IMPACTS
OF THE ELIMINATION OF ORGANOPHOSPHATES AND CARBAMATES FROM CARROT PRODUCTION

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Lynn Brandenberger, Horticulturist, Texas A&M University

Agricultural and Food Policy Center
Department of Agricultural Economics
Texas Agricultural Experiment Station
Texas Agricultural Extension Service
Texas A&M University

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College Station, Texas 77843-2124
Telephone: (409) 845-5913
http://afpc1.tamu.edu/pesticides.htm

Pesticides and registered trade names included in this report are not intended to be a complete listing. The trade names are included merely as some examples of the pesticides. They are not an endorsement of any particular chemical company's product or an indication that any such product is the exclusive trade name used for any particular purpose.

Introduction

Carrot production and consumption in the United States are undergoing a period of growth. Production of carrots increased 34.3 percent between 1987-1997 and is expected to increase during the next ten years another 18.7 percent (Table 1). This increased production is being encouraged by an increase in carrot consumption. Consumption of fresh carrots had increased to 10.3 pounds per person in 1997, a 24.3 percent increase since 1987, and consumption is expected to increase another 6.1 percent by 2007. Processed carrots are also being consumed in greater quantity with per capita consumption in 1997 up to 4.7 pounds, nearly a 57 percent increase since 1987. Additional increases of 17.6 percent are expected in processed carrot consumption during the next ten years.

Carrots are considered to be a very healthful and nutritious foodstuff. During the past decade, Americans in general have begun to be more health conscious and concerned about the nutritional aspects of their diet. This in itself can account for a significant portion of the increased consumption of both fresh and processed carrots but is not the sole reason for the increase. A new product, the cut and peeled carrot, is very likely responsible for part of the increased utilization of this nutritious vegetable. This new product, combined with the development of sweeter and more nutritious cultivars of carrots, is a big plus for the public. Consumers want and will purchase products that offer convenience, taste, and nutrition in one package, and this minimally processed product offers just that. The carrot industry has responded to the market, and vegetable packers around the country are cutting, peeling, and packaging this convenient product.

Major production areas in the United States include California, Colorado, Florida, Michigan, Texas, and Washington State. These states accounted for nearly 100 percent of the fresh carrots produced in the US and for approximately 56 percent of the processed crop in 1997 (Table 2). Carrot production overall consists of 67 percent fresh product and 33 percent processed carrots. California leads in fresh carrot production with a little over 76 percent of the crop coming from that state followed by Colorado, Michigan, Texas, Florida, and Washington in descending order of fresh product produced. Washington produces nearly 31 percent of the processing carrots in the US followed by California at near 16 percent, then by Michigan and Texas. No production of processed carrots was reported in 1997 by either Colorado or Florida.

Baseline Production Practices

Carrots are a cool season crop that is widely adapted to several growing areas throughout the United States. Optimum production conditions would include cool days (60-75°F) and cooler nights (45-50°F), but carrots can tolerate higher temperatures although this may result in lower quality roots at harvest. Temperatures below 20°F can damage the foliage of the crop, reducing yield, and, if occurring at harvest time, can prevent harvest when tops are required for pulling the carrots.

The crop will grow in a wide range of soils but prefers deep well-drained soils that are slightly acidic to alkaline (pH 6.5-7.8). Soil preparation prior to planting usually will include some form of deep tillage, disk harrowing, raised soil bed establishment and shaping, and possibly fumigation of the field for the control of soil insects, disease, and weeds. Carrots are established by direct seeding at a shallow depth (1/8-1/4 inch deep) normally utilizing a precision seeder to plant multiple lines on top of raised soil beds that are spaced 38-40 inches from bed center to bed center. Seeding rates vary between 1.5-4 pounds of seed per acre.

Nutritional requirements for carrots include 80 pounds of nitrogen, 80 pounds of phosphorus (P_2O_5), and 100 pounds of potassium (K_2O) per acre. Producers routinely will take soil samples from production sites, have the soil analyzed, and base application rates upon soil laboratory recommendations. Phosphorus, potassium, and part of the nitrogen are normally applied prior to planting with the balance of nitrogen being applied in one or two side dress applications.

Water requirements for this crop are between 10-15 inches of water applied evenly over the 3-4.5 month long production period. The critical water period for carrots is during germination because of the small seed size and the shallow planting depth.

Carrot pests can be divided up into three categories: disease, insects, weeds. Major diseases for this crop include both Alternaria and Cercospora leaf blights, powdery mildew, seedling damping off, white mold, and nematodes. A majority of production areas experience damage from leaf blight (Alternaria dauci) which can defoliate the crop, reducing yields and sometimes render the crop un-harvestable. Primary insects that damage carrots include carrot weevil, wireworm, white grubs, aphids, leafhoppers, mites, flea beetle, and army worms. Several of the insect pests can be quite serious, but carrot weevil is most often given as a problem for carrot producers across the US. Weeds that compete with carrots in production sites include several cool season broadleaf weeds and nutsedge, but this varies from one production area to another. Weed competition is of particular interest during the early part of the season when carrot seedlings are small and have a difficult time competing. Table 3 indicates organophosphate and carbamate pesticides labeled for carrot production in the US.

Carrots can be harvested several ways, but most often the raised beds are undercut to sever small feeder roots and to loosen the soil surrounding the carrots. After this, the carrots are lifted by the harvester and elevated into a trailer or directly into a truck for transport to the carrot processing facility. At the processing facility, carrots are unloaded, washed, sorted, and either bagged or bulk packed unless they will be used for cut and peeled carrots. Cut and peeled carrots will require further sorting, cutting, peeling, washing, and then packaging.

Survey Results

A survey of carrot production practices was carried out using contacts at Land Grant Universities in five of the six major carrot producing states in the US. Contacts with extension personnel in California, Colorado, Michigan, Texas, and Washington provided access to extension

crop enterprise budgets for carrots. These were utilized to develop a baseline for production practices and to document pesticide use in growing carrots. These data and those gathered from extensive surveying of the carrot industry were used to ascertain what the effect would be on the carrot industry if organophosphate and carbamate materials were no longer available for use in producing carrots.

The loss of organophosphate and carbamate materials would not immediately result in a major negative effect upon overall carrot production and availability within the Unites States. Loss estimates for carrots from the National Agricultural Pesticide Impact Assessment Program (NAPIAP) indicate that Washington and Texas would have the highest potential for production losses. Production loss estimates in these states are between 20-25 percent of their overall production due to the loss of organophosphate and carbamate materials. Soil borne insects account for the majority of these potential losses. Potential losses in other production areas were considerably less, with little or no change in carrot yields expected in California, Colorado, and Michigan as a result of not using organophosphate and carbamate materials.

Based on the survey results, a majority of the carrot industry has already made the shift from the older organophosphate and carbamate materials to newer materials that are healthier for carrot consumers and safer on an environmental basis. US carrot producers, in general, have rapidly adopted Integrated Pest Management (IPM) principles for several reasons. First, economic and environmental issues have created serious incentives for producers to adopt practices that will reduce the number of pesticide applications. Growers, in general, have reduced the number of applications to a minimum to reduce production costs and to minimize any environmental effects. Second, baby food processors, fresh marketers, and the rest of the food industry are working with carrot producers to provide an extremely safe product, free of pesticide residues.

Immediate changes in US carrot supplies would not result from the elimination of these two groups of materials, but other effects should be taken into consideration. A majority of the newer pest control materials have been formulated to effectively control a very specific group of insects, diseases, or weeds. Because of this, many of the newer materials should be used in conjunction or in rotation with non-related compounds with a broader pest control spectrum to prevent the development of resistant pest populations which would render the new materials ineffective. Therefore, it is imperative that alternative compounds are available to insure an effective IPM strategy. Second, although production losses may increase only in certain areas of the country, it is important to recognize that as a specific crop's production areas are reduced, overall risk to crop supply increases. This in essence boils down to putting more eggs in one basket and the resulting increased risk involved with that.

Table 1. Carrot production and consumption summary from US carrot supply and utilization.

Category	1987 Reported	1997 Reported	% increase 1987 to 1997	2007 Projected	% increase 1987 to 2007	% increase 1997 to 2007
US total acres	88,100	107,100	21.6	123,100	39.7	14.9
Carrots produced (1000 cwt)	28,700	38,600	34.3	45,800	59.4	18.7
Fresh per capita consumption (lbs)	8.3	10.3	24.3	11.0	31.9	6.1
Processed per capita consumption (lbs)	3.0	4.7	56.7	5.5	84.3	17.6

Source: Fruit and Vegetable Baseline (1998).

Table 2. 1997 carrot production by state, summary from US carrot supply and utilization.

Category	U.S. totals	California	Colorado	Florida	Michigan	Texas	Washington
Fresh production (1000 cwt)	25,924	19,790	1,697	1,051	1,354	1,178	854
Percent of US fresh production	NA	76.3	6.5	4.1	5.2	4.5	3.3
Processor production (1000 cwt)	12,647	1,982	0.0	0.0	681	476	3,867
Percent of US processor production	NA	15.7	0.0	0.0	5.4	3.8	30.6
Total production (1000 cwt)	38,571	21,772	1,697	1,051	2,035	1,654	4,721
Percent of total US production	NA	56.4	4.4	2.7	5.3	4.3	12.2

Source: Fruit and Vegetable Baseline (1998).

Table 3. Organophosphate and carbamate pesticides labeled for carrot production in the US.

Common name	Trade name	Type
bensulide	Prefar	OP herbicide
methyl parathion	Penncap-M, Methyl Parathion	OP insecticide
trichlorfon	Trichlorotox	OP insecticide
mevinphos	Phosdrin	OP insecticide
Diazinon	Diazinon, Spectracide	OP insecticide
carbaryl	Sevin	Carbamate insecticide
Malathion	Malathion, Fyfanon	OP insecticide
methomyl	Lannate	Carbamate insecticide
mancozeb	Dithane	Carbamate fungicide

Scientists Consulted:

Erik Sorensen, Washington State University
Bernard Zandstra, Vegetable Specialist, Michigan State University
Scott Nissen, Colorado State University
Mike Davis, Plant Pathologist, University of California, Davis
Roland Roberts, Horticulturist, Texas A&M University
Jose Peña, Agricultural Economist, Texas A&M University
Dorothy Valdez, General Manager, Holden Wallace Produce, Texas
Mark Conner, Agri-Chemical Salesman, Mid Valley Chemicals, Texas
Larry Stein, Horticulturist, Texas A&M University
Joe Nunez, Farm Advisor Vegetable Crops & Plant Pathology, University of California, Davis
Gregg Nuessly, Vegetable Entomologist, IFAS, Florida
John Lacky, General Manager, McManis Produce, Texas
Kent Hill, Production Manager, High Plains Carrots, Texas
Marvin Miller, Plant Pathologist, Texas A&M University
Holden Wallace, CEO, Holden Wallace Produce, Texas
Todd Dekryger, Agricultural Research Specialist, Gerber, Michigan
Chris Falak, Produce Buyer, Gerber, Michigan
Carol Suter, Nutritionist, Texas A&M University
Joe Lucio, Production Manager, Holden Wallace Produce, Texas
Kent Smith, Plant Pathologist, USDA/ARS Office of Pest Management Policy

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Appendix I:
Production Data for Carrots

Table 4. Carrot production data.

	1995	1996	1997	Average	Percent US	1995	1996	1997	Average	Percent US	1995	1996	1997	Average
	Planted Acres (000)					**Production (000 cwt)**					**Yield cwt/acre**			
Fresh														
California	55	66	70.9	64.0	68.78%	15950	19800	25524	20425	73.09%	290	300	360	317
Colorado	4	4.3	5.5	4.6	4.95%	1710	1435	2450	1865	6.67%	428	334	445	402
Michigan	6.2	6	5.5	5.9	6.34%	1938	1300	1325	1521	5.44%	313	217	241	257
Texas	5.2	5.1	3.7	4.7	5.02%	750	907	578	745	2.67%	144	178	156	159
Washington	1.9	2.1	2.2	2.1	2.22%	760	900	903	854	3.06%	400	429	410	413
US	84.5	95.5	99.0	93.0		23478	26760	33599	27946		278	280	339	299
Processing														
Texas	5.3	5.1	4.8	5.1	18.99%	1020	931	1680	1210	10.66%	192	183	350	242
Washington	7.5	6.8	6.6	7.0	26.12%	4380	3640	3840	3953	34.81%	584	535	582	567
US	29.4	26.7	23.9	26.7		11711	11332	11029	11357		398	424	462	428
Total														
California	55	66	70.9	64.0	53.45%	15950	19800	25524	20425	51.97%	290	300	360	317
Colorado	4	4.3	5.5	4.6	3.84%	1710	1435	2450	1865	4.75%	428	334	445	402
Michigan	6.2	6	5.5	5.9	4.93%	1938	1300	1325	1521	3.87%	313	217	241	257
Texas	10.5	10.2	8.5	9.7	8.13%	1770	1838	2258	1955	4.98%	169	180	266	205
Washington	9.4	8.9	8.8	9.0	7.55%	5140	4540	4743	4808	12.23%	547	510	539	532
US	113.9	122.3	122.9	119.7		35189	38092	44628	39303		309	312	363	328

Source: Table developed by Edward G. Smith, Agricultural and Food Policy Center, Texas A&M University, College Station, Texas, 1999.

Appendix II:

Budget Data for Carrots

Table 5. Budget for producing fresh carrots with and without organophosphates and carbamates.

	United States Fresh			California Fresh			Colorado Fresh			Michigan Fresh			Texas Fresh			Washington Fresh		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwts/acre)	406.86	388.35	-4.55%	400	384	-4.00%	660	660	0.00%	385	385	0.00%	220	165	-25.00%	540	432	-20.00%
Cash expenses ($/acre): Seed	$171.05	$171.05	0.00%	$175.80	$175.80	0.00%	$250.00	$250.00	0.00%	$110.00	$110.00	0.00%	$92.50	$92.50	0.00%	$200.00	$200.00	0.00%
Fertilizer, and Growth Reg	$142.85	$142.85	0.00%	$154.60	$154.60	0.00%	$131.00	$131.00	0.00%	$109.80	$109.80	0.00%	$37.73	$37.73	0.00%	$137.27	$137.27	0.00%
Chemical and Sprays	$307.43	$303.33	-1.34%	$341.97	$341.30	-0.20%	$63.95	$63.95	0.00%	$226.62	$226.62	0.00%	$149.73	$89.36	-40.32%	$367.74	$363.49	-1.16%
Fuel & Lube	$15.58	$15.58	0.00%	$0.00	$0.00	0.00%	$25.00	$25.00	0.00%	$169.00	$169.00	0.00%	$23.67	$23.67	0.00%	$20.85	$20.85	0.00%
Irrigation	$335.23	$335.23	0.00%	$415.94	$415.94	0.00%	$45.00	$45.00	0.00%	$0.00	$0.00	??	$47.07	$47.07	0.00%	$90.70	$90.70	0.00%
Labor	$10.43	$10.43	0.00%	$0.00	$0.00	0.00%	$40.00	$40.00	0.00%	$70.35	$70.35	0.00%	$30.50	$30.50	0.00%	$51.06	$51.06	0.00%
Harvest	$2,757.47	$2,629.59	-4.64%	$3,080.00	$2,957.00	-3.99%	$1,600.00	$1,600.00	0.00%	$1,482.40	$1,482.40	0.00%	$2,124.83	$1,609.75	-24.24%	$417.83	$363.83	-12.92%
Other variable cash expenses	$185.21	$185.21	0.00%	$195.75	$195.75	0.00%	$377.00	$377.00	0.00%	$61.75	$61.75	0.00%	$16.24	$16.24	0.00%	$165.64	$165.64	0.00%
Total variable cash expenses	$3,925.25	$3,793.26	-3.36%	$4,364.06	$4,240.39	-2.83%	$2,531.95	$2,531.95	0.00%	$2,229.92	$2,229.92	0.00%	$2,522.27	$1,946.82	-22.81%	$1,451.09	$1,392.84	-4.01%

Source: Table developed by Edward G. Smith, Agricultural and Food Policy Center, Texas A&M University, College Station, Texas, 1999.

Table 6. Budget for producing processed carrots with and without organophosphates and carbamates.

	United States Processed			Texas Processed			Washington Processed		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwts/acre)	585.30	462.14	-21.04%	290.00	217.50	-25.00%	800.00	640.00	-20.00%
Cash expenses ($/acre): Seed	$21.00	$21.00	0.00%	$15.50	$15.50	0.00%	$25.00	$25.00	0.00%
Fertilizer, and Growth Reg	$95.37	$95.37	0.00%	$37.73	$37.73	0.00%	$137.27	$137.27	0.00%
Chemical and Sprays	$149.31	$121.43	-18.67%	$149.73	$89.36	-40.32%	$149.00	$144.75	-2.85%
Fuel & Lube	$22.04	$22.04	0.00%	$23.67	$23.67	0.00%	$20.85	$20.85	0.00%
Irrigation	$72.33	$72.33	0.00%	$47.07	$47.07	0.00%	$90.70	$90.70	0.00%
Labor	$42.40	$42.40	0.00%	$30.50	$30.50	0.00%	$51.06	$51.06	0.00%
Harvest	$503.03	$423.29	-15.85%	$406.00	$326.62	-19.55%	$573.58	$493.58	-13.95%
Other variable cash expenses	$98.42	$98.42	0.00%	$16.24	$16.24	0.00%	$158.17	$158.17	0.00%
Total variable cash expenses	$1,003.90	$896.29	-10.72%	$726.44	$586.69	-19.24%	$1,205.63	$1,121.38	-6.99%

Source: Table developed by Edward G. Smith, Agricultural and Food Policy Center, Texas A&M University, College Station, Texas, 1999.

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