proper completion of tasks that do not show any immediate impact but are critical to maintaining the quality of our carrots at later links in the chain.

This manual describes the management program we developed for controlling the activities and factors affecting the quality of our carrot shipments. The elements of the program are based on international standard ISO 9004, *Quality Management and Quality System Elements - Guidelines.* The purpose of this manual is to communicate details of our management policies, plans, and procedures to all employees.

The process of organizing our plans and operations into a written manual was useful for clarifying the responsibilities of each employee and for identifying the communications necessary among various departments. Viewing the packinghouse as a complete system resulted in changes that will improve operating efficiency as well as product quality.

After implementing this program, we will be in a position to build on the foundation begun by this first written QUALITY ASSURANCE MANUAL. Continual improvements are expected as we expand our initial efforts.

APPENDIX E

Proposed Table of Contents

Section		Revision	Effective Date
Title Page		-0-	15 June 97
Foreword		-0-	15 June 97
1	Preface	-0-	15 June 97
2	Contents	-0-	15 June 97
3	Quality Policy	-0-	15 June 97
4	Organization	-0-	15 June 97
5	Quality Assurance	-0-	15 June 97
6	Marketing	-0-	15 June 97
7	Specifications and Designs	-0-	15 June 97
8	Packinghouse Operations	-0-	15 June 97
9	Procurement and Receiving Assessment	-0-	15 June 97
10	Final Product Inspection	-0-	15 June 97
11	Cooler Inventory	-0-	15 June 97
12	Packinghouse Sanitation and Personal Hygiene	-0-	15 June 97
13	Personnel	-0-	15 June 97
14	Safety and Liability	-0-	15 June 97

APPENDIX F

Proposed Quality Policy

This section describes the quality policy and objectives to be fulfilled.

The quality policy of the co-op, packinghouse manager, and workers at Georgia Sweet Carrot Cooperative is to continuously improve management practices as a means to make consistently superior sweet carrots available to the consumers at costs resulting in long-run profits for the co-op.

Our quality policy will be achieved by accomplishing the following objectives:

- To implement the policy, plans, procedures, and other quality system activities described in this manual.
- To maintain evidence that carrots were grown, harvested, packed, handled, and shipped in ways that ensure consumers receive carrots that are: extra sweet, safe, wholesome, and high in value.
- To invest the resources necessary to minimize quality losses during packing and shipment.
- To develop improved marketing policies and procedures.
- To evaluate this management program after one year and to enhance it as necessary.

Table 1. Atlanta Consumer Survey - December 1994

	Do you pay attention to the country of origin of fresh vegetables when you buy them?			
Carrot buying frequency	**Never**	**Sometimes**	**Most of the time**	**Always**
	percent			
Often	24	51	22	2
Very often	22	45	16	17
Total sample	25	49	17	9

	Do you think the place of vegetable origin influences quality perception?		
	No	**Yes**	**Don't know**
	percent		
Often	10	63	27
Very often	10	70	20
Total sample	10	67	23

Source: W. J. Florkowski and C. L. Huang, Department of Agricultural and Applied Economics, The University of Georgia, College of Agricultural and Environmental Sciences, Griffin Campus, Griffin, Georgia.

Table 2. Preferences for the Origin of Vegetables Reported in the Atlanta Consumer Survey - December 1994

	Percent of respondents assigning the rank			
Carrot buying frequency	**1**	**2**	**3**	**4**
		USA		
Often	27	68	3	2
Very often	41	57	2	0
Total sample	36	60	2	1
		GEORGIA		
Often	79	21	0	0
Very often	66	31	3	0
Total sample	69	28	3	0

Source: W. J. Florkowski and C. L. Huang, Department of Agricultural and Applied Economics, The University of Georgia, College of Agricultural and Environmental Sciences, Griffin Campus, Griffin, Georgia.

Table 3. Atlanta Consumer Survey - December 1994

Reason for eating fresh vegetables	Carrot purchase frequency		Total for both frequencies
	Often	Very often	
	percent		
Like taste			
Agree	14	13	27
Strongly agree	21	51	72
Inexpensive			
Agree	2	9	11
Strongly agree	18	37	55
Easy to prepare			
Agree	23	34	57
Strongly agree	4	22	26
Vegetables are good			
Agree	19	14	33
Strongly Agree	16	50	66
Vegetables are a source of vitamins			
Agree	17	15	32
Strongly agree	18	47	65

Note: The figures do not add to 100 percent because the remaining respondents selected from among other options: “somewhat agree,” “disagree,” and “don’t know.”

Source: W. J. Florkowski and C. L. Huang, Department of Agricultural and Applied Economics, The University of Georgia, College of Agricultural and Environmental Sciences, Griffin Campus, Griffin, Georgia.

Soluble Solids and pH of Supermarket Carrots

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Materials and Methods:

Carrots were obtained from five local supermarkets. Soluble solids and pH measurements of these carrots were compared by type – fresh market or baby carrots – and state. Locally-grown carrots, variety 'Choctaw' (planted September 10, 1996), and carrots from a Michigan storage company (carrots stored since **November** 1996) were used to gauge carrot quality. The carrots were obtained February 13, 1997, and were sampled twice on two different dates. All samples were placed in cold storage at 40 degrees F for 5 days before testing and between testing dates.

A Fisherbrand hand held refractometer was used to measure soluble solids, and an Orion portable pH/mV temperature meter was used to measure pH. From the fresh market carrots, three carrots from each sample were sampled; from the baby carrots, only a third of each sample was used. These carrots were peeled and 1 in. discarded from each end, fresh market carrots only. The samples were then blended to a mulch and juiced using a kitchen sieve and pestle. The juice was filtered using doubled coffee filters. The pH electrode was triple rinsed between samples using distilled water, 70% ethanol, and distilled water. The 70% ethanol was used to prevent a film from forming on the electrode bulb.

Results and Discussion:

In Trial #1 (February 18), soluble solid and pH readings in the fresh type carrots were higher than in the baby type carrots (Table 1). While soluble solid readings in fresh carrots ranged from 7.0 to 10.0 and pH measurements were from 6.17 to 6.44, the baby carrot's soluble solids readings were 6.5 to 8.5 and pH measurements from 4.97 to 6.4. By state/region, the California carrots' (fresh type) soluble solid and pH readings were higher on average followed by Florida (soluble solids) and Canada (pH).

In Trial #2 (March 20), the soluble solid and most pH readings were lower; only carrots from Florida showed an increase in pH. However, fresh carrots' readings (6.9 to 9.5 soluble solids and 5.95 to 6.63 pH) were still higher than baby carrots' (7.2 to 8.4 soluble solids and 5.52 to 6.34 pH). Also, California carrots were still averaging higher soluble solids readings than Florida and Canada, but Florida's pH readings were higher.

From the carrots used to gauge the quality of these carrots, pH and soluble solid readings were high at the beginning of storage and began to decrease after extended storage. These findings were consistent with the supermarket carrot findings.

Table 1. pH and Soluble Solids of Supermarket Carrots

					February 18, 1997		March 20, 1997	
#	Vendor	Type	Producer	Location	% Solids	pH	% Solids	pH
1	CPES, Hort.	Fresh	CPES, Horticulture Dept.	Tifton, GA	9.5	6.59	8.5	6.34
2	Michigan Storage	Processing	Michigan Storage	Michigan	9.0	6.24	8.7	6.23
15	Winn Dixie	Baby	Kern Ridge Growers, LLC	Arvin, CA	8.5	6.40	8.4	6.34
11	Piggly Wiggly	Baby	Grimmway Farms	Bakersfield, CA	8.0	6.18	7.2	5.94
16	Winn Dixie	Baby	Taylor Packing, Inc.	Lamont, CA	7.7	6.43	7.7	6.42
9	Food Lion	Baby	Fresh 1 Marketing, Inc.	Los Angeles, CA	7.5	6.26	7.5	5.59
7	FoodMax	Baby	Grimmway Farms	Bakersfield, CA	7.5	6.40	7.5	5.98
3	Harveys	Baby	Dole Fresh Veg., Inc.	Salinas, CA	7.2	5.86	7.7	5.52
14	Winn Dixie	Baby	Peter Rabbit Farms	Coachella, CA	6.5	4.97	--	--
8	FoodMax	Fresh	Grimmway Farms	Bakersfield, CA	9.5	6.33	8.5	6.13
10	Food Lion	Fresh	Fresh 1 Marketing, Inc.	Los Angeles, CA	9.0	6.33	8.4	6.06
12	Piggly Wiggly	Fresh	Grimmway Farms	Bakersfield, CA	8.2	6.35	8.1	6.23
13	Piggly Wiggly	Fresh	A. Duda and Sons, Inc.	Oviedo, FL	10.0	6.41	9.2	6.48
19	Winn Dixie	Fresh	Growers Precoolers, Inc.	Apoka, FL	8.5	6.20	8.0	6.49
17	Winn Dixie	Fresh	A. Duda and Sons, Inc.	Oviedo, FL	8.5	6.19	9.5	6.63
5	Harveys	Fresh	Zellwinn Farms Co.	Zellwood, FL	8.2	6.36	7.5	6.04
18	Winn Dixie	Fresh	Zellwinn Farms Co.	Zellwood, FL	8.0	6.29	8.4	6.44
20	Winn Dixie	Fresh	Long Farms, Inc.	Apoka, FL	7.0	6.17	6.9	6.27
6	Harveys	Fresh	Carron Farms Limited	Bradford, CAN	9.0	6.44	8.1	5.95
4	Harveys	Fresh	Exeter Produce & Storage	Holland Landing, CAN	7.5	6.34	7.5	6.12

Consumer Acceptance and Physicochemical Measurements Of Quality of Georgia Carrots

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Introduction:

To be competitive in the carrot industry, Georgia carrots should be acceptable to consumers. Quality is important in the selection of carrots. The perceived quality of carrots at the market place influences its purchase by consumers. Once purchased, the carrots must have the eating quality that is expected or the consumers will not purchase the carrots again. Much research has been conducted on characterizing the quality of raw carrots. These studies have been conducted to compare carrots grown in several states including California, Florida, and Texas; however, no studies have been conducted on the quality of Georgia carrots.

The objective of this study was to compare Georgia cultivars with market samples of California and Florida carrots. Specific objectives were to:

1. measure overall acceptability and hedonic ratings for color, flavor, sweetness, tenderness /hardness and fibrousness/pithiness/woodiness, and
2. determine the relations between ^{o}Brix, percent total sugars, moisture content and selected sensory attributes of Georgia, California and Florida carrots.

Materials and Methods:

Samples

Two studies were conducted on Georgia carrots grown in Jefferson and Wayne counties, Georgia, planted on October 1, 1996, and November 4, 1996, and harvested on March 27, 1997, and May 8, 1997, respectively. Carrot cultivars were screened for ^{o}Brix and percent total solids content and production data. Production and quality parameters were used to select 10 cultivars.

Carrots with the highest ^{o}Brix and percent total solids content were used to select 5 cultivars. These carrots were stored for approximately two weeks at 0 degrees C, 65% relative humidity and 2.2 degrees C, 80% relative humidity, respectively. Market samples of carrots from Bakersfield, CA, and Apopka, FL, were purchased and stored under identical conditions as the Georgia samples used in study 1, and samples from Bakersfield, CA, and Oviedo, FL, used in study 2. The samples evaluated during the two studies are shown in Table 1.

Consumer Sensory Evaluations:

Consumers evaluated a total of nine carrot samples consisting of five Georgia carrots, two California carrots, and two Florida carrots in each of two sessions. On the test date, carrots were taken out of storage, dipped in a chlorine solution, then rinsed and dried. Samples were prepared by peeling, then slicing the middle third portion of the carrot into 0.5 cm slices. Two to three pieces, approximately 8 g, were placed into a 60 ml capacity plastic cup with lid, pre-labeled with a three digit random number. Ten to sixteen cups of samples were prepared for each cultivar, the cups were placed in a plastic bag and held in the refrigerator until served to consumers. Two replications of the studies were conducted.

A total of 135 consumers were recruited to obtain a minimum of 100 responses. Consumers were recruited by telephone according to a recruitment screener from a consumer database maintained at the Center for Food Safety and Quality Enhancement at the Georgia Experiment Station in Griffin, GA, or from a telephone directory. Additional participants were recruited at central locations such as grocery and retail stores, fast-food establishments and through referrals. Qualifications for participation were that panelists (1) be between 18-65 years old, (2) not be allergic to carrots, and (3) eat raw carrots at least twice a month.

During the test, consumers were asked to register and instructed to fill out consent forms, honorarium forms, and a demographic questionnaire. A brief orientation was given to consumers to instruct them on the use of the signal lights, which minimize contact between themselves and servers. Consumers evaluated samples while in partitioned booths, which help to minimize communication between themselves and other panelists. Panelists evaluated samples under incandescent lights and environmentally controlled conditions. A balance sequential monadic presentation was used to serve carrot samples to consumers. During each evaluation session, consumers evaluated five samples, had a compulsory three-minute break, and then evaluated another four samples. Consumers were instructed to rinse their mouths out with water between samples.

The sensory ballots used in the evaluation of carrots were developed using the Sensorex (Version 4.03, Softex, Inc., Lancaster, PA) software program for automated data entry. A 9-point hedonic scale, with 1= dislike extremely and 9= like extremely, was used for evaluating carrots for overall acceptance, color, flavor, sweetness, tenderness/hardness, and fibrousness/pithiness/woodiness.

^{o}Brix Measurements:

Three carrots of each replication were selected for measurements of ^{o}Brix and percent total sugars. Approximately 2" was cut off from each end and the middle portion was used for analysis. The samples were blended into a puree using a retail juicer and filtered through Whatman #1 filter paper to remove particulates. The filtrate was used to obtain measurements of ^{o}Brix and percent total sugar. ^{o}Brix measurements were obtained from 3-4 drops of the carrot juice placed on the refractometer stage using a Pasteur pipette and directly recorded.

Total Sugars:

A 2 ml filtrate was pipetted into centrifuge tubes and 30 ml of 100% ethanol was added to each tube immediately followed by addition of Celite, a settling agent. The tubes were then shaken to ensure proper distribution of ethanol and Celite, and steamed 10 minutes in a 55 - 80-degree C water bath. The tubes were weighed and balanced with 100% ethanol to ensure no more than 0.5g difference in weight between samples.

The tubes were centrifuged at 15,000 rpm for 10 minutes, then decanted through Whatman #1 filter paper into 100 ml volumetric flasks. The centrifuge tubes with Celite were then refilled with 30 ml of 60% ethanol, steamed and centrifuged as previously described. After the second centrifugation, the 60% ethanol was filtered and filtrate added to the filtrate in the volumetric flask. The volumetric flask was filled to volume with 100% ethanol then shaken to ensure even distribution.

Two (2) ml of solution from each 100 ml volumetric flask were pipetted into each of three centrifuge tubes. One (1) ml of 5% phenol and 5 ml of 95.5% concentrated sulfuric acid were added to each tube and then allowed to stand 10 min, followed by gentle shaking to obtain equal reactivity throughout the tube. The tubes were then placed in a 30-degree C water bath for 15 minutes. Dilutions were made to enable accurate readings on a spectrophotometer. It was determined that a dilution of 1:4 would be required, or 3 ml of the prepared acid/phenol extract from each tube to 9 ml of distilled water. The diluted mixture was shaken using a test tube shaker. An aliquot of the diluted mixture was then poured into clean, dry spectrophotometer tubes. A "blank" was prepared with 2 ml distilled water, 1 ml phenol, and 5 ml sulfuric acid. Absorbance was read at 490 nm. To determine the percent sugar, the average absorbence readings were calculated and compared with a standard curve, which was prepared using 1 ml of 5% phenol, 5 ml sulfuric acid and 10, 25, 50, 75 and 100 mg glucose. Glucose was diluted and made to volume with distilled water. Using values obtained from the glucose standards, values were estimated for the carrots using absorbence readings in comparison with the glucose samples. Values obtained from the curve, representing the mg/ml glucose in the carrot samples was used for further calculations (mg/ml glucose x 0.1 x 0.25). The final calculation represents the percent sugar for each determination.

Moisture:

Moisture was measured using a vacuum oven. One (1)g of unfiltered carrot puree was weighed into dry, pre-weighed aluminum dishes and placed in the oven set to 20 psi with an internal temperature of 80 degrees C. The samples were allowed to dry 24 hr, cooled, and then weighed.

Results:

Demographic Characteristics:

Demographic characteristics of participants. A total of 111 and 104 consumers participated in study 1 and study 2 , respectively. Their demographic characteristics are presented in tables 2 and 3.

Consumer Sensory Evaluations:

Consumer acceptance ratings are shown in Tables 4 and 5 for study 1 and 2, respectively. Mean scores for overall acceptance, color, flavor, sweetness, tenderness/hardness, and fibrousness/pithiness/ woodiness are shown for the nine samples tested in each study.

Overall acceptance. In study 1 (Table 4), mean ratings for overall acceptance from California 1 and 2 and Georgia cultivar 'XPH 3973' were rated at least a 6 or *like slightly* by consumers. No significant differences between these three samples were found. 'Vitasweet 711' was found not significantly different from 'XPH 3973' but significantly lower than California 1 and 2. No significant differences were found between 'Six Pack F1,' 'Choctaw,' and 'Ireland.' Carrots from Florida were least accepted by consumers.

In study 2, California carrots had the highest overall acceptance ratings, while Florida carrots had the lowest ratings. The Georgia cultivars had intermediate ratings.

Color. Although the color of all the carrot samples were found to be acceptable in study 1, the color of California, 'Vitasweet 711' and 'Ireland' carrots received the highest ratings (7 = "like moderately" or higher). In study 2, all Georgia and California carrots had an acceptable color. The color of Florida carrots was not acceptable to consumers.

Flavor. In both studies 1 and 2, flavor of California carrots was most preferred by consumers and that of Florida carrots were least preferred. The Georgia cultivars were preferred less than the California carrots and more than Florida carrots. In both studies, 'Choctaw' had the least acceptable flavor, which was significantly rated lowest in study 1, and was significantly lower than both California samples and 'Dawn Dee' in study 2.

Sweetness. In both studies, California carrots had the highest sweetness acceptance ratings, while Florida carrots had the lowest. Georgia carrots received intermediate ratings for sweetness that were significantly lower than the California carrots but higher than the Florida carrots. 'Choctaw' was the least sweet among Georgia cultivars in study 1, but in study 2 was not found less sweet than other Georgia carrots.

Tenderness/Hardness. The tenderness/hardness of both California carrots was preferred in studies 1 and 2. 'Cheyenne' was preferred as much as the California carrots in Study 1. Florida carrots were given the lowest ratings for tenderness and hardness in study 1, but in study 2 were not less accepted than 'Choctaw,' 'Vitasweet 711,' and 'Asgrow 3016.'

Fibrousness/Pithiness/Woodiness. In studies 1 and 2, California cultivars were most preferred, indicating that they were not fibrous, pithy or woody. 'XPH 3973' received the same ratings (study 1). Florida carrots received low acceptance ratings for fibrousness, which were not different from 'Choctaw' and 'Six Pack F1' ratings in study 1. In study 2, however, Florida carrots received the lowest acceptance ratings for fibrousness and all Georgia cultivars received ratings intermediate to California and Florida cultivars.

^{o}Brix, Total Sugars and Moisture Contents:

^{o}Brix, total sugars and moisture content are shown in Tables 6 and 7 for studies 1 and 2, respectively. ^{o}Brix reading of the California carrots were highest and Florida carrots lowest in study 1. Georgia carrots had intermediate ^{o}Brix readings. 'XPH3973,' 'Choctaw' and 'Ireland' had the highest readings among the Georgia carrots. In study 2, 'Dawn Dee' had the highest ^{o}Brix reading followed by 'California 2' and 'Choctaw.' 'Cheyenne' and 'Florida 2' had lowest readings; however, 'Florida 2' was not significantly different from 'Vitasweet,' 'Asgrow' and 'Florida 1.'

'California 2' had the highest total sugar and Florida 1 and 2 had the lowest total sugar in study 1. 'California 1' and all Georgia carrots had intermediate total sugar readings. In study 2, 'California 2' had the highest total sugar, followed by 'Choctaw' and 'Florida 2,' while 'Asgrow' had the lowest. However, there were no differences between 'Asgrow' and 'Florida 1,' which was similar to several other carrots.

Relations Between Compositional and Sensory Measurements:

Correlation coefficients between °Brix, total sugars, moisture content and sensory ratings are shown in Table 6. The correlation coefficients between °Brix, total sugars and moisture content are significant ($p \leq 0.05$). However, the magnitude of the correlations are too low to be considered important (correlation of 1.00 = very highly correlated; 0.00 = no correlation). This indicates that while °Brix may be an indicator of the soluble solids (includes sugars) in the sample, perceived sweetness and overall acceptance may be rated lower when the carrots contain flavor compounds such as those contributing harsh, carroty, bitter and astringent flavors, which may affect the perception of sweetness.

Discussion:

In general, the acceptability of California carrots was highest, followed by Georgia carrots then Florida carrots. In most instances, some Georgia cultivars were not as acceptable as the California carrots, but were more acceptable than Florida carrots. Some Georgia cultivars were either more or less acceptable than the other Georgia carrots.

Among the Georgia carrots, 'XPH 3973' and 'Vitasweet 711' were most preferred. The 'XPH 3973' can compete with the California carrots on overall acceptance. The flavor of 'Choctaw' carrots deleteriously influenced its acceptance as demonstrated in both studies. 'Choctaw' was found least sweet among the Georgia carrots. Although 'Choctaw' had a high sugar content, its perceived sweetness does not reflect this in study 1.

'Choctaw' is the cultivar that is most widely grown throughout Georgia. Although our results are based on two studies, they indicate that there are cultural conditions that may influence the overall acceptability of the carrots. Conversely, other conditions may result in cultivars such as 'XPH 3973' receiving overall acceptance ratings as high as the California cultivars.

It is extremely important to quantify the quality of Georgia carrots that are high yielding and to determine the cultural conditions that influence their variability. Likewise, it is important to conduct studies that will help to determine what cultural and post-harvest handling practices require sufficient controls to produce Georgia carrots that are high in consumer acceptability.

Table 1. Samples evaluated during two harvest studies.

Sample Code	Cultivated/Market Sample
Study 1	
GA 1	Six Pack F1
GA 2	XPH 3973
GA 3	Choctaw
GA 4	Vitasweet 711
GA 5	Ireland
CA 1	California 1 (Bakersfield, CA)
CA 2	California 2 (Bakersfield, CA)
FL 1	Florida 1 (Apopka, FL)
FL 2	Florida 2 (Apopka, FL)
Study 2	
GA 1	Choctaw
GA 2	Cheyenne
GA 3	Vitasweet 711
GA 4	Dawn Dee
GA 5	Asgrow
CA 1	California 1 (Bakersfield, CA)
CA 2	California 2 (Arvin, CA)
FL 1	Florida 1 (Oviedo, FL)
FL 1	Florida 2 (Oviedo, FL)

Table 2. Demographic characteristics of participants for study 1.

Variable	Term	Percent (%)
Age (n=106)	18-24 yrs old	10.0
	25-34 yrs old	12.7
	35-44 yrs old	31.8
	45-54 yrs old	31.8
	55-65 yrs old	13.7
Sex (n=107)	Male	19.6
	Female	80.4
Race (n=106)	White	80.7
	Others (Black, Spanish/Hispanic, etc.)	19.3
Marital Status (n=106)	Single	28.4
	Married	71.6
Education (n=107)	Less than 7 yrs of school	0.9
	Junior high school	5.6
	Some high school	8.4
	Completed high school or equivalent	33.6
	Some college	27.1
	Completed college	15.0
	Graduate or professional school	9.3
Employ (n=106)	Employed full time	38.5
	Employed part time	17.4
	Home maker	21.1
	Student	2.8
	Others (retired, unemployed, disabled)	20.2
Income (n=106)	Under $9,999	6.6
	$10,000-$19,999	13.2
	$20,000-$29,999	14.2
	$30,000-$39,999	26.4
	$40,000-$49,999	14.2
	$50,000-$59,999	11.3
	$60,000-$69,999	7.5
	$70,000 and over	6.6

Table 3. Demographic characteristics of participants for study 2.

Variable	Term	Percent (%)
Age (n=104)	18-24 yrs old	25.0
	25-34 yrs old	15.4
	35-44 yrs old	21.2
	45-54 yrs old	22.1
	55-65 yrs old	16.3
Sex (n=104)	Male (n=60)	43.3
	Female (n=61)	56.7
Race (n=103)	White	79.6
	Others (Black, Spanish/Hispanic, etc.)	20.4
Marital Status (n=104)	Single	27.0
	Married	73.0
Education (n=104)	Less than 7 yrs of school	1.0
	Junior high school	2.9
	Some high school	7.7
	Completed high school or equivalent	25.0
	Some college	43.3
	Completed college	11.5
	Graduate or professional school	8.7
Employ (n=104)	Employed full time	34.6
	Employed part time	12.5
	Home maker	12.5
	Student	14.4
	Others (retired, unemployed, disabled)	26.0
Income (n=101)	Under $9,999	5.0
	$10,000-$19,999	12.9
	$20,000-$29,999	17.8
	$30,000-$39,999	23.8
	$40,000-$49,999	10.9
	$50,000-$59,999	11.9
	$60,000-$69,999	6.9
	$70,000 and over	10.9

Table 4. Mean hedonic ratings[1,2] of overall acceptance, color, flavor, sweetness, tenderness/hardness, and fibrousness/pithiness/woodiness of raw carrots for study 1.

Cultivar/ Market sample[3]	Overall Acceptance	Color	Flavor	Sweetness	Tenderness/ Hardness	Fibrousness/ Pithiness/ Woodiness
Six Pack F1	5.8cd	6.4d	5.8b	5.7c	6.2c	5.9bc
XPH 3973	6.4ab	6.8bc	6.2b	6.2b	6.8ab	6.6a
Choctaw	5.4d	6.4cd	5.3c	5.0d	5.6d	5.4d
Vitasweet 711	6.3bc	7.1ab	6.2b	5.9bc	6.4bc	6.1b
Ireland	5.8cd	7.1ab	5.8b	5.6c	6.2c	6.1b
CA 1	6.9a	7.5a	6.8a	6.8a	6.9a	6.8a
CA 2	6.9a	7.3a	6.8a	6.8a	6.8ab	6.7a
FL 1	4.7e	6.6cd	4.3d	4.1e	5.8d	5.5cd
FL 2	4.6e	6.8bc	4.4d	4.1e	5.6d	5.5cd

[1] Attributes were rated according to the following hedonic scale:

1 = dislike extremely
2 = dislike very much
3 = dislike moderately
4 = dislike slightly
5 = neither like nor dislike
6 = like slightly
7 = like moderately
8 = like very much
9 = like extremely

[2] Values not followed by the same letter columnwise are significantly different ($p<0.05$). Mean separation test used was the least-significant-difference (LSD) mean comparison test.
[3] Carrots are: CA 1 = California 1 (Grimmway, Bakersfield, CA); CA 2 = California 2 (Grimmway, Bakersfield, CA); FL 1 = Florida 1 (Growers Precooler, Inc., Apopka, FL); FL 2 = Florida 2 (Long Farms, Inc., Apopka, FL).

Table 5. Mean hedonic ratings[1,2] of overall acceptance, color, flavor, sweetness, tenderness/hardness, and fibrousness/pithiness/woodiness of raw carrots for study 2.

Cultivar/ Market sample[3]	Overall Acceptance	Color	Flavor	Sweetness	Tenderness/ Hardness	Fibrousness/ Pithiness/ Woodiness
Choctaw	5.7b	6.7c	5.4c	5.3b	6.2bc	5.8b
Cheyenne	6.0b	6.8bc	5.8bc	5.4b	6.8a	6.0b
Vitasweet 711	6.0b	6.8bc	5.8bc	5.5b	5.6d	6.1b
Dawn Dee	6.1b	7.1abc	6.1b	5.8b	6.3b	6.2b
Asgrow	6.0b	6.9bc	5.8bc	5.4b	6.2bc	6.1b
CA 1	7.1a	7.2ab	6.6a	6.6a	6.8a	6.7a
CA 2	6.8a	7.4a	6.9a	6.9a	6.7a	7.0a
FL 1	4.2c	4.8d	4.0d	3.7c	5.8cd	4.8c
FL 2	4.0c	4.5d	3.7d	3.6c	5.6d	4.8c

[1] Attributes were rated according to the following hedonic scale:

1 = dislike extremely
2 = dislike very much
3 = dislike moderately
4 = dislike slightly
5 = neither like nor dislike
6 = like slightly
7 = like moderately
8 = like very much
9 = like extremely

[2] Values not followed by the same letter columnwise are significantly different ($p<0.05$). Mean separation test used was the least-significant-difference (LSD) mean comparison test.
[3] Carrots are: CA 1 = California 1 (Grimmway, Bakersfield, CA); CA 2 = California 2 (Kern Ridge, Arvin, CA); FL 1 = Florida 1 and FL 2 = Florida 2 (A. Duda & Sons, Inc., Oviedo, FL).

Table 6. Mean ratings[1] of Brix (°) and sugar content (%) measured before and during sensory evaluation and moisture content (%) measured during sensory evaluation of raw carrots for study 1.

	Before sensory evaluation		During sensory evaluation		
Cultivar	**Brix**	**Sugar**	**Brix**	**Sugar**	**Moisture**
Six Pack F1	9.16bc	7.81bc	8.74c	6.84e	90.59d
XPH 3973/1	9.08bc	8.13b	9.34b	6.03e	90.52d
Choctaw/1	9.53a	10.81a	9.22b	7.63d	89.44f
Vitasweet	9.0c	7.50bc	8.64c	8.42c	91.33c
Ireland/1	9.33ab	7.05c	9.52b	6.28e	90.52d
CA 1	----	----	10.13a	10.42b	89.88e
CA 2	----	----	10.53a	11.78a	89.36f
FL 1	----	----	7.07d	4.56f	92.89a
FL 2	----	----	7.53d	5.03f	92.34b

[1] Values not followed by the same letter columnwise are significantly different ($p<0.05$). Mean separation test used was least-significant-difference (LSD) mean comparison test.

Table 7. Mean ratings[1] of Brix (°) and sugar content (%) measured before and during sensory evaluation and moisture content (%) measured during sensory evaluation of raw carrots for study 2.

	Before sensory evaluation		During sensory evaluation		
Cultivar	**Brix**	**Sugar**	**Brix**	**Sugar**	**Moisture**
Dawn Dee	9.40c	6.73c	10.00a	8.71d	90.00d
Asgrow	9.63c	7.67b	7.80d	7.04fg	91.38a
Choctaw	10.47a	8.89a	9.04b	9.72b	89.94d
Cheyenne	9.47c	8.57a	8.07d	7.93de	90.70bc
VitaSweet	9.93b	7.78b	8.55c	9.54c	90.59c
CA 1	----	----	8.53c	8.58cde	91.38a
CA 2	----	----	9.30b	11.41a	89.86d
FL 1	----	----	8.60c	7.71ef	90.99b
FL 2	----	----	8.14cd	6.17g	91.58a

[1] Values not followed by the same letter columnwise are significantly different ($p<0.05$). Mean separation test used was least-significant-difference (LSD) mean comparison test.

Table 8. Correlation coefficient of Brix (°) measurement, total sugar content (%), moisture content (%), and sensory attributes of overall acceptance, flavor, and sweetness for carrot samples after harvested and during sensory evaluation period.

	Brix (°)		Total sugar content		Moisture	
Sensory Attribute	Correlation Coefficient	p-value	Correlation Coefficient	p-value	Correlation Coefficient	p-value
Overall Acceptance	0.49	0.009	0.53	0.004	-0.45	0.016
Flavor	0.53	0.004	0.50	0.006	-0.47	0.011
Sweetness	0.57	0.002	0.53	0.004	-0.50	0.007

Value-Added Produce - Market Niche or Future Staple?[2]

William O. Mizelle, Jr., Extension Economist

Market Trends:

Recent studies reveal that today's consumer is looking for high-quality, healthful products that can be prepared quickly. The trend toward healthier eating is resulting in increased consumption of fresh fruits and vegetables. The convenience factor is also helping to stimulate produce sales. With more two-income families, preparation time, and quality of the product appear to be more important than price in determining what products consumers buy. As well, the demographic shift toward smaller families and more singles and seniors means smaller quantities of all products are desired. Together, the health, convenience, and quality considerations are increasing demand for portion-packs of branded, pre-cut fruits and vegetables.

Adding Value:

One way of increasing profits is to cater to the consumer's need for healthful, convenient food by adding value to items in the produce department. Retailers are doing this by pre-cutting fruits and vegetables and either selling them in bulk or packaging them in shrink-wrap to maintain freshness.

Branded Produce:

Brand fruits have been around a long time. For example, Sunkist brand oranges have been around since 1907. However, branded vegetables, on a large scale, are newer arrivals and are experiencing slow but steady growth. Produce giant Dole Food Co. is aggressively marketing branded vegetables. Dole lettuce, celery and cauliflower are becoming familiar sights on retail counters. Del Monte now packages pre-cut celery and carrot sticks, broccoli and cauliflower florets, washed spinach, and coleslaw in retail stores. Executives interviewed by *Supermarket News* agreed that consumers are buying these products for the quality more than for the brand. Yet the fact that these companies, with a reputation for quality, put their name on a product and back it with advertising is establishing consumer confidence and steady growth.

Branded produce is a growing market, already accounting for $4.5 billion of the $37 billion produce industry. Many products have met consumer demands while proving to be quite profitable. In response to consumer demands for a variety of fresh fruits and vegetables, some distributors are marketing exotic and organic produce and charging premiums for Israeli tomatoes, Sun World International's seedless watermelons and other such items. Obviously, there is a lucrative market for precut, cleaned, and efficiently packaged fruits and vegetables.

[2]Adapted from an article by Gerry Rakobowchuk

Foodservice:

The dramatic growth of the fast-food industry, along with the ever-increasing cost of labor, created a demand for pre-cut salad vegetables and fruits. Pre-cut iceberg lettuce was introduced in the late 1960s and has become a staple in the food-service industry.

Pre-cut produce offers operators many advantages over bulk. Most importantly, it significantly lowers labor costs, since most pre-cut products are ready to eat or prepare. Because the product is less bulky, it is packed in smaller boxes and takes up less space in storage, thus decreasing packaging and warehousing costs. As well, the entire product is used, meaning less waste and reduced garbage disposal costs to the buyer.

Food-service buyers are turning to branded produce for its consistent quality, higher yield, and supplier reputation. Large shippers are marketing packaged salad mixes, pre-cut french fries, coleslaw, and spinach for the food-service and consumer markets.

Summary:

Sales of value-added produce, including those that are pre-cut and branded, are growing in both the retail and food-service markets. There is evidence that pre-cut fruits and vegetables, whether branded or not, increase overall sales in the produce department. The retailers feel that there is a market for both pre-cut and bulk fruits and vegetables. Retailers still cut up and package fresh fruits and vegetables and have begun to carry more name-brand products.

Outlook:

Changing demographics should continue to increase sales of value-added produce. Busy consumers will still look for healthful products that are easy to prepare. Older people will continue to eat more fresh fruits and vegetables, yet require smaller quantities, and to prefer individual portions or pre-cut products to avoid waste. Lastly, as labor costs continue to increase, more food-service operators will buy products that require minimum preparation time. These trends provide an opportunity for higher profits at all levels of the food industry by adding value to traditional products.

Carrots:

U. S. vegetable production increased 5 percent in 1996. Most of the gain was in fresh market. Per capita use increased for most items in 1996, with most of the gain in watermelon, cantaloup, **carrots**, bell peppers and sweet corn. The surging popularity of baby-cut and fresh-cut carrots continues to drive fresh carrot use higher. In 1996, **fresh carrot use rose 13 percent** to 10.2 pounds, compared with an average of 7.5 pounds in the 1980s. (Source: USDA, ERS, July 24, 1997)

Buyers of Carrots for Fresh Cut:

Some buy on the market, others buy on a fixed price. Segments are cut from jumbos, while tip ends are the 2-inch cuts. Some use 30-40000 pounds per week. However, distribution is seasonal, since schools are big users. Two-inch cuts hold 60 percent of the fresh cut market, while 4-inch cuts hold 40 percent. Some buyers are not interested in nonpeeled segments. Some sell mostly to food-service -- sticks, shreds, anything the customer wants.

Fresh Cut:

Vegetables' – $690 million – growth is likely to exceed salad sales in 1997 for the second year in a row. Vegetable sales grew by 19.5 percent in 1996. Salads grew at 16 percent. Growth in salads is decreasing. Fresh-cut carrots are about $480 million. Large growth is expected in baby peeled carrots. (Source: *The Packer,* A. C. Nielsen scan data). Mann Packing and Grimmway Farms place fresh cut (including carrots) at $1.2-1.3 billion in 1996 (April 7, *The Packer*). Different sources place baby peeled carrots among the three fastest growing fresh-cut items.

Refrigerated Salad Sales in 1996

Rank	City	Million $
13.	Los Angeles	73.6
14.	New York	62.4
15.	Chicago	41.1
16.	San Francisco	39.6
17.	Philadelphia	23.7
18.	Boston	19.8
19.	Denver	19.5
20.	Seattle	19.3
21.	Minneapolis	19.2
22.	Dallas	18.0

(Source: Information Resources, Inc.)

Grimmway Farms claims to be the world's largest producer of carrots. Sources say that Grimmway and Bolthouse control about 80 percent of U.S. carrot production. Golden Valley, a new operation in California, has hopes of gaining a 10 percent share of the market.

Shipping Containers:

50 lb. table carton
48 1-lb. carton
25 lb. table poly bags 24 2-lb. cartons
16 3-lb. cartons
10 5-lb. carton

Baby-peeled

24 1-lb. cartons
20 1-lb. cartons
10 2-lb. cartons
8 5-lb. cartons
73 3-oz carton

Food-service

50 and 25 lb. poly jumbo

Consumer packs

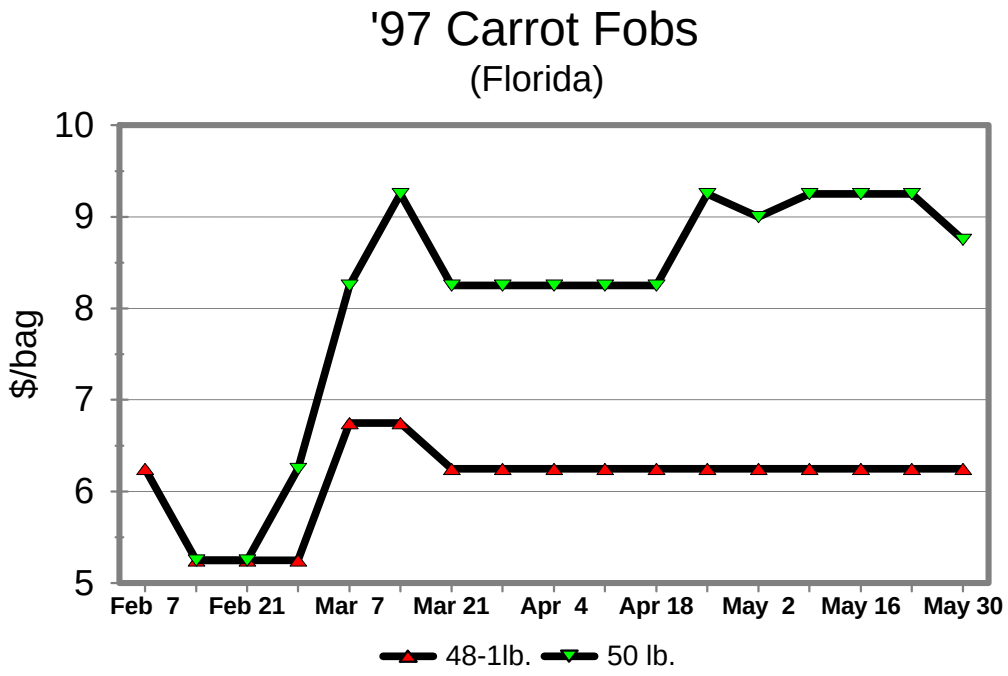
1, 2, 3, 5, and 10 lb. bags

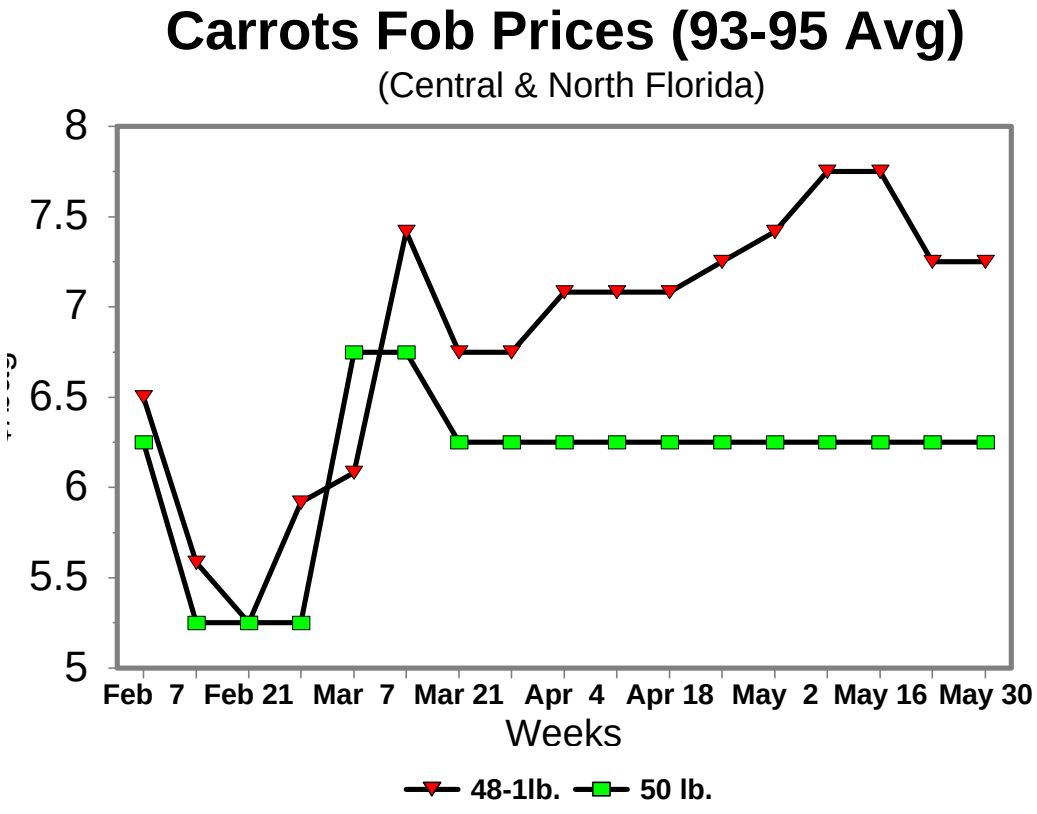
Value added packs

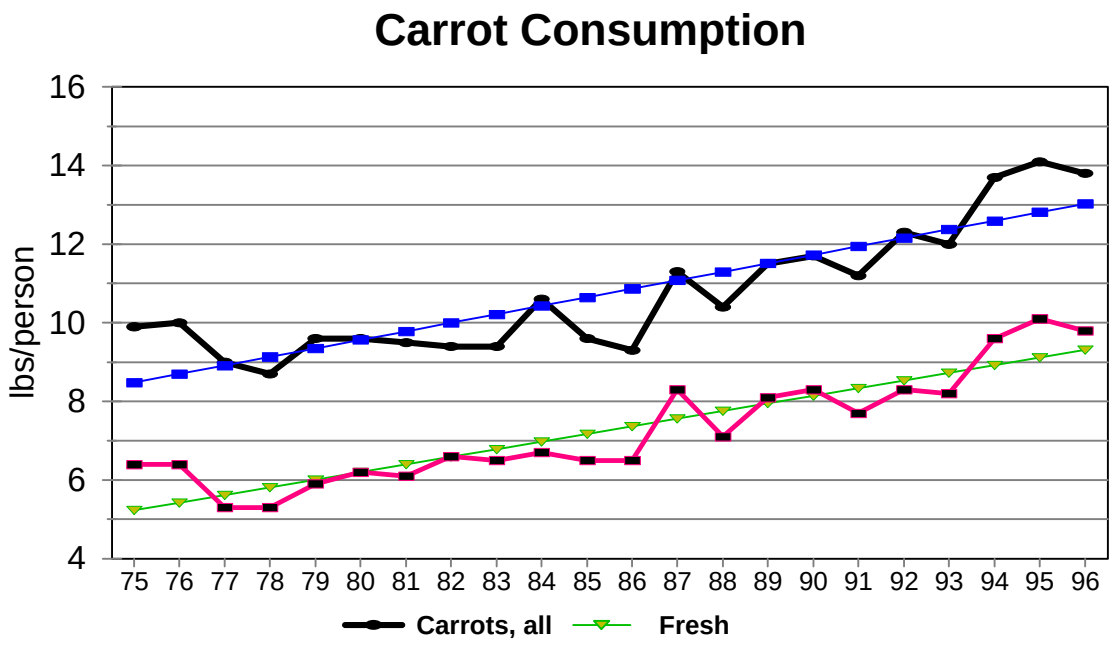
Cartons of 4 5-lb. bags of shredded carrots, carrot sticks and match sticks (Julienne-cut). Other cuts available are crinkle-cut sticks, diced, sliced, whole peeled or coined.

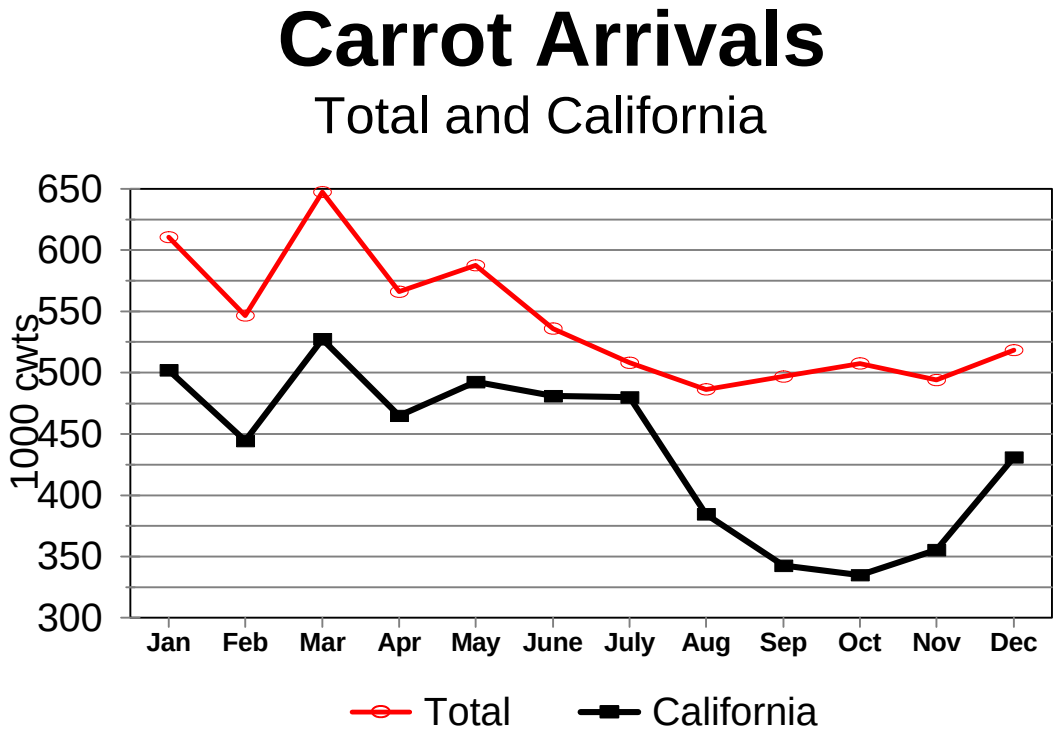
Charts Below

The first two charts show Florida f.o.b. spring carrots prices for 1997 and average spring prices. Georgia volume is not sufficient at this time for official price quotes. The second set of charts consumption trends and the size of California's carrot industry relative to the total U. S. supplies.


'97 Carrot Fobs
(Florida)
10
9
8
7
6
5
$/bag
Feb 7
Feb 21
Mar 7
Mar 21
Apr 4
Apr 18
May 2
May 16
May 30
48-1lb.
50 lb.


Carrots Fob Prices (93-95 Avg)
(Central & North Florida)
8
7.5
7
6.5
6
5.5
5
Feb 7
Feb 21
Mar 7
Mar 21
Apr 4
Apr 18
May 2
May 16
May 30
Weeks
48-1lb.
50 lb.


Carrot Consumption
16
14
12
10
8
6
4
lbs/person
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
Carrots, all
Fresh


Carrot Arrivals
Total and California
650
600
550
500
450
400
350
300
1000 cwts
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
Total
California

Economics

This chapter is divided into two sections. Section I is essentially a progress report to the Board of Directors of Georgia Sweet Carrot, Inc., by Mr. Rodney E. Bennett. Section II is a summary and analysis of the costs and returns from carrots.

SECTION I:

Progress Report of Georgia Sweet Carrot, Inc.

Rodney E. Bennett

My observation is that the initial year of operation has been eminently successful. The harvest season began on March 14, 1997. The last carrots were processed on June 6, 1997. Preliminary data indicate that in excess of 85,000 (50 Lbs.) masters were shipped. All masters processed for shipment were delivered to an end user. None were left over and none left in storage.

Carrot Quality/Marketing:

The farmers planted approximately 400 acres for the 1996/97 crop year. All of the acreage was harvested and processed except for a few acres that were graded unsatisfactory in the field. Those were too old or of such poor quality, they did not meet grading standards. Most were not worth harvesting due to disease or poor cultural practices.

The company experienced only one shipment of returned merchandise. Apparently one batch shipped to Canada had a high content of nitrogen that caused discoloration during shipment. The company replaced those carrots to that purchaser, who was one of the largest single buyers.

Carrot sales were in excess of $500,000.00 in operating revenue. Preliminary data indicate the price realized from sale of masters was a low of $4.50 to a high of $9.25, with an average of approximately $6.10.

Carrot Culture:

It has become increasingly apparent that farmers who use good cultural practices can produce a superior quality carrot. Tests conducted by the University of Georgia revealed that Georgia-grown carrots are of superior quality, second only to certain carrots grown in California. The difference is hard to detect. The carrots were well received by a widely diverse market.

Carrot quality is directly influenced by field practices. Too much or too little fertilizer and/or water, or lack of weed or disease control, will affect the quality and the quantity of carrots produced. As one might expect, the largest farmer produced the best and most carrots.

The one returned shipment was made up of carrots that had been heavily fertilized but not irrigated due to pump failure in the field. Upon discovery of the problem, the harvester was immediately moved to another field, so as not to interrupt production. The harvester was moved back to that field after rain, and the carrots were determined to be of good quality.

Fortunately, few natural enemies attack carrots; they are grown in the cool season when most pests are dormant.The Cooperative Extension Service has supported the planting and process operation with research and continues monitoring the crop and packing effort. Solutions have been developed for each problem, and further research is assured.

Accordingly, it appears that area farmers including the stockholders of Georgia Sweet Carrot, Inc., may plant as many as 800 acres in the 1997/98 crop year and as many as 1,000 acres in the 1998/99. If that occurs, the processing plant will need to operate longer hours and potentially with additional capacity.

Georgia sweet carrots were shipped by truck mostly along the Eastern seaboard and Canada, with a few going as far away as the state of Washington. There was a diverse market. Carrots are shipped in as small as one-pound bags with others in 2-, 3-, 5-, 10- and up to 50-pound bags. Some are processed into 50-pound bags of processed increments for further preparation. Significant amounts of market-ready packages were shipped to Winn Dixie, Ingles, J. H. Harvey stores, and Publix. There were remarkable numbers of reorders from each of these large users. Carrots were sold to approximately 180 customers.

Trademark:

The company designed a distinctive logo that was printed on the packing bags. The logo features a bunny holding a carrot. The process to register the trade name *Georgia Sweet Carrots* and the logo was initiated through a special attorney. Approval is expected immediately.

Finances:

The company borrowed funds with which to purchase equipment and provide operating capital. The Bacon County Development Authority committed additional operating capital.

The company sold merchandise through Sy Katz Produce Company. That company committed to pay for carrots shipped after 21 days. It honored that commitment. All funds have been collected. All labor has been paid and the bulk of other operating costs have been paid as accrued. The major unpaid item is the farmers themselves. They have been paid a portion of their accrued costs and have been willing to wait on further payment. Their philosophy is to leave sufficient capital in the company to assure an orderly operation.

In April, the farmers determined that there would be a need for increased capital. They responded by injecting capital to avoid other borrowing.

Equipment:

The company has purchased equipment with which to plant, harvest, and process/pack carrots. It operated from a previously under-utilized building, owned and subleased to them through the Bacon County Development Authority; that building served the needs of the company very well for the initial year.

The University of Georgia furnished via lease certain equipment used along with the purchased equipment. Accordingly, the company has benefited from several favorable conditions that relieved the need for massive borrowing and large real estate debt. All lease payments have been met out of cash flow.

A question has been raised about the value of some items of equipment. Several items, when received, were in pieces that required assembly. These were not usable and indeed are of little value until assembled and attached to other sections of the assembly line. The labor to assemble is a real cost and should be considered in the final evaluation. The company can account for every dollar spent on equipment whether for initial parts, labor to assemble, labor to attach, or ancillary parts that furnish power, water, etc., needed to operate. Management has produced a reliable list that delineates leased from purchase equipment.

During the operating season, it became clear that modifications will be needed to the in-plant production equipment to increase the efficiency and capacity of the operation. Lack of dependable labor suggests a need for an automatic bagger. A ready market for processed increments suggests a need for a better cutter. Some of the conveyors are too slow for the rest of the equipment. An ever-increasing need for sanitation mandates the installation of better personal hygiene equipment and better waste water management.

Effective operation of mechanized harvest equipment requires specific planting. The planter must deliver seeds at a specific rate, depth, and spacing. There were problems in the field that were attributed initially to the harvester. These later were determined to be a result of inexperience and inaccurate use of the planter. Accordingly, management and the board is cognizant of the need for planned equipment modification.

Waste and Spoilage:

Previous experience had taught the principles that they could expect a large volume of carrots that were not suitable for the fresh market. Indeed, while edible, as many as 30% to 40% are usually sorted out because of minor blemishes and lack of shelf appeal. A relationship was developed with a neighbor business that produces dried fruit as an aside to blueberry processing. The goal is to develop a market-ready product from cull carrots. The finished product produced during trials, which includes a sugar-infused *ready to eat* carrot as well as a totally dried animal feed, appears marketable. However, the relationship has been less than satisfactory due to the other company's inability to reach a level of production that would make it profitable to dry carrots. The carrot company purchased a dicer, peeler, and blancher to assist with the research and development project. That equipment may be used in other production efforts if the dried product does not work out. The sugar-infused product is attractive and tastes very good.

The volume of waste indicates a need to develop a market for cull carrots both *as is* and processed. Specialty animal keepers, such as zoos, are being considered as a target market next season. It is felt that carrot juice may be a viable product.

Future Plans:

The company is composed of a group of farmers who wish to gain a value added price to the produce they grow. They were willing to invest cash capital and personally guarantee large notes to provide a facility to process carrots. The success experienced this initial year indicates their faith was and continues to be well founded. One year does not a success make. Ultimate success cannot be claimed until they have experienced several years of profitable operation. It is the stated goal of the company to continue carrot culture, product development, market expansion and through possible use of a cooperative styled organization, to expand the production of carrots with farmers other than stockholders. An internal brokerage service may be viable in the future.

Continual development of carrot variety bodes well for the grower. A carrot that will grow in winter, survive drought, hold in the field for extended times, resist disease and rot, maintain sweetness, and forgive mismanagement would be welcome. An extended storage facility could offer year round sales.

Economic Benefits:

Most of the production labor staff was low to moderate income personnel with limited skill levels. Many were migrants who lived within a 30-mile radius. The company purchased, to the extent possible, all supplies locally. The more than $500,000.00 in sales provided an economic impact of more than $1,000,000.00 on the economy of the area.

Conclusion:

It is very gratifying to be able to report the considerable success of any company, much less a brand new company.

SECTION II

Cost and Returns

George O. Westberry
Extension Agricultural Economist

Analyzing costs and returns for a new enterprise may be a troubling task. If only actual numbers are used, the situation can look bad. If numbers are used reflecting what should be expected, an unrealistic picture may be shown. Following is an attempt to show a realistic picture of the production cost for carrots.

Yields for new growers of any crop can be expected to be lower than those of experienced growers. The group of growers observed in this study had many of the problems one would expect; however, they possess the ability to correct problems and increase yield potential. Observation of this group allowed for the development of cost and returns scenarios.

The first scenario is for a median yield of 500 masters (50 lb. bag) per acre. Table 1 shows this example in detail.

Table 2 shows what should be expected of this group in future years. A yield of 700 masters may reasonably be expected by good, experienced growers. Achieving this level of production creates an opportunity for a profitable situation, assuming the market price remains stable.

Table 1: Costs and Returns Expected for Carrots in 1997/1998

	BEST	OPT	MEDIAN	PESS	WORST
Yield (50# bags)	1000	750	500	250	0
Price per bag	9.00	7.00	6.00	5.00	3.00

Item	Unit	Quantity	Price	Amt/acre	Total	Yours
Variable Costs						
Seed	Lbs	2.00	38.00	76.00	76	_____
Lime, applied	Ton	1.00	26.00	26.00	26	_____
Fertilizer	Acre	1.00	133.83	133.83	134	_____
Calcium/Boron	Gal	1.25	6.50	8.13	8	_____
Land Plaster	Ton	0.25	35.00	8.75	9	
Fumigant	Gal	8.30	10.00	83.00	83	
Epsom Salts	Acre	1.00	4.50	4.50	5	_____
Fungicide	Acre	1.00	51.06	51.06	51	_____
Insecticide	Acre					_____
Herbicide	Acre	1.00	49.78	49.78	50	_____
Other(Rye, tissue test,etc)	Acre	1.00	2.75	2.75	3	
Machinery	Hr.	4.35	10.33	44.94	45	_____
Labor	Hr.	5.50	6.00	33.00	33	_____
Land rent	Acre	1.00	0.00	0.00	0	_____
Irrigation	Appl.	6.00	5.95	35.70	36	_____
Interest on Oper. Cap.	$	557.43	10.00%	27.87	28	_____
PreHarvest Variable Costs				585.30	585	_____
Harvest and Marketing Costs						
Harvest	Acre	1	29.79	29.79	30	
Haul	Bag	500	0.095	47.50	48	_____
Grading & Packing	Bag	500	2.00	1000.00	1,000	_____
Marketing 8.00%	Bag	500	0.48	240.00	240	_____
Total Harvest and Marketing				1317.29	1,317	_____
Total Variable Costs				**1902.59**	**1903**	_____
Machinery & Irrigation	Acre	1.00	86.36	86.36	86	_____
Land	Acre	1.00	0.00	0.00	0	_____
Overhead & Management	$	585	0.15	87.80	88	_____
Total Fixed Costs				**174.15**	**174**	_____
Total budgeted cost per acre				2076.74	2077	_____

Table 1: Costs and Returns Expected for Carrots in 1997/1998, cont.

Costs Per Bag	
Preharvest variable cost per bag	1.17
Harvest & marketing cost per bag	2.63
Fixed Costs per bag	0.35
Total budgeted cost per bag	4.15

EXPECTED RETURNS FROM TOTAL ACREAGE

ACRES	EXPECTED YIELD/AC	VOLUME MARKETED	EXPECTED PRICE	TOTAL RETURNS
1	500	500	6.00	3,000

RISK RATED RETURNS OVER TOTAL COSTS

Net return levels (TOP ROW);
The chances of obtaining this level or more (MIDDLE ROW); and
The chances of obtaining this level or less (BOTTOM ROW).

		Optimistic		Expected		Pessimistic	
Returns ($)	2,495	1,971	1,447	923	399	(125)	(649)
Chances	7%	16%	31%	50%			
Chances				50%	31%	16%	7%
CHANCES FOR PROFIT	**81%**			**BASE BUDGETED NET REVENUE**			**923**

Investment and Annual Fixed Costs

Number of acres of this crop 70
Interest rate = 0.10

Equipment Costs for this crop

Item	% of time for This crop	Cost	Salvage Value	Yrs. of Life	Depr.	Int.	Tax & Ins	FC/Ac.
Tractor	10%	60000	12000	15	320	360	50.40	10.43
Plow	2%	6600	1320	12	9	8	1.11	0.25
Disk	2%	12000	2400	12	16	14	2.02	0.46
Appl. Herb	2%	1700	340	10	3	2	0.29	0.07
Rototiller	18%	5000	1000	10	70	53	7.35	1.86
Planter	18%	12000	2400	10	168	126	17.64	4.45
Cultivator	0%	3500	700	10	0	0	0.00	0.00
Sprayer	5%	32000	6400	12	107	96	13.44	3.09
Wagons	18%	2000	400	10	28	21	2.94	0.74
Harvester	18%	45000	9000	15	420	473	66.15	14
Irrigation	50%	59000	11800	15	1573	1770	247.80	51.30
Total		48706	9741		2714	2922	409	86

Interest on Investment (Ave. Inv. X Int. Rate)	2922.36
Taxes and Insurance (Ave. Inv. X .014)	409.13
Total Annual Fixed Costs	6045
Total Annual Fixed Costs Per Acre	86.4

Table 2. Costs and returns expected for carrots in the future years.

	BEST	OPT	MEDIAN	PESS	WORST
Yield (50# bags)	1200	950	700	350	0
Price per bag	9.00	7.00	6.00	5.00	3.00

Item	Unit	Quantity	Price	Amt/Acre	Total	Yours
Variable Costs						
Seed	Lbs	2	38.00	76.00	76	_____
Lime, applied	Ton	1	26.00	26.00	26	_____
Fertilizer	Acre	1	133.83	133.83	134	_____
Calcium/Boron	Gal	1	6.50	8.13	8	_____
Land Plaster	Ton	0.25	35.00	8.75	9	_____
Fumigant	Gal	8.3	10.00	83.00	83	_____
Epsom Salts	Acre	1	4.50	4.50	5	_____
Fungicide	Acre	1	51.06	51.06	51	_____
Insecticide	Acre					_____
Herbicide	Acre	1	49.78	49.78	50	_____
Other (rye, tissue test, etc.)	Acre	1	2.75	2.75	3	_____
Machinery	Hr.	4	10.33	44.94	45	_____
Labor	Hr.	6	6.00	33.00	33	_____
Land rent	Acre	1	0.00	0.00	0	_____
Irrigation	Appl.	6	5.95	34.70	36	_____
Interest on operating capital	$	557	10.00%	27.87	28	_____
PreHarvest Variable Costs				585.30	585	_____
Harvest and Marketing Costs						
Harvest	Acre	1	29.79	29.79	30	_____
Haul	Bag	700	0.10	66.50	67	_____
Grading and packing	Bag	700	2.00	1400.00	1400	_____
Marketing	Bag	700	0.48	336.00	336	_____
				1832.29	1832	_____
Total Variable Costs				2417.59	2418	_____

Machinery	**Acre**	**1**	**86.36**	**86.36**	**86**	
Land	**Acre**	**1**	**0.00**	**0.00**	**0**	
Overhead & Management	**$**	**585**	**0.15**	**87.80**	**88**	
Total Fixed Costs				**174.15**	**174**	
Total budgeted cost per acre				**2591.74**	**2592**	

Costs Per Bag

Preharvest variable cost per bag	**0.88**
Harvest & marketing cost per bag	**2.75**
Fixed costs per bag	**0.26**
Total budgeted cost per bag	**3.89**

EXPECTED RETURNS FROM TOTAL ACREAGE

ACRES	EXPECTED YIELD/AC	VOLUME MARKETED	EXPECTED PRICE	TOTAL RETURNS
1	**667**	**667**	**6**	**4002**

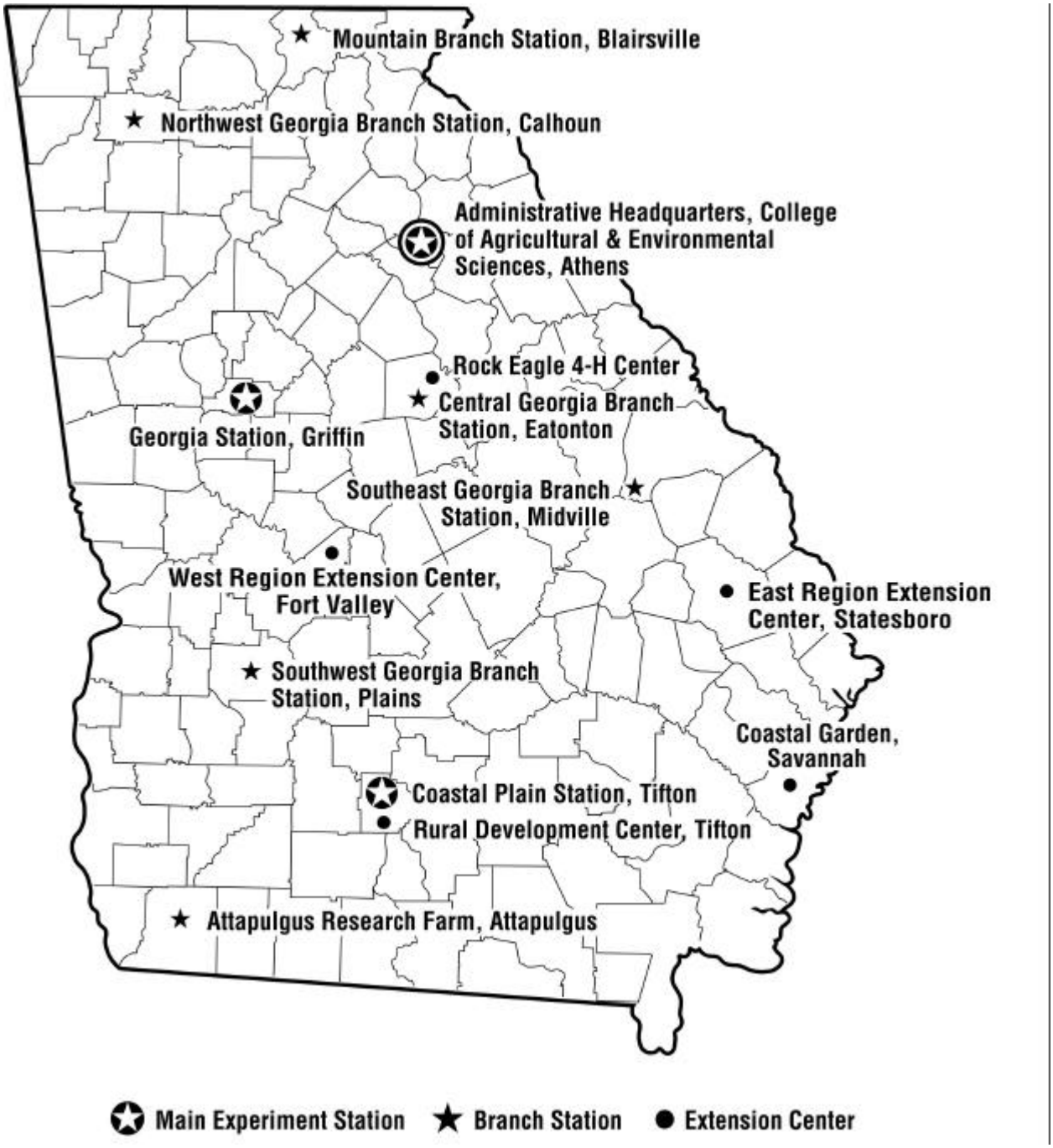
RISK RATED RETURNS OVER TOTAL COSTS

Net return levels (TOP ROW);
The chances of obtaining this level or more (MIDDLE ROW); and
The chances of obtaining this level or less (BOTTOM ROW).

		Optimistic		Expected		Pessimistic	
Returns ($)	**3185**	**2563**	**1941**	**1320**	**657**	**-6**	**-669**
Chances	**6%**	**16%**	**32%**	**51%**			
Chances				**49%**	**30%**	**16%**	**7%**
CHANCES FOR PROFIT		**84%**		**BASE BUDGETED NET REVENUE**			**1608**

Investments and Annual Fixed Costs same as Table 1.

Georgia Experiment Stations



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