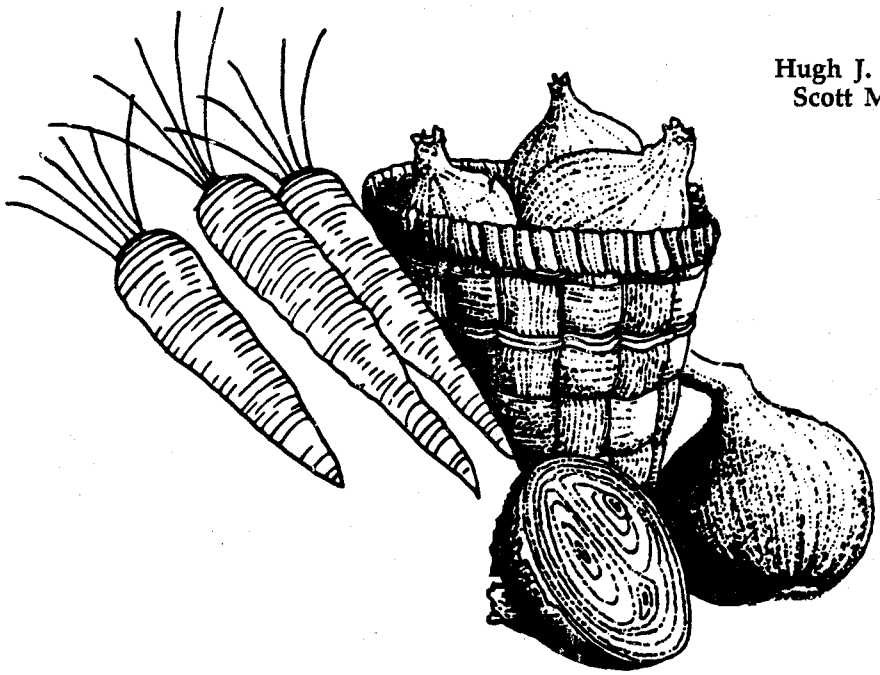
Agricultural Economics Report No. 259 June 1990

Economic Feasibility of Vegetable Production, Marketing, and Processing in the Red River Valley of North Dakota



Hugh J. Dufner, Delmer L. Helgeson,
Scott M. Wulff, Gary W. Rourke,
and Joel T. Golz

Department of Agricultural Economics • Agricultural Experiment Station
North Dakota State University • Fargo, ND 58105-5636

N.D. Agricultural Products Utilization Commission
USDA-CSRS Project No. 8802822
Rural Development Research in North Dakota

Acknowledgements

The authors are indebted to vegetable growers and a number of businesses and governmental agencies who have provided support and data to this study.

Special recognition is given for the financial support provided by the USDA-CSRS, under Project Number 8802822, the North Dakota Agricultural Products Utilization Commission, and the North Dakota Agricultural Experiment Station.

The authors are indebted to Drs. Roger G. Johnson, Lawrence E. Mack, and Professor Timothy A. Petry, colleagues in the Department of Agricultural Economics, and to Dr. Art Boe, Chair, Department of Horticulture, for manuscript review. Sincere appreciation is expressed for the patience and assistance of Marna Unterseher in typing draft copies and the final copy. The authors accept sole responsibility for any omissions or errors in the text.

Table of Contents

List of Tables

List of Tables, Continued

List of Tables, Continued

List of Tables, Continued

List of Figures

Highlights

The potential for competitive commercial production of vegetables in North Dakota was examined in this study. Production and marketing aspects were reviewed for 53 vegetables. The crops discerned by local authorities as having the most production and marketing potential were onions, carrots, and red beets.

Transportation costs from North Dakota and competing production areas were compared to determine transportation advantages (disadvantages) for shipping carrots and onions to selected markets. North Dakota primarily had transportation advantages in local markets.

A case study of a small vegetable production/marketing operation was analyzed. The vegetable operation was started in the central Red River valley in 1987 and continued in 1988. Production in 1987 concentrated on carrots while 1988 production shifted in favor of onions. Cost, yield and price data were collected from the case study.

An expanded model was developed from the case study data to evaluate the economic feasibility of a commercial-sized operation for producing either carrots or onions. Both carrots and onions were projected to have positive net returns under specified cost, yield, and price assumptions.

Economic Feasibility of Vegetable Production, Marketing, and Processing in the Red River Valley of North Dakota

Hugh J. Dufner, Delmer L. Helgeson, Scott M. Wulff, Gary W. Rourke, and Joel T. Golz*

The motivation for this study has been a desire to determine whether horticultural crops could be competitively produced and marketed in North Dakota. The purpose is to identify crops which hold the greatest potential for successful production and marketing and to analyze the constraints to successful operations. Attention was given to the state's natural endowments of climate and soil which define what vegetables can be successfully grown as well as the demand for these products on a local, regional, and national basis. Complementarity with existing production and marketing was also analyzed, focussing on machinery requirements as well as storage and marketing synergies.

Since market demand is key to any industry, the competitive environment was carefully analyzed in view of existing production areas, time periods, shipping costs, and product differentiation.

Project Objectives

The objective of this study was to determine the economic feasibility of expanded vegetable production in North Dakota.

Specific objectives were:

a) To identify vegetable crops agronomically suitable for commercial production in North Dakota

b) To assess the economic feasibility of producing vegetables to be marketed in local, regional and national markets.

Methodology

Existing growers and specialists in the field of horticulture were interviewed to assess the constraints limiting production and marketing of vegetable crops in North Dakota.

---

*Former research assistant, professor, former research assistants, and research assistant, respectively.

Since local vegetable processing facilities are currently non-existent, particular attention was given to crop perishability and storage characteristics that define the market window for each crop. The possibility of mechanization was also considered an important evaluation criteria since labor availability is often a serious constraint during the short northern growing season. Assuming processing facilities were available, a "what if" approach was taken when analyzing production potential for various crops.

Information concerning the production and marketing feasibility of various crops from a case study operation in the central Red River Valley was used as a basis for analyzing production and marketing costs for a small scale operation. The knowledge from this operation was cited to provide insight into the practical difficulties associated with dry land vegetable production in North Dakota. Based on production coefficients derived from this operation, an expanded operation was synthesized to determine estimated costs and project profitability of a commercial-sized operation. Data were then compared with production costs from other areas, with break even yields and prices presented.

Since market demand is key to profitability, free-on-board (FOB) point of origin and cost-insurance and freight (CIF) wholesale product prices were obtained for two products, giving attention to point of origin and shipping costs. A standardized product was assumed to exist in either case. A transportation model was used to determine the low cost supplier by season. Attention was given to seasonal price differentials to determine return to storage for Northern-grown products. Product differentiation and market niches were also considered as alternative means of competing in the market. Local, regional and national markets were considered.

Recommendations are provided for crops that offer the greatest potential for commercial production in North Dakota, as well as the most likely constraints. Areas needing further study were developed based on information and findings resulting from this study.

Horticultural Crop Survey Design and Implementation

A short survey was conducted of two area growers, two NDSU horticulture department staff members, and the Fargo Farmers' Market coordinator to determine the production, marketing and processing feasibility of various vegetable crops in North Dakota. Those interviewed were asked to rank crops according to various criteria on a scale of zero to five, with zero signifying the crop had no potential and five signifying it had excellent potential. The rankings were then consolidated, accepting the most common rankings and rejecting those that deviated greatly (Table 1). Crops for which some potential may exist, but with some uncertainty, were designated with a question mark (?).

Survey Results; Evaluation of Crops

The opinions of those surveyed were generally quite consistent, signifying a relatively high level of consensus for most vegetable crops. Survey results suggest perennials, rhubarb, asparagus, and horseradish, are well adapted to production in North Dakota. The first two have good fresh market potential as well as potential for freezing and canning. It is uncertain whether these crops could be marketed fresh in regional markets. Unfortunately, these crops do not appear to lend themselves to more than a low level of mechanization, a factor inhibiting their production on a large scale.

The survey further suggests root crops are viewed favorably for production, marketing, and processing potential, particularly beets, carrots, garlic, onions and potatoes. Other root crops deemed feasible with less optimism and consensus are rutabagas, turnips, parsnips, and radishes. While most individuals felt the latter items could be successfully raised, they cited various problems which may limit their production potential in North Dakota. These opinions are noted in the comment section of Table 1. All root crops cited above lend themselves to harvest mechanization.

Among cole crops, cabbage (excluding chinese) ranked highest in production and marketing feasibility. They offer excellent production potential as well as strong local

TABLE 1. HORTICULTURAL CROP EVALUATION SUMMARY, NORTH DAKOTA, 1988

Horticultural Crop[a]	Production Feasibility[b]	Dryland Quality	Irrigated Quality	Mechanization Feasibility	Fresh Market Feasibility[c]			Processed Market Feasibility[d]			Comments
					Local	Regional	National	Frozen	Canned	Dried/Other	
Artichokes, Jerusalem	4	4	4	4	0-1	?	?	-	-	-	Low demand for item
Asparagus	4-5	4	5	2-3	4	?	?	4	4	-	Perenial; 3-4 years to establish
Beans, green or snap	3-4	3	4	4	3	-	-	4	4	-	Limited local market; may be hurt by midsummer heat
Beets	4-5	4	5	5	3	?	?	4	4	-	Limited local market; ethnic population potential - Slavic, Russian, German
Broccoli	2-4	2	4	2-3	4	-	-	4	-	-	May be hurt by midsummer heat
Brussel Sprouts	3-4	3	4	?	4	-	-	4	-	-	Late fall crop only
Cabbage, early	4-5	4	5	2	4	?	-	-	-	-	Small heads 3-4 lbs for fresh market, large heads for salad/cole slaw
Cabbage, late	4-5	4	5	2	4	?	-	-	-	3	Small heads for fresh market, large heads for kraut or cole slaw
Cabbage, chinese	1-2	1	2	2	1	-	-	-	-	-	Bolting problem
Cabbage, savoy	4-5	4	5	2	2	-	-	-	-	-	-
Carrots, mature	3-4	3	4	5	4	?	-	4	4	-	Emergence problem on heavy soils, requires early planting if dry land
Carrots, packaging	3-4	3	4	5	4	?	-	-	-	-	Short varieties best suited to heavy soils, but have limited acceptance when packaged
Cauliflower	2-3	2	3	2-3	4	-	-	4	-	-	Inconsistent late fall crop; weather constraints Celery
	1-2	1	2		2	-	-	-	-	-	Little local experience
Collards	3-4	3	4	-	0-1	-	-	-	-	-	Largely unknown to northern populace
Corn, sweet	4-5	4	5	4	5	?	-	3	3	-	Excellent quality; lower yields than more southern areas
Cucumbers, slicers	3-4	3	4	2-3	3-4	?	-	-	2	-	Pickling factory in Chaska, MN; local demand may be quite limited
Cucumbers, picklers	3-4	3	4	1-2	4-5	?	-	-	2	-	Pickling factory in Chaska, MN; local demand may be quite limited
Egg plant	3-4	3	4	1-2	1-3	-	-	-	-	-	Limited fresh market
Endive and Escarole	3-4	3	4	-	-	-	-	2	-	-	Little grower experience
Garlic, dry	3-4	3	4	4	4	3	3	-	-	4	Limited demand in most markets
Greens, leafy	2-3	2	3	-	3	-	-	-	-	-	Can be hurt by midsummer heat
Horseradish	4	4	-	?	1	-	-	-	-	2	Very limited demand; normally processed before sale
Kale	4-5	-	-	-	1	-	-	-	-	-	Limited demand
Kohlrabi	3-4	3	4	-	1	-	-	-	-	-	Limited local demand
Leeks, green	2-3	2	3	-	3	-	-	-	-	-	Limited local demand
Lettuce, head	1-2	1	2	-	4	-	-	-	-	-	Hurt by midsummer heat
Melon, musk-	4-5	4	5	2	5	?	-	3	-	-	Local market may be saturated
Melon, honey dew	3-4	3	4	2	3-4	-	-	3	-	-	Problem with cracked shells near maturity, may depend upon variety
Melon, water	3	3	4	2	3-4	-	-	-	-	-	Southern grown melons arrive first, limited local sales

–CONTINUED–

TABLE 1. HORTICULTURAL CROP EVALUATION SUMMARY, NORTH DAKOTA, 1988, continued

Horticultural Crop[a]	Production Feasibility[b]	Dryland Quality	Irrigated Quality	Mechanization Feasibility	Fresh Market Feasibility[c]			Processed Market Feasibility[d]			Comments
					Local	Regional	National	Frozen	Canned	Dried/Other	
Onions, dry	4-5	4-5	-	5	5	2	-	-	-	-	Competition from western states
Onions, green table	3-4	3	4	-	2-3	-	-	-	-	-	Product is highly perishable
Parsley	4-5	4	5	-	1	-	-	-	-	-	Limited demand
Parsnips	2-4	3	4	5	1	?	?	-	-	-	Late germinator; problem with emergence in crusted soils
Peas, green	3-4	3	4	5	3	-	-	3	-	-	Limited local demand; yields may be mediocre
Peas, sugar	3-4	3	4	-	4	?	-	3	-	-	Limited local demand
Peas, snow	3-4	3	4	-	4	?	-	3	-	-	Limited local demand
Peppers, chile	3-4	3	4	?	1-2	-	-	-	1	3	Ethnic food, may have potential dried for processors
Peppers, sweet	2-4	2	4	-	4	-	-	-	-	-	Frost sensitive; season sometimes too short irrigation important
Potato, red table	5	5	5	5	5	5	5	5	3	3	Marketed across eastern half of USA
Potato, white baker	5	5	5	5	5	4	3	-	-	-	Favorable local market
Potato, chipping	5	5	-	5	-	-	-	5	4	-	Established markets
Pumpkins	3-5	3-4	4-5	2	3-5	2	-	3	3	-	Highly seasonal demand
Radishes, spring	2-4	2	4	4	2	?	-	-	-	-	Local demand may be too small to permit mechanization
Radishes, winter	2-4	2	4	?	1	?	-	-	-	-	Mechanization potential uncertain
Rhubarb	4-5	4-5	-	-	4	?	-	4	4	-	Limited local fresh demand
Rutabagus	1-4	-	-	5	2-3	?	-	-	-	-	Thrives in moist, freshly broken, alkalyn soil, cool weather crop, root maggot problem
Spinach	2-3	2	3	-	2	-	-	-	-	-	Limited local demand
Squash, summer	3-4	3	4	2	3-4	-	-	2	-	-	-
Squash, winter	4-5	4	5	2	4-5	-	-	4	-	-	-
Sweetpotatoes	2	1	2	4	3	-	-	-	-	-	Season a bit too short
Tomatoes	2-5	2-4	3-5	2	4	-	-	-	3	-	Short season may reduce yield
Turnips	2-4	2-3	3-4	5	1	?	-	-	-	-	Limited local demand, root maggot problem

[a]Each crop evaluated by several criteria on a scale of 0-5, zero meaning no potential, 5 meaning excellent potential.

[b]Ability to consistently produce a quality product in North Dakota.

[c]Ability to competitively produce and deliver a product in acceptable condition to existing markets.

[d]Product appropriate for processing if facility were available.

SOURCE: Opinions derived from survey of area growers and NDSU Horticulture Department staff.

demand and potential for processing. Brussels sprouts, broccoli, and cauliflower offer some potential but are inconsistent producers. None of the cole crops offer the possibility for a high level of harvest mechanization.

Among melons, muskmelon ranked highest, showing excellent potential for production and marketing, with some potential for freezing. Honeydew and watermelon were viewed with less favor. Limited possibilities for harvest mechanization exist for melons.

Winter squashes and pumpkins ranked high in production and marketing and also seem to have excellent processing potential. Summer squashes were also viewed favorably. The potential for harvest mechanization is limited in both cases.

Everyone interviewed was enthused about sweetcorn, partly as a result of the short crop and premium prices paid for the product during crop year 1988, but also in light of numerous years of experience with the crop. It was ranked as highly feasible in terms of production and fresh marketing, with some processing feasibility. Harvest mechanization for the fresh market is questionable, since a mechanical harvester damages a high percentage of the ears.

Cucumbers were deemed feasible to produce and local market potential seems good, but again it is a labor intensive crop. Mechanical harvesting is possible, but it is a once over operation which limits potential yield. A processing plant for cucumbers is located in central Minnesota, a reasonable distance for shipment. Past experience with commercial production for processing suggests labor availability and management is the key to success.[1]

Green peas and beans can be mechanically harvested and produce well. The local market is limited, however, and dryland yields in North Dakota may be less than in Southern states where they are raised for processing. Under irrigation, they might yield well in North Dakota. It is questionable whether local demand would be sufficient to

---

[1]Based on an interview with Caledonia, North Dakota, growers, spring of 1988.

justify the expense of a mechanical harvester. Harvesters could be justified if processing were established.

Tomatoes are deemed a feasible crop, but North Dakota yields would be lower and less dependable than yields in Southern states where the growing season is longer and tomatoes are grown for processing. If a plant existed, North Dakota-grown tomatoes might be processed on a small scale as one of a line of products or as an ingredient to other main-line products.

The more succulent greens such as lettuce are adversely affected by midsummer heat. If produced, they may offer the greatest potential in early spring.

Selection of Crops for Large Scale Production

The local market for most perishable crops is restrictive, because large amounts of these products come onto the market in late summer or early fall, depressing local prices until the supply is consumed or the product is spoiled. Although product quality may be high at harvest, the abundance is often more than can be consumed, and marketing of these items in distant markets is usually difficult because fresh product is abundant most places during the fall season.

In the absence of a processing facility or any method of product preservation, perishability becomes a major concern and an important criteria in crop selection. Items with storage capacity can be marketed over their storage life, allowing for larger market windows. Less perishable crops permit establishment of regular delivery schedules and penetration of distant markets, based on product quality criteria rather than on temporal availability.

North Dakota is currently a supplier of stored potatoes. Farmers are accustomed to storing and shipping them to distant points across the eastern half of the U.S. With slight modification in existing facilities, new products could be stored, marketed and shipped, either together with or parallel with potato shipments. The additional

investment required to adapt current facilities for storage of lesser perishable crops would be considerably lower and less risky than the construction of processing plants.

Storage of Less Perishable Crops

Analysis of storage characteristics for less perishable crops reveals several items could be stored together, based on their storage temperature and relative humidity requirements. These less perishable products have been grouped into four storage classes (Table 2).

Storage Class A.

Products in this class store best at 32°F and relative humidity of 90-95%.[2] Items include jerusalem artichokes, beets, cabbage, carrots, horseradish, leeks, parsnips, radishes, rutabagas, and turnips.

Storage Class B.

Products in this class would be stored at 32°F and relative humidity between 65-70%. Items to be stored include dry garlic, dry onions, and dry chile peppers.

Storage Class C.

Products in this class could be stored at 50-55°F and relative humidity between 70-75%. Products include pumpkin, winter squash, sweet potatoes and dry chile peppers. Chipping potatoes might also fit this category, although they ideally require higher humidity.

Storage Class D.

Potato table stock has its own unique storage requirements of 38-40°F and relative humidity of 90%. This temperature is too high for class A items and too low for Class C. However, this is close to the normal temperature (i.e., 40-42°F) which most shippers and common warehousers store product in transit or for proximate use.

---

[2]All temperatures are in fahrenheit.

Table 2. Recommended Temperature, Relative Humidity, Approximate Storage Life, Highest Freezing Temperature, and Frost Susceptibility of Lesser Perishiable Vegetable Crops

	Storage Commodity Class	Temperature	Relative Humidity	Approximate Storage Life	Highest Freezing Point	Suscept to Frost Injury	Other Requirement
			percent	months		1=high, 3=low	
A	Artichokes, Jerusalem	31-32	90-95	2-5	--	3	
A	Beets (D)	32[a]	95	3-5	30.3	3	Open/ventilated containers
A	Cabbage (late)	32	90-95	3-4	30.4	2	Much ventilation
A	Carrots (mature)	32	90-95	4-5	29.5	2	Air movement for uniform temperature
A	Carrots (immature)	32	90-95	4-6	29.5		Air movement for uniform temperature
B	Garlic (dry)	32	65-70	6-7	30.5		Air circulation
A	Horseradish	30-32	90-95	10-12	28.7		Late digging
A	Leeks, green	32	90-95	1-3	30.7		
B	Onions (dry)	32	65-70	1-8	30.6	2	Air circulation
A	Parsnips	32	90-95	2-6	30.4	3	Same as carrots
C	Peppers, chile (dry)	32-50	60-70	6			10-15% moisture content
D	Potatoes (late crop)	38-40[b]	90	5-8	30.9	1	Air movement
C	Pumpkins	50-55	50-75	2-3	30.5		10-20 days curing at 80-85%[c]
A	Radishes (spring)	32	90-95	3-4	30.7	2	Cool quickly
A	Radishes (winter)	32	90-95	2-4			Same as carrots
A	Rutabagus	32	90-95	2-4	30.1	3	Same as carrots
C	Sweet Potatoes	55-60	85-90	4-6	29.7	1	Cure at 85 F., 85-90% humidity[d]
A	Turnips	32	90-95	4-5	30.1	3	Same as carrots
C	Winter squash	50-55	50-75	6	30.5	2	10-20 days curing at 80-85%[c]

[a]Experiments in England showed less spoilage of beets at 40 degrees than at 36 or 32, fact which suggests chilling injury for product grown in some regions.

[b]Optimal temperature varies according to potato condition, intended use and length of storage desired. Normal temperature for long term storage of table stock is 38-40 degrees.

[c]Experiment on Hubbard, Butternut, should be stored at 50% humidity; expected life is 2-3 months. Hubbard can be stored at 70-75% humidity for 6 months.

[d]Sweet potatoes should be cured within 2 days after digging. They should not be chilled below 50 degrees before or after harvest. Conditions should not be excessively wet before harvest.

Note: Susceptibility to frost categories refer to product in storage. They are defined as:

1. Most susceptible, those that are likely to be injured by even one light freezing.
2. Moderately susceptible, those that will recover from one or two light freezings.
3. Least susceptible, those that can be lightly frozen several times without serious damage.

Source: Adapted from Lutz, J.M., Hardenburg, R.E. 1968. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks. United States Department of Agriculture Handbook No. 66; p. 20, and pp. 37-53. (Storage classes not specified in above journal.)

Some of the products designated for the above storage classes have recommended storage characteristics which differ slightly from other items in their class. The differences are small and probably inconsequential, particularly if the storage period is short. Few warehouses would have enough rooms with independent temperature and humidity control to ideally fit each product.

An alternative to independent storage for each product might be to package or cover products with high humidity requirements (e.g., class A items) and store them with uncovered items requiring the same temperature (e.g., class B items), thereby reducing the number of storage areas. Air circulation around the packaged product ensures removal of internal heat generated by the product.

Choosing Among Less Perishables

Most of the less perishable crops mentioned may offer some potential for success in North Dakota. Some crops are more readily mechanized than others and fit North Dakota climate and soil types better. North Dakota farmers in the Red River Valley are accustomed to root crop production. Potatoes and sugarbeets prosper well in the black, potassium rich soils of the Valley where organic matter is typically around 5 percent. Some of the equipment required to produce and store alternative root crops is identical or similar to what farmers currently use. Other equipment for certain root crops is specialized, but nearly all the root crops lend themselves to mechanical harvesting. Thus, the production of alternative root crops represents a relatively easy transition for producers.

Analysis of Specific Root Crops

Red Beets

Red Beets offer potential for production in North Dakota. They are similar to sugar beets, which have proven their production feasibility in the state. They appear to have no major production constraints. Their local market demand is reported to be moderate, but

fresh beets could be shipped with potatoes in mixed loads to distant regional or national fresh markets. The mechanical harvester commonly used for carrots can also be used to harvest beets.

Carrots

Carrots thrive in Northern cool climates. Large volumes of carrots for processing are raised in southern Minnesota, and several large packaging operations have been producing carrots in the Anoka area for many years. A large carrot packaging operation has started recently in Traill, Minnesota and the same firm has started a carrot dehydration operation at Foston, Minnesota. The production around Anoka and Traill is largely on organic[3] peat or muck soils, although carrots are also grown around Traill on mineral soils.

Carrots for Packaging

Major constraints to the production of carrots for packaging in North Dakota are the relative absence of peat soils. Production of carrots for packaging in mineral soils poses certain problems:

a. Spring emergence -- Carrot seedlings have difficulty penetrating a crusted soil surface.

b. Carrot length -- The production of long carrot varieties, which have become the norm for packaged product, is more difficult in mineral soils than in peat, requiring carrots be grown on raised beds to permit root penetration and development. Harvesting long carrots on mineral soils with a mechanical harvester is also more difficult, since the soil clings to the roots and results in a higher percentage of misses and broken product.

---

[3]Defined by NDSU Soils Department as soil having 40% or more organic matter.

c. Wet conditions -- Harvesting in wet conditions on mineral soils is not feasible. Rainfall at harvest is a greater problem in mineral soils than on peat.

The problem of spring emergence can be partially overcome through early spring planting or irrigation. The problem of misses and breakage can be overcome by loosening the carrots prior to harvest and planting shorter varieties, but market acceptance of a short carrot is a serious constraint for regional and national markets. The problem of harvesting in sticky soils can be addressed by timing harvest during dry periods.

Carrots for Processing

Since short carrot varieties are typically used for processing, the processed carrot market appears to offer excellent potential for North Dakota. However, the closest carrot processing plant currently operating is United Foods Company at Fairmont, Minnesota, some 280 miles from Fargo.

Carrots grown for processing in Minnesota are raised on beds and are crowned (i.e., the stem is cut off) prior to harvest to reduce the need for hand labor. It appears crowning machines used for sugarbeets would also work for carrots. Next, carrots are mechanically dug and hauled to the processing plant where they are purchased on the basis of proper crowning. Deeper crowning represents yield loss to the producer but a higher product grade, since less post-harvest labor is required to trim the roots after the carrots arrive at the plant.

Yields of processed carrots in southern Minnesota were reported to be as high as 30 tons per acre. Grower contract prices in 1988 were around $43 per ton, based on normal percentages of 75% properly crowned and 30% oversized product. This amounts to gross returns of $1,290/acre.[4]

---

[4]Telephone interview with Mr. Jerry Voyles, Agricultural Manager for United Foods Company, Fairmont, Minnesota, March 25, 1988).

Garlic

Garlic has storage characteristics similar to onions. Area growers have reported success with both fall and spring planted garlic. However, no local grower has mechanized production of this crop. Garlic has limited local demand but could be marketed regionally or nationally and could also be dehydrated.

Onions

Onions were a significant crop in the Fargo-Moorhead area during the 1940s and 1950s. Farmers are said to have reached a total acreage in excess of 1700 acres.[5] The major onion producers around Fargo-Moorhead gradually dropped out of onion production due to price instability and competition from Western growers who popularized the mild Spanish onion types. Onions were also raised on a large scale in the Grand Forks area and farther north. Currently, one major onion grower remains in the Fargo-Moorhead area with an annual production of about 50 acres. Smaller amounts are raised by a limited number of farmers in the northern Red River Valley. Commercial onion prices continue to be volatile.

Local market demand for onions is strong, but volume requirements are not enough to support a massive expansion in acreage. Regional marketing may be feasible, so the potential for onion production and marketing appears quite good. This is because the product keeps well and lends itself to mechanized harvesting. Existing potato storage facilities can be adapted for onion storage. Production of direct seeded onions can be accomplished by planting early in the spring, particularly when planting fast-maturing types. Direct seeding of Spanish onions is risky due to the long growing period required for this type and the difficulty in curing them under wet harvest conditions. Transplanting greenhouse or Southern grown Spanish onions is feasible for small acreages,

[5]Interview with Bud Romkey, onion grower and packager of Moorhead, Minnesota, Spring, 1989.

as it permits producers to enter the market at least one month earlier than with direct seeded onions. Fast maturing winter storage varieties are recommended for large acreages rather than transplants which are too expensive. Weeds are a serious problem for onions, but chemical methods of weed control are available.

For small acreages, onions can be hand harvested into burlap sacks and allowed to dry in the field. This is particularly appropriate for large Spanish onions which suffer bruising from mechanical harvesters. For large commercial acreages, specialized equipment is recommended including a rod weeder for uprooting the bulbs, a windrower to gather the bulbs after they are dry (can use an adapted two-row potato digger), and an onion harvester to lift them into trucks after curing.

Onions (depending on variety) can be stored for up to eight months at 32°F and rather low humidity. The continual movement of air around and through them is important to keep them dry to avoid sprouting. Commercial onion markets continue to be volatile.

Parsnips

Parsnips, closely related to carrots, grow well in the heavy soils of North Dakota. A major problem with their production appears to lie in seedling emergence. The seeds, when planted 1/2 inch deep at a soil temperature of 50°F, require 27 days to emerge compared to 17 days for carrots (Lorenz, p. 56). Like carrots, parsnip seedlings have difficulty penetrating crusted soils.

Parsnips, depending upon variety, require 100 to 130 days from planting to reach maturity compared to carrots requiring 60-85 days. Parsnips are a slow mover in supermarkets, and since they desiccate rapidly, they are waxed prior to sale.

Radishes

Spring radishes planted in early spring reach maturity within 22-40 days of planting, while winter radishes require 50-60 days. Radishes are quick and strong germinators

requiring moist growing conditions to avoid bitterness. Radishes are susceptible to attack by flea beetles. They can be hand harvested, bunched, and sold as greentop radishes or mechanically topped and harvested. Spring radish harvesters are highly specialized and can be seen in the Anoka, Minnesota area where considerable production occurs on peat soils. While production on black mineral soils of North Dakota seems feasible, it is questionable whether demand for the product would be sufficient to justify purchase of harvesting equipment. Irrigation is important for radishes.

Rutabagas

This crop grows best in Northern cool climates on virgin soils. Like the radish, it is also a strong germinator and its leaves are highly susceptible to attack by flea beetles. Its roots are susceptible to attack by root maggots. Either chemical applications or careful plot selection is required to avoid maggot problems. Irrigation is not required for successful production. Common varieties mature in 90 days, and roots tend to enlarge quickly in cool fall weather. Rutabagas can be harvested with carrot harvesting equipment. Local growers have at times noted a problem of bitterness in locally grown rutabagas which limits market acceptance. Rutabagas are waxed prior to sale, and local demand is moderate.

Turnips

Like rutabagas and radishes, turnips are strong germinators and susceptible to flea beetles and root maggots. They grow rather quickly, reaching maturity between 40-75 days after planting. They can be harvested with a carrot harvester, but demand for turnips in the North appears quite limited. Like rutabagas and parsnips, they are waxed prior to sale.

The Most Feasible Root Crops for Large Scale Production

Of the above mentioned root crops, red beets, onions and carrots appear to hold the best potential for large scale commercial production in North Dakota. All can be

processed and have some fresh market demand. Onions can be marketed fresh on a large scale, both locally and regionally. Beets can be marketed fresh but have a limited fresh market demand, which may require penetration of distant markets. Carrots have a strong fresh market demand, but their large scale success in North Dakota appears to depend upon consumer acceptance of a short highly flavorful carrot.

Rutabagas, garlic and turnips offer less feasible production/marketing opportunities. Not enough is known about parsnip production to reliably assess feasibility, although local demand is known to be quite limited.

Large acreages are not required for production and marketing of a crop to be feasible for a farmer. Smaller niche markets can be profitable for a limited number of individuals. For this reason alternatives with production potential but restricted market demand should not be ruled out for individual growers.

Onion Production Potential for North Dakota

U.S. onion production has gradually increased over the past 10 years from 35.9 million cwt. in 1978 to 45 million cwt. in 1987 (Figure 1). Increased yields rather than additional acreage is primarily responsible for additional production. The 1978-1982 average yield was 309 cwt. per acre compared to 369 cwt. for the 1983-1987 average.

The growing demand for onions is driven by two factors, population growth and increased per capita consumption of onions. From 1978 to 1987 U.S. resident population increased 21 million to 243 million, a 10 percent increase. Per capita consumption during the same period increased from 13.7 pounds in 1978 to 16.3 pounds in 1987, a 19 percent increase, (Table 3).

Seasonal Production

The USDA classifies onion production into four categories; spring, summer-non-storage, summer-storage, and summer-California. Although onion production has increased dramatically over the past ten years, relative market share between USDA

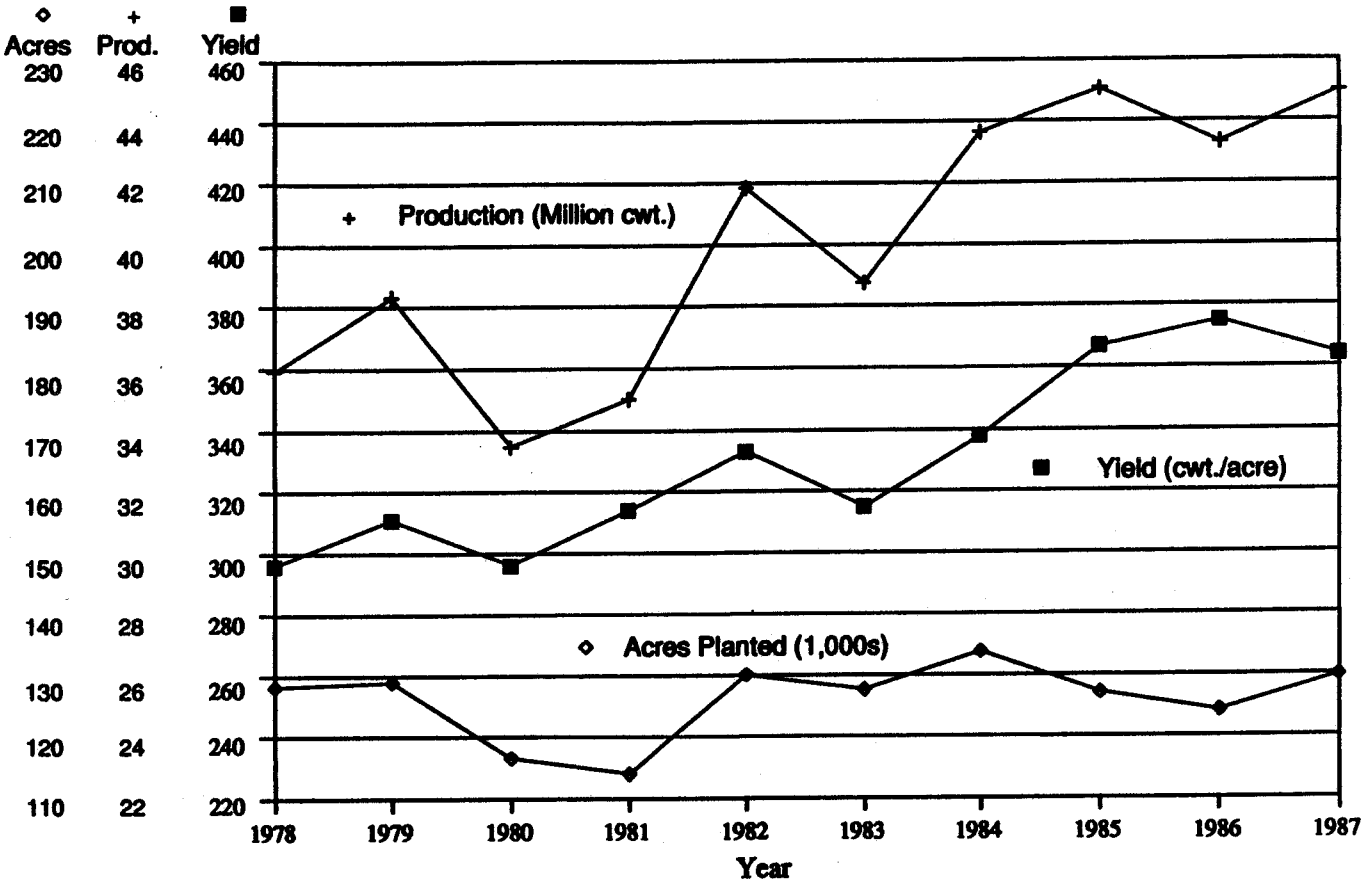


Figure 1. Acreage, Production, and Yield for U.S. Onions, 1978-1987.

SOURCE: USDA, Vegetable Summary, Various Issues.

TABLE 3. U.S. PER-CAPITA CONSUMPTION, ONIONS, 1970-1987

Year	lbs.	Year	lbs.	Year	lbs.
1970	12.4	1976	13.1	1982	15.2
1971	13.1	1977	13.5	1983	15.3
1972	12.6	1978	13.7	1984	16.1
1973	12.5	1979	14.7	1985	16.5
1974	13.9	1980	13.7	1986	17.9
1975	13.3	1981	13.1	1987	16.3

SOURCE: USDA, ERS, Food Consumption, Prices, and Expenditures, 1989.

categories has remained fairly constant. Spring production accounts for 16 percent of total production, while summer non-storage onions account for 7.8 percent of production. Summer storage onions account for 54 percent of production and summer California onions account for 22 percent of production. Comparing 1978-82 averages with 1983-87 averages indicates spring and summer California production has remained constant while summer non-storage onions experienced a slight downward trend. Summer storage onions have experienced an upward trend (Table 4).

Unlike seasonal production groups where market share is constant, there are distinctive trends in individual states' market shares. California's share of spring onions is growing at the expense of Arizona and Texas. Market share of Texas' summer onions has also decreased. Colorado, Idaho, and Oregon have increased their market share of summer storage onions. Washington also marginally increased its market share. The primary loser of market share was New York, and to a lesser extent Michigan. Minnesota, Ohio, Utah and Wisconsin each decreased slightly in market share (Table 5).

California is the largest producer of onions, accounting for 28.99 percent of production during the five-year period from 1983-87. Oregon is second at 14.76 percent followed by Texas at 10.75 and Colorado at 10.52 percent, Idaho fifth at 7.82 percent, and New York sixth at 7.75 percent. These six states accounted for over 80 percent of U.S. onion production.

TABLE 4. U.S. SEASONAL MARKET SHARE OF ONIONS, 1978-82 and 1983-87

	1978-1982	1983-1987
	percent	
Spring	16.27	15.99
Summer - non-storage	8.62	7.76
- storage	52.81	53.98
- California	22.30	22.27

SOURCE: Adapted from Vegetables, Agricultural Statistics Board, USDA, 1978-1987.

TABLE 5. ONION PRODUCTION AND MARKET SHARE BY SEASON AND STATE, 1978-1987

	Production										Market Share	
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1978-82	1983-87
	(1,000 cwt)										percent	
Spring												
Arizona	738	536	623	512	876	656	805	564	660	585	1.78	1.52
California	1,590	1,904	1,683	2,160	2,805	2,166	2,734	3,510	2,886	3,198	5.49	6.72
Texas	3,345	3,504	3,569	2,700	3,492	3,800	3,348	3,230	3,600	2,750	9.00	7.75
Subtotal	5,673	5,944	5,875	5,372	7,173	6,622	6,887	7,304	7,146	6,533	16.27	15.99
Summer non-storage												
New Jersey	84	115	75	104	90	-	-	-	-	-	.25	.00
New Mexico	1,184	960	1,131	1,242	1,643	1,248	1,365	1,463	1,810	2,106	3.34	3.70
Texas	1,502	1,520	1,764	1,488	1,544	1,643	1,560	943	1,537	799	4.23	3.00
Washington	304	278	257	320	315	492	432	390	429	532	.80	1.05
Subtotal	3,074	2,873	3,227	3,154	3,592	3,383	3,357	2,796	3,776	3,437	8.62	7.76
Summer-storage												
Colorado	2,730	2,535	2,460	2,925	3,255	3,432	4,636	5,355	4,590	4,688	7.53	10.52
Idaho	2,470	2,295	2,453	2,625	2,475	2,475	2,323	3,740	3,710	4,620	6.67	7.82
Michigan	2,448	2,414	1,800	2,446	2,560	2,573	2,933	2,535	1,653	1,900	6.32	5.37
Minnesota	223	125	201	199	168	158	156	194	208	195	.50	.42
New York	4,309	4,818	4,433	3,933	4,550	2,793	3,384	3,960	3,456	3,132	11.94	7.75
Ohio	231	221	165	170	165	193	205	221	169	139	.52	.43
Oregon-Malheur	3,373	3,672	3,434	3,360	3,687	4,242	5,505	5,280	4,505	5,520	9.49	11.61
Oregon-West	814	1,104	1,104	1,100	1,134	1,050	1,280	1,505	1,440	1,512	2.85	3.15
Utah	720	830	656	777	730	570	693	720	469	825	2.01	1.52
Washington	1,178	1,560	1,320	1,480	1,482	1,540	1,935	1,763	1,848	2,300	3.80	4.35
Wisconsin	443	435	348	455	495	552	544	436	378	336	1.18	1.04
Subtotal	18,939	20,009	18,374	19,470	20,701	19,578	23,594	25,709	22,426	25,167	52.81	53.98
California	8,250	9,504	6,000	7,025	10,395	9,179	9,819	9,250	9,953	9,860	22.30	22.27
Total Summer	30,263	32,386	27,601	29,649	34,688	32,140	36,770	37,755	36,155	38,464	83.73	84.01
U.S.	35,936	38,330	33,476	35,021	41,861	38,762	43,657	45,059	43,301	44,997	100.00	100.00

SOURCE: USDA, Vegetables, Annual Summaries, 1978-1988

Foreign Trade

The U.S. was a net exporter of onions prior to 1982. In five of the six following years the U.S. was a net importer (Table 6). Exports marginally exceeded imports in 1984, but by 1987 a net trade deficit of 1.75 million cwt existed, approximately 4.3 percent of domestic consumption. Import prices are seasonal and are generally lowest during August and September. Price increases occur monthly until peaking in March or April (Figure 2).

TABLE 6. U.S. ONION EXPORTS AND IMPORTS, 1970-1987

Year	Imports	Exports	Net Exports (Imports)	Year	Imports	Exports	Net Exports (Imports)
	1,000 lbs				1,000 lbs		
1970	76,185	147,160	70,975	1979	157,381	156,705	(676)
1971	50,882	137,018	86,136	1980	132,831	256,555	123,724
1972	61,451	128,817	67,366	1981	136,147	420,141	283,994
1973	148,368	186,155	37,787	1982	165,680	140,698	(24,982)
1974	98,293	147,629	49,336	1983	204,929	183,163	(21,766)
1975	81,005	152,473	71,468	1984	267,161	273,890	6,729
1976	78,025	326,580	248,555	1985	263,649	121,607	(142,042)
1977	144,144	189,195	45,051	1986	247,696	164,406	(83,290)
1978	138,698	249,500	110,802	1987	371,159	195,826	(175,333)

SOURCE: USDA, Vegetables and Specialties, November, 1988.

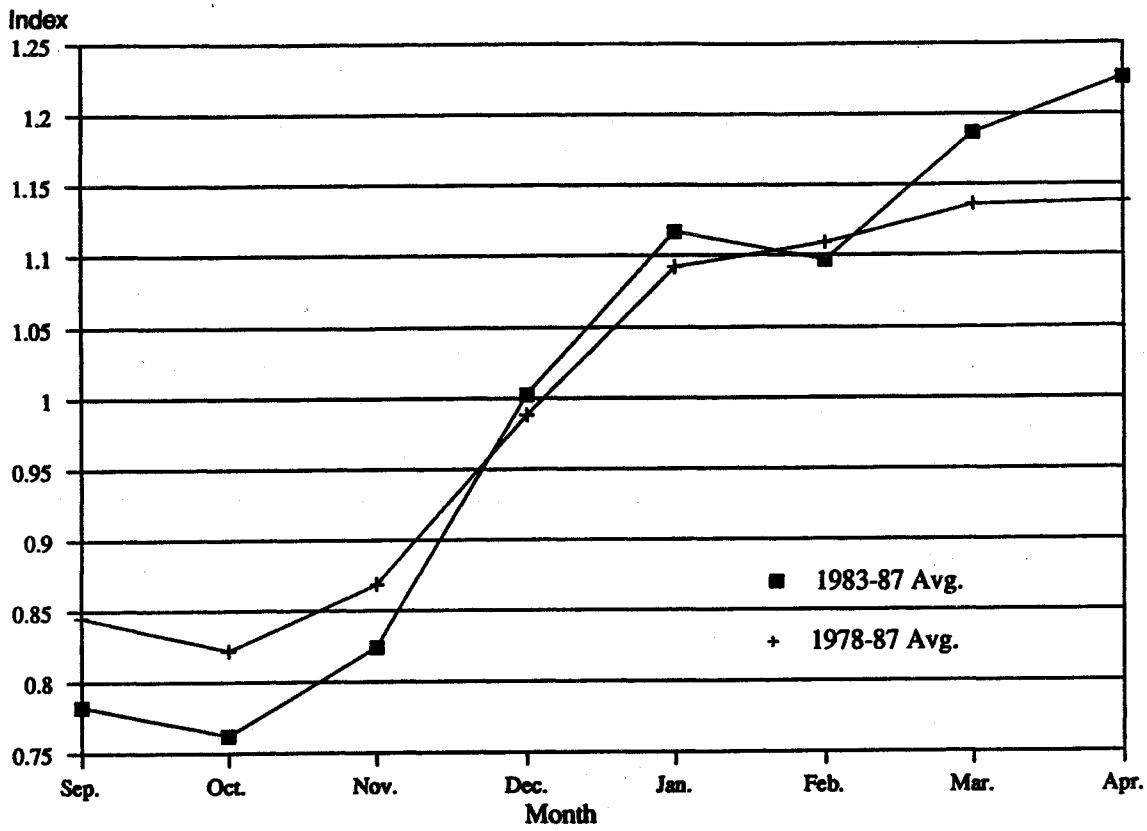


Figure 2. Monthly Price Indices for Idaho-Oregon Onions Using Wholesale Chicago Prices.

SOURCE: USDA, Fresh Fruit and Vegetable Prices, 1978-1987.

The majority of onion imports are from Latin America with Mexico being the largest Latin American supplier. Canada is the next largest supplier accounting for 14.7 and 8.4 percent of the imports in 1986 and 1987 (Table 7).

Seasonal Shipping

Shipping seasons vary in time and length depending on production and climate of the producing states. Arizona, California, and Texas typically do not store crops as refrigeration is too expensive in these climates. Production in these states is generally planned to supply fresh products when Northern states cannot meet supply requirements.

Arizona generally ships products during May and June, New Mexico from June to August, Texas from April to August, and California all year round with most products shipped from May to August. Colorado, Idaho, Michigan, Oregon, and Washington generally begin shipping in August when harvest begins and continue until March or April as onions are removed from storage (Table 8). Eighty percent of onion shipments were by truck during 1987, 13.5 percent were by rail, of which 3 percent were by piggyback rail.

TABLE 7. U.S. ONION IMPORTS BY COUNTRY OF ORIGIN, 1986 AND 1987

	1986	1987
	metric tons	
Latin America	94,081	148,583
Mexico	93,199	138,352
Chile	379	9,344
Other	503	656
Canada	16,754	14,081
Other	3,247	4,328
Total	114,082	166,992

SOURCE: Foreign Agricultural Trade of the United States, 1988.

TABLE 8. ONION SHIPMENTS BY STATE, ORIGINS, AND MONTHS, 1987

Origin		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
		1,000 cwt												
Onions, Dry - Rail														
Arizona		-	-	-	-	11	-	-	-	-	-	-	-	11
Calif Cent		-	-	-	-	8	50	1	1	-	1	-	1	62
Calif Cent	Expt	-	-	-	-	1	-	-	-	-	-	-	-	1
Calif South	Expt	-	-	-	-	5	1	-	-	-	-	-	-	6
Colorado		-	-	-	-	-	-	-	2	-	-	2	3	7
Idaho		296	143	90	2	-	-	2	37	199	243	208	276	1,496
Oregon		288	189	141	9	-	-	-	45	177	231	178	210	1,468
Texas		-	-	-	5	15	-	-	-	-	-	-	-	20
Utah		-	-	-	-	-	-	-	-	3	3	2	3	11
Washington		2	1	-	-	-	-	-	-	14	9	-	1	27
Total		586	333	231	16	40	51	3	85	393	487	390	494	3,109
Onions, Dry - Piggyback														
Arizona		-	-	-	-	55	12	-	-	-	-	-	-	67
Calif Cent		-	-	-	-	14	166	230	36	9	15	2	2	474
Calif South		-	2	-	-	-	-	-	-	-	-	-	4	6
Calif Imp Vly		-	-	-	8	124	10	-	-	-	-	-	-	142
Colorado		-	-	-	-	-	-	-	6	20	2	2	-	30
Idaho		15	13	14	-	-	-	-	8	13	7	5	9	84
New Mexico		-	-	-	-	-	4	-	-	-	-	-	-	4
Oregon		13	14	36	2	-	-	1	9	13	7	3	7	105
Texas		-	-	-	5	7	-	-	-	-	-	-	-	12
Utah		2	-	-	-	-	-	-	-	-	-	-	-	2
Washington		10	7	4	-	-	2	9	-	1	1	-	1	35
Total		40	36	54	15	200	194	240	59	56	32	12	23	961
Onions, Dry - Available Truck														
Arizona		-	-	-	-	285	163	4	-	-	-	-	-	452
Calif Cent		82	30	46	-	182	891	990	458	133	100	67	52	3,031
Calif Cent	Expt	-	-	-	-	-	4	4	2	-	1	1	-	12
Calif South		85	54	84	29	-	13	30	37	38	65	79	56	570
Calif Imp Vly		-	-	-	187	817	54	-	-	-	-	-	-	1,058
Colorado		348	192	16	-	-	-	58	492	631	591	513	434	3,275
Florida		-	-	-	8	1	-	-	-	-	-	-	-	9
Georgia		-	-	-	28	279	62	-	-	-	-	-	-	369
Idaho		126	121	132	38	-	-	-	92	185	234	179	223	1,330
Idaho	Expt	-	-	-	-	-	-	-	-	-	16	6	-	22
Michigan		192	126	105	-	-	-	-	105	150	145	151	186	1,160
New Mexico		-	-	-	-	3	691	527	337	94	-	-	-	1,652
New York		367	290	343	140	-	-	3	179	367	317	315	296	2,617
New York	Expt	1	-	-	-	-	-	-	-	-	-	-	-	1
Oregon		396	400	424	55	-	9	41	271	394	409	321	417	3,137
Oregon	Expt	17	13	21	3	-	6	2	19	41	59	101	191	473
Texas		-	-	78	1257	1231	320	440	207	-	-	-	-	3,533
Utah		86	24	-	-	-	-	-	4	115	177	137	99	642
Washington		208	214	126	14	-	164	301	152	226	193	186	167	1,951
Washington	Expt	31	27	17	2	-	8	18	18	36	45	102	79	383
Total		1,939	1,491	1,392	1,761	2,798	2,385	2,418	2,373	2,410	2,352	2,158	2,200	25,677
U.S. TOTAL		2,565	1,860	1,677	1,792	3,038	2,630	2,661	2,517	2,859	2,871	2,560	2,717	29,747

SOURCE: USDA, Fresh Fruit and Vegetable Shipments, 1988.

Seasonal Pricing and Returns to Storage

Chicago wholesale prices were used as the basis in determining seasonality of prices and returns to storage. Major terminal market prices were used because they would clearly reflect the overall U.S. market condition and not be subject to individual local factors not indicative of the U.S. industry during a specific year.

The USDA only publishes comprehensive wholesale prices for two major markets, New York and Chicago. Chicago was chosen as this would most likely be a major market for North Dakota produce.

Analysis was limited to a September through March time period because the primary market season for summer storage onions would most likely be produced in North Dakota. Consequently, prices are generally not reported from April to August for summer storage onions as not enough produce is shipped to establish a price series. Also, market is generally supplied with spring season production from Southern states. The price series used were Idaho-Oregon Yellow Spanish Jumbo onions and Michigan Yellow Medium onions as reported by the USDA. Monthly prices are reported in Tables 9 and 10. Onion prices tend to be variable from year to year, ranging from $5.35 for 50 pounds in November 1979 to $11.25 in November 1981 for Idaho-Oregon Spanish onions.

Five-year (1983-1987) and ten year (1978-1987) indices of monthly onion prices are presented in Figures 2 and 3. Both indices indicate traditional price behavior with prices lowest during harvest and increasing thereafter. Higher prices reward the producer for additional costs associated with storage of the commodity. Both classes exhibit the same behavior. Prices actually are higher at the beginning of harvest and then drop and then rise throughout the season.

Prices generally increase throughout the year, but every year is unique. Idaho-Oregon onion prices have historically had a higher probability of increasing. Prices during the ten-year period 1978-1987 increased eight of ten years for both three-month and five-month storage periods. Michigan prices increased only four years when storing three-months and six years when storing five-months. During the recent five-year period,

TABLE 9. WHOLESALE-CHICAGO PRICES FOR U.S. NO. 1 IDAHO-OREGON YELLOW SPANISH JUMBO ONIONS, 1977-1987

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
	$/50 lb. sack							
1977	4.60	4.76	4.95	4.76	4.60	3.84	7.38	8.00
1978	5.38	5.64	6.50	9.00	10.80	12.63	10.00	8.50
1979	5.65	5.35	5.35	5.15	4.69	4.53	4.35	4.67
1980	8.20	7.43	8.06	10.32	10.94	11.00	17.25	15.50
1981	8.25	9.09	11.25	11.05	14.13	14.19	8.60	6.95
1982	7.69	6.97	5.70	4.88	4.88	5.35	6.15	7.75
1983	6.66	7.16	8.50	13.13	13.85	14.00	18.50	15.38
1984	7.33	7.30	7.75	9.75	8.92	7.94	7.68	10.03
1985	6.00	5.47	5.72	6.60	6.75	6.13	5.95	5.97
1986	6.93	7.31	7.63	8.40	11.00	11.93	14.30	15.75
1987	6.72	6.00	6.60	7.03	9.75	9.90	9.19	9.38

SOURCE: USDA, Fresh Fruit and Vegetable Prices, 1978-88.

TABLE 10. DRY ONION PRICES FOR MICHIGAN YELLOW MEDIUM ONIONS, WHOLESALE-CHICAGO, 1977-1987

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar
	$/50 lb. sack						
1977	4.25	4.20	3.70	4.14	3.95	3.59	3.81
1978	4.80	4.28	3.84	3.57	3.87	4.00	4.00
1979	5.16	4.12	3.75	3.45	3.28	3.01	2.85
1980	8.20	7.43	8.06	7.06	8.31	9.44	11.35
1981	6.95	6.28	6.25	6.21	6.59	7.25	6.90
1982	5.41	4.50	4.30	3.98	3.86	4.25	4.93
1983	7.38	7.70	7.50	8.00	8.70	9.66	11.63
1984	7.06	5.93	5.10	5.25	4.89	4.56	4.34
1985	5.38	3.88	4.06	4.30	5.56	5.85	4.95
1986	6.80	6.75	6.85	7.25	8.43	10.00	11.94
1987	6.88	6.50	7.00	7.00	9.06	9.95	9.19

SOURCE: USDA, Fresh Fruit and Vegetable Prices, 1978-1987

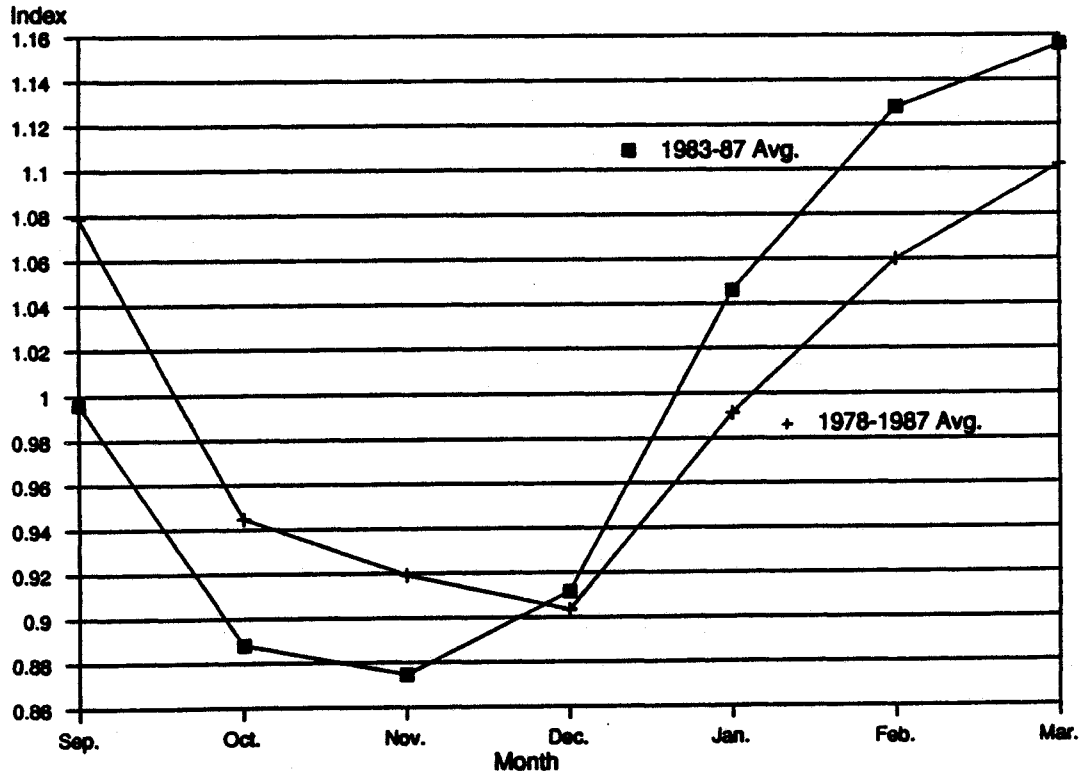


Figure 3. Monthly Price Indices for Michigan Onions Using Wholesale Chicago Prices.

SOURCE: USDA, Fresh Fruit and Vegetable Prices, 1978-1987.

1983-1987, there has been a positive return to storage in every year for Idaho-Oregon onions and for four years for Michigan onions. Production in 1984 increased significantly over the previous year, 43.7 versus 38.8 million cwt. This large increase in production may have prevented prices from rising. Average increase in price was $1.62 and $2.44 per 50 pound sack of Idaho-Oregon onion for three- and five-month storage periods from 1978-1987. Price increases were greater during the five-year period from 1983-1987, averaging $2.83 and $3.87 for three- and five-month storage periods (Table 11). Price behavior has been similar for Michigan onions; however, prices have not increased to the extent of Idaho-Oregon onions. Price increases averaged $.42 and $1.78 for three- and five-month storage periods from 1983 to 1987. This is less than half of those for Idaho-Oregon (Table 12).

TABLE 11. RETURN TO STORAGE FOR IDAHO-OREGON YELLOW SPANISH ONIONS (3[a] AND 5[b] MONTH PRICE CHANGES), 1978-1987

Year	Months		Year	Months	
	Three	Five		Three	Five
	----$/50 lb. sack----			----$/50 lb. sack----	
1978	4.40	5.81	1983	6.58	9.34
1979	-.58	-1.06	1984	2.02	.50
1980	2.82	6.31	1985	.94	.31
1981	3.92	2.73	1986	2.58	6.00
1982	-2.45	-1.58	1987	2.03	3.19
1978-87 average	2.23	3.15	1983-87 average	2.83	3.87

[a]Dec.-Jan. average minus Sept.-Oct. average.
[b]Feb.-Mar. average minus Sept.-Oct. average.

SOURCE: Adapted from Table 9.

TABLE 12. RETURN TO STORAGE FOR MICHIGAN YELLOW MEDIUM ONIONS (3[a] AND 5[b] MONTH PRICE CHANGES), 1977-1987

Year	Months		Year	Months	
	Three	Five		Three	Five
	----$/50 lb. sack----			----$/50 lb. sack----	
1978	-.82	0.54	1983	.81	3.11
1979	-1.28	-1.71	1984	-1.43	-2.05
1980	-.13	2.5	1985	.30	.77
1981	-.22	.46	1986	1.07	4.20
1982	-1.04	-.37	1987	1.07	4.20
1978-87 average	-.14	.93	1983-87 average	.42	1.78

[a]Dec.-Jan. average minus Sept.-Oct. average.
[b]Feb.-Mar. average minus Sept.-Oct. average.

SOURCE: Adapted from Table 10.

Market Competitiveness

The market competitiveness of North Dakota depends upon one major factor; the ability to deliver products to a market at equal or less cost than other suppliers assuming acceptable quality standards are maintained. Production and shipping costs are the major components in determining final cost.

Published data are not available on production costs for major producing regions in the U.S. However, North Dakota's advantage (disadvantage) in shipping cost can be estimated. For the market where North Dakota has a shipping cost advantage, the state can be a competitive supplier providing the differential in production costs does not exceed the shipping cost advantage.

Since primary production of storage onions is located in the West, the potential market for North Dakota production would be markets east or southeast of North Dakota. These would include Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, South Dakota, and North Dakota. Although many of these states also produce onions, they still remain net importers, including North and South Dakota. The exception is Michigan, which is a net exporter of onions. This eight state region is a net importer based on historical production and population estimates. The eight state region accounts for 19.52 percent of U.S. population but only 7.26 percent of U.S. onion production (Table 13). Assuming regional consumption is similar to U.S. consumption, the eight state region produces only 38 percent of what it consumes. In reality this may overstate market potential. The eight states, during late spring and summer, are supplied by Southern states when regional produce is not available. However, since North Dakota is in a deficit region and has a transportation advantage over Western producing states, it has the potential to be a market supplier.

Transportation costs were estimated for six markets in estimating North Dakota's transportation advantage (disadvantage) relative to three other supply points. The markets selected were Fargo, Minneapolis, Chicago, New York, Atlanta, and Sioux Falls to

TABLE 13. REGIONAL MARKET SHARES FOR PRODUCTION OF ONIONS AND POPULATION, 1988

State	U.S. Population	U.S. Onion Production
	----------%----------	
Illinois	4.76	--
Indiana	2.27	--
Michigan	3.78	5.37
Minnesota	1.74	.42
North Dakota	.28	--
South Dakota	.29	--
Ohio	4.43	.43
Wisconsin	1.97	1.04
Total	19.52	7.26

SOURCE: U.S. Census 1980 and Table 5.

represent local, regional, and national markets. Major competing supply regions would be Colorado, Oregon-Idaho-Washington, Michigan, and Grand Forks, representing the Red River Valley of North Dakota. Transportation cost advantages (disadvantages) were estimated for the Red River Valley (Tables 14 and 15).

The Red River Valley has a transportation advantage serving all markets over the Pacific Northwest. The transportation advantage ranges from $1.75 per 50 pounds to Minneapolis to $1.33 to Atlanta. The Red River Valley also has a cost advantage over Colorado in all markets. Michigan has a cost advantage in supplying Atlanta, New York, and Chicago markets.

Onions are also shipped by rail from the Northwest. A comparison of rail and truck costs for the Northwest indicated rail reduced costs by approximately $.40 to $.80 per 50 pounds. This cost reduction reduces the Red River Valley transportation advantages. Rail also incurs additional costs including longer delivery times, potentially higher inventory costs, and greater handling costs. Non-cost considerations include less control over shipping once shipment occurs, potential car scheduling problems, and more restrictive planning horizons.

TABLE 14. ESTIMATED TRANSPORTATION COSTS FOR ONIONS FROM SELECTED ORIGINS TO SELECTED MARKETS, UNITED STATES[a], 1989

Market Destinations	Origin			
	Grand Forks	Denver	Pacific Northwest	Michigan
	----------$/50 lb.----------			
Fargo	.23	1.35	2.09	1.41
Minneapolis	.57	1.42	2.32	1.07
Chicago	1.15	1.53	2.72	.51
New York	2.28	2.63	3.85	1.17
Atlanta	2.09	2.10	3.42	1.29
Sioux Falls	.58	1.09	2.25	1.30

[a]Rates estimated by following formula: Rate/50 lb. unit = (100 + 1.25 * miles)/880 units.

SOURCE: Based on Tariffs derived from industry sources.

TABLE 15. RED RIVER VALLEY'S ESTIMATED TRANSPORTATION COST ADVANTAGE (DISADVANTAGE) IN SUPPLYING SELECTED MARKETS, UNITED STATES, 1989

Market Destinations	Origins		
	Denver	Pacific Northwest	Michigan
	----------$/50 lb.----------		
Fargo	.98	1.50	1.05
Minneapolis	.74	1.53	.46
Chicago	.36	1.32	(.53)
New York	.32	1.28	(.94)
Atlanta	(.05)	1.03	(.77)
Sioux Falls	.48	1.48	.69

SOURCE: Adapted from Table 14.

Carrot Production Potential for North Dakota

U.S. carrot production has increased from 20.6 million cwt. in 1978 to 25.5 million cwt. in 1987. Both increased yield and acreage have been responsible for the additional

production. The 1978-1982 average yield was 273.8 cwt. per acre compared to 289.4 cwt. for the 1983-1987 period (Table 16). Harvested acreage averaged 76.1 thousand acres between 1978-1982 rising slightly to 78.8 between 1983 and 1987.

The growing demand for carrots is driven by two factors, population growth and increased per capita consumption. From 1978 to 1987 U.S. resident population increased by 21 million, a 10 percent increase. Per capita consumption of carrots during the same period increased from 9 to 11.8 pounds. This increase slightly exaggerates the increasing trend as 1978 consumption was abnormally low and 1987 abnormally high. Nevertheless, an increasing trend is apparent (Figure 4).

State Production

Collection of seasonal production data was discontinued by the USDA in 1978. The largest carrot producing state was California, accounting for 50 percent of total U.S. production from 1983 to 1987 (Table 17). The second largest producing state was Texas at

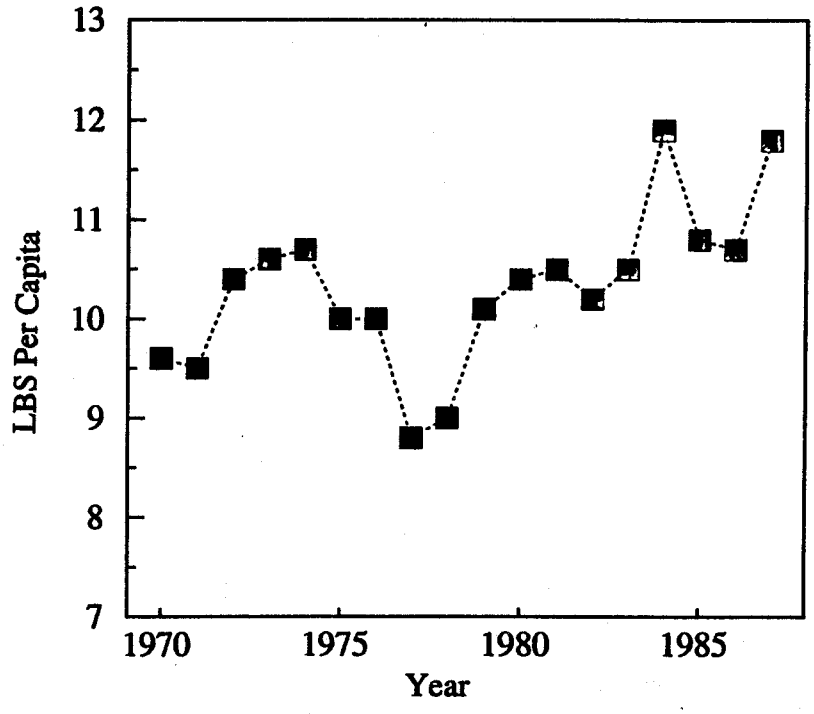


Figure 4. U.S. Per Capita Carrot Consumption, 1970-1987.

SOURCE: USDA, Food Consumption, Prices and Expenditures, 1988.

TABLE 16. UNITED STATES CARROT PRODUCTION, HARVESTED ACREAGE, AND YIELDS, 1978-1987

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	5 Year Averages 1978-82	5 Year Averages 1983-87
Production (million cwt)	20.6	22.4	20.9	21.8	24.1	23.2	23.7	22.9	23.4	25.5	22.0	23.8
Yield[a] (cwt/acre)	258	269	270	277	295	285	277	278	305	302	273.8	289.4
Harvested[a] Acreage (1,000 acres)	76.8	78.2	72.5	73.9	79.4	77.4	83	78.7	73.9	81	76.1	78.8

[a]Excludes Florida from 1982 to 1987, to make series consistent, as Florida was not included prior to 1982.

SOURCE: The Almanac of the Canning, Freezing, Preserving Industries, 1988

TABLE 17. U.S. CARROT PRODUCTION BY STATE AND MARKET SHARE BY STATE, FIVE YEAR AVERAGES, 1978-1987

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	5 Year Average 1978-82	5 Year Average 1983-87
	1,000 cwt										%	
Arizona	255	241	294	223	449	543	377	396	396	400	1.32	1.78
California	8,536	10,291	10,385	9,735	11,447	11,490	12,011	10,959	12,568	12,580	45.81	50.19
Colorado	250	245	264	385	350	248	280	350	408	449	1.36	1.46
Florida	1,216[a]	1,245[a]	1,349[a]	1,365[a]	921[a]	1,100	731	1,058	849	1,065	5.59	4.05
Michigan	1,614	1,713	1,340	1,316	1,710	1,655	2,025	1,664	926	1,926	7.00	6.89
Minnesota	553	609	494	416	555	441	429	456	479	541	2.39	1.97
New York	571	551	365	391	527	520	568	539	560	432	2.19	2.21
Oregon	449	617	699	889	1,002	540	516	527	460	381	3.30	2.05
Texas	3,107	2,176	2,049	2,751	2,446	2,751	2,175	2,001	2,030	2,185	11.46	9.40
Washington	1,821	2,237	1,938	1,760	2,088	1,600	1,829	2,264	2,407	3,037	8.96	9.33
Other states	1,236	1,403	588	710	788	760	895	1,152	828	798	4.29	3.74
Wisconsin	1,025	1,118	1,125	1,890	1,800	1,488	1,898	1,551	1,523	1,750	6.32	6.92
Total	20,633	22,446	20,890	21,831	24,083	23,136	23,734	22,917	23,434	25,544	100.0	100.0

[a]Florida was not included in original data from 1978 to 1982, included by authors.

SOURCE: The Almanac of Canning, Freezing, Preserving Industries, 1989.

9.4 percent, followed by Washington at 9.3 percent. Wisconsin was fourth at 7.2 percent and Michigan was fifth at 6.9 percent. When comparing 1978-82 averages with 1983-87 averages, certain state production trends were detected. Comparing the two period averages indicates California, Wisconsin, Arizona, and Washington increased their market shares, while Florida, Oregon, Texas, Michigan, Minnesota, and Ohio/New Jersey lost market share.

Fresh Versus Processed Carrots

Carrot production and consumption are comprised of two major market components, the fresh and the processed markets. These two markets have different characteristics. Although per capita carrot consumption has increased, the consumption of processed carrots has actually declined. Throughout the 1970's the fresh market accounted for 62-64 percent of production. By the 1980's the fresh market accounted for about 70 percent of all consumption (Table 18). Consequently per-capita consumption of carrots has increased.

TABLE 18. MARKET SHARES AND PER CAPITA CONSUMPTION OF FRESH AND PROCESSED CARROTS IN THE U.S., 1970-1987

Year	Market Share		Per Capita Consumption		
	Fresh	Processed	Fresh	Processed	Total
	%		lbs. per capita		
1970	62.5	37.5	6.0	3.6	9.6
1971	64.2	35.8	6.1	3.4	9.5
1972	62.5	37.5	6.5	3.9	10.4
1973	63.2	36.8	6.7	3.9	10.6
1974	64.5	35.5	6.9	3.8	10.7
1975	64.0	36.0	6.4	3.6	10.0
1976	64.0	36.0	6.4	3.6	10.0
1977	58.0	42.0	5.1	3.7	8.8
1978	62.2	37.8	5.6	3.4	9.0
1979	63.4	36.6	6.4	3.7	10.1
1980	67.3	32.7	7.0	3.4	10.4
1981	67.6	32.4	7.1	3.4	10.5
1982	71.6	28.4	7.3	2.9	10.2
1983	71.4	28.6	7.5	3.0	10.5
1984	66.4	33.6	7.9	4.0	11.9
1985	70.4	29.6	7.6	3.2	10.8
1986	72.0	28.0	7.7	3.0	10.7
1987	72.0	28.0	8.5	3.3	11.8

SOURCE: USDA, ERS, Food Consumption, Prices and Expenditures, 1989.

Although 67 percent (1983-1987 average) of total carrot production is for the fresh market, this varies widely among states. Three states, Arizona, Colorado, and Florida, produce entirely for the fresh market (Table 19).

Over 80 percent of production in California and Texas was for the fresh market. Production in Wisconsin, Ohio, Minnesota, New York, Oregon, and Washington, was primarily for the processed market. Michigan's production was similar to the national average with 64 percent of production sold in the fresh market. Wisconsin/Ohio/New Jersey production was almost entirely for the processed market (Table 19). Increased consumption of fresh carrots is due to (1) a shift away from processed carrots, (2) an increase in overall per capita consumption, and (3) an increase in population. Total production of processed carrots has not decreased as population increases have more than offset declining per capita consumption. This has resulted in a 64 percent increase in fresh market production since 1970, from 10.95 million cwt. to 17.9 million cwt. in 1987.

A market shift to the fresh market is occurring in California, Oregon and Texas, while Michigan, Minnesota, and New York are shifting production from fresh to processed. California, Washington, and Wisconsin/Ohio/New Jersey account for 75 percent of all processed carrots with five-year market shares of 23, 22, and 30 percent, respectively (1983-1987 average) (Table 20). Likewise two states, California and Texas, account for 75 percent of the fresh market with 63 and 12 percent of the market, respectively.

TABLE 19. MARKET SHARE OF STATES FIVE-YEAR CONSUMPTION AS A PERCENT OF STATES PRODUCTION FOR FRESH CARROTS 5 YEAR AVERAGES, 1978-1982 and 1983-1987

State	1978-82	1983-87	State	1978-82	1983-87
	----------%----------			----------%----------	
Arizona	100.00	100.00	New York	47.16	42.07
California	77.99	84.84	Oregon	16.30	24.02
Colorado	100.00	100.00	Texas	78.98	84.07
Florida	100.00	100.00	Washington	21.27	22.46
Michigan	65.18	63.72	Other states[a]	7.38	7.85
Minnesota	42.10	37.24	United States	62.89	70.44

[a]Includes Wisconsin, Ohio, and New Jersey.

SOURCE: USDA, ERS, Food Consumption, Prices and Expenditures, 1989.

TABLE 20. MARKET SHARE OF PROCESSED CARROTS, AS A PERCENT OF STATES PRODUCTION, FIVE-YEAR AVERAGES, 1978-1982 AND 1983-1987

State	1978-82	1983-87
	%	
Michigan	6.57	7.42
Minnesota	3.73	3.78
New York	3.08	3.87
Wisconsin	.00	.00
California	26.79	23.03
Oregon	7.57	4.77
Texas	6.62	4.68
Washington	19.00	22.43
Other	26.65	30.01
Total	100.00	100.00

SOURCE: USDA, ERS, Food Consumption, Prices, and Expenditures.

Foreign Trade

Prior to 1979 the U.S. was a net exporter of carrots. Two exceptions were 1970 and 1974 when the U.S. was a net importer. Since 1980 the U.S. has been a net importer of carrots. In 1984 the trade deficit peaked at 1.3 million cwt. or 5.6 percent of domestic product. By 1987 the trade deficit was reduced to .44 million cwt. or 1.7 percent of production (Table 21).

TABLE 21. U.S. CARROT EXPORTS, IMPORTS AND NET EXPORTS (IMPORTS) 1970-1987

Year	Imports	Exports	Net Exports
	1,000 lbs		
1970	56,185	50,628	(5,557)
1971	52,647	69,647	17,000
1972	51,030	80,188	29,158
1973	48,008	63,255	15,247
1974	70,063	65,882	(4,181)
1975	60,797	92,971	32,174
1976	67,300	69,285	1,985
1977	72,557	119,443	46,886
1978	72,308	117,867	45,559
1979	94,825	104,201	9,376
1980	108,683	62,464	(46,219)
1981	87,882	87,396	(486)
1982	105,126	78,423	(26,703)
1983	102,515	69,252	(33,263)
1984	212,870	80,634	(132,236)
1985	147,789	60,184	(87,605)
1986	113,473	58,956	(54,517)
1987	99,760	55,586	(44,174)

SOURCE: USDA, Vegetables and Specialties, November 1988.

Imports are seasonal in nature. The majority of imports in 1987 were during the period from September to December. Canada is the major supplier, accounting for over 80 percent of the shipments in 1987 (Table 22).

Seasonal Shipments

Carrot shipments are greater from January to June than from August to December. Data do not exist to determine whether carrot consumption is seasonal in nature. However, one possible explanation for seasonal shipments is that during late summer and fall homegrown produce and local truck farms may supply a significant portion of the demand.

Shipping seasons also vary among states. Although central California ships yearlong, southern California and the Imperial Valley are major suppliers from December through May (Table 23). Arizona, Florida, and Texas also ship mainly from December through May. Michigan and Washington's primary shipping season is from August through November. Shipments are primarily by truck, 77 percent in 1987, with rail accounting for 23 percent of which 5 percent was by piggyback rail.

Seasonal Pricing and Returns to Storage

Chicago wholesale prices were used to determine seasonality of prices and returns to storage. A major terminal market was chosen as prices there would more clearly reflect the overall U.S. market condition and not be subject to individual local factors not indicative of the U.S. industry during a specific year. The price at Chicago is the result of all local supply and demand factors. The USDA only publishes comprehensive wholesale prices for the major markets of New York and Chicago. The Chicago market

TABLE 22. CARROT IMPORTS BY COUNTRY OF ORIGIN, 1987

Import	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	1,000 cwt												
Belgium	5	2	3	5	4	2	3	2	3	3	3	2	37
Canada	57	12	3	1	-	-	11	66	141	166	186	173	816
Israel	1	2	2	4	3	7	9	2	1	3	1	1	36
Mexico	5	4	6	8	2	2	2	1	4	21	28	41	124
IMPORT TOTAL	68	20	14	18	9	11	25	71	149	193	218	217	1,013

SOURCE: Foreign Agricultural Trade of the United States, 1988.

was used as the most likely major market for North Dakota produce. A monthly index of Chicago wholesale prices was completed for a ten-year period from 1978 to 1987. These prices were based on a calendar year basis; a distinctive crop production and marketing year does not exist, because production occurs throughout the year. Carrots from Northern states generally are marketed during late summer and fall while carrots from Southern states are marketed from late winter to spring. Central California markets throughout the year. A ten-year index (1978-1987) of Chicago wholesale carrot prices (Table 24) is presented in Figure 5. The index has two price peaks, a major peak in January, price index of 1.09, and a minor peak in July, a price index of 1.02. These correspond approximately with seasonal production of Northern and Southern states.

TABLE 23. CARROT SHIPMENTS BY STATE-OF-ORIGIN, 1987

Origin	Ja	Fe	Mr	Ap	My	Jn	Jy	Au	Se	Oc	No	De	Total
	1,000 cwt.												
Carrots - rail													
Arizona	2	–	3	3	12	4	3	–	–	–	–	–	27
Arizona[a]	–	–	1	5	5	–	1	–	–	–	–	–	12
Calif cent	232	159	154	171	181	228	230	82	106	93	157	175	1,968
Calif cent[a]	7	13	10	18	7	21	19	–	–	–	1	2	98
Calif south	9	1	22	22	8	3	–	–	–	–	2	5	72
Calif south[a]	–		1	9	16	16	7	–	–	–	–	–	49
Calif Imp Vly	7	15	38	59	45	33	1	–	–	–	–	–	198
Calif Imp Vly[a]	5	19	54	103	115	27	–	–	–	–	–	–	323
Texas	5	6	13	13	4	–	–	–	–	–	–	–	42
TOTAL	267	214	304	410	393	323	254	82	106	93	161	182	2,789
Carrots - piggyback													
Arizona	1	–	1	3	1	–	–	–	–	–	–	–	6
Calif cent	35	26	18	26	28	50	41	14	18	20	25	37	338
Calif south	13	12	14	10	14	3	1	–	–	–	–	1	68
Calif Imp Vly	10	16	19	16	11	3	–	–	–	–	–	7	82
Florida	6	12	13	17	14	4	–	–	–	–	–	4	70
TOTAL	65	66	65	72	68	60	42	14	18	20	25	49	564
Carrots - available truck													
Arizona	21	11	25	35	43	51	29	2	–	–	–	–	217
Calif cent	630	481	444	417	447	679	693	539	558	549	611	542	6,590
Calif south	100	108	109	110	83	31	–	–	–	–	12	40	593
Calif Imp Vly	73	136	200	249	218	72	–	–	–	–	–	38	986
Florida	105	143	171	136	98	52	–	–	–	–	–	40	746
Florida[a]	11	7	2	3	1	2	–	–	–	–	–	–	26
Michigan	–	–	–	–	–	–	50	290	221	240	83	–	884
Texas	118	161	225	202	93	1	00	00	00	00	9	47	856
Washington	2	–	–	–	–	–	30	43	56	70	88	35	324
TOTAL	1,060	1,047	1,176	1,152	983	888	802	874	835	859	804	742	11,222
U.S. TOTAL	1,392	1,327	1,545	1,634	1,444	1,271	1,098	970	959	972	990	973	14,575

[a]Export.

SOURCE: USDA Fresh Fruits and Vegetable Shipments, 1988.

Prices are lowest during and shortly after harvest of the winter crop, April and May, and then rise as supply decreases. Prices rise until the Northern states start to supply the market place in late summer. Prices then drop during the harvest of the Northern states and rise until winter production is marketed in January and February. The price index summarizes monthly price behavior over the ten-year period. However, monthly prices may behave differently within individual years. To check accuracy of the index, monthly prices from individual years were analyzed to determine if they followed predicted patterns. In nine of the ten years prices declined from January to May. The average decline was $1.59 for 48 lbs. for the period 1978-1987. Although prices on average incrased from May to August, prices actually only increased in five of ten years. Prices decreased from August to October in seven of the ten years, while prices decreased an average of $.59. Prices increased from October to January during eight years and decreased in 1980 and 1986. The average change in price was $1.50 (Table 25).

In general, the strongest price pattern was the decrease from January to May and the increase in prices from October to January. This price behavior indicates that a positive return to storage does exist for carrots harvested in the fall and marketed during the winter but storing carrots until spring may result in either higher or lower prices as compared to marketing earlier.

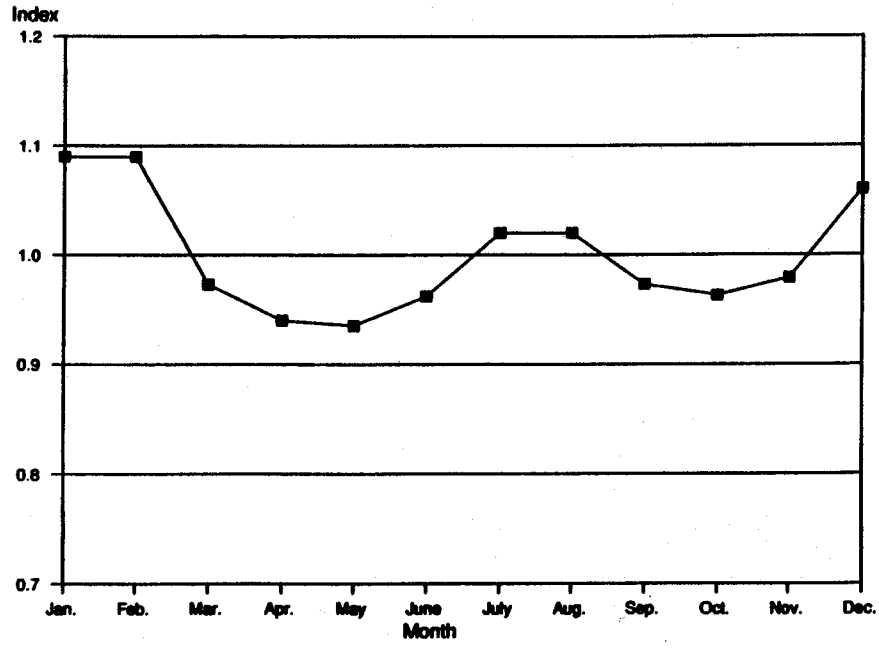


Figure 5. Monthly Price Indices for California Carrots Using Wholesale Chicago Prices.

SOURCE: USDA, Fresh Fruit and Vegetable Prices, 1978-1987.

TABLE 24. CHICAGO WHOLESALE CARROT PRICES WITH CALIFORNIA ORIGIN, 1977-1988

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	$/48 lb. Film Bag											
1977	12.94	12.50	9.23	8.92	8.30	7.30	7.02	6.98	7.75	8.00	7.33	8.45
1978	8.91	9.71	7.20	7.25	8.00	8.13	11.81	10.65	9.31	8.90	7.75	8.45
1979	10.70	10.25	9.06	8.38	8.75	8.75	10.08	8.63	8.50	7.85	7.63	7.63
1980	8.85	8.56	7.48	7.85	8.19	8.66	10.85	9.88	10.60	11.67	12.66	13.00
1981	11.25	11.06	10.15	9.50	11.83	11.25	11.06	11.50	10.40	10.18	11.00	11.70
1982	12.75	12.94	12.15	11.63	10.38	9.40	9.69	8.80	8.13	8.38	8.75	11.63
1983	12.06	12.13	10.50	8.88	8.69	9.81	13.13	13.80	11.56	10.87	11.10	12.75
1984	12.60	15.25	12.69	13.75	10.75	9.88	10.60	10.44	9.56	9.50	9.56	9.63
1985	10.38	11.44	10.31	9.38	8.75	9.00	8.80	9.75	10.10	9.56	9.88	11.18
1986	11.44	9.75	9.30	9.38	9.50	10.60	11.25	12.31	11.00	12.75	11.56	11.15
1987	11.69	11.06	9.95	9.56	9.88	12.25	9.69	8.45	8.81	8.69	9.60	11.38
1988	11.63	10.85	9.88	9.75	10.81	10.75	11.44	12.70	12.75	10.95	10.38	10.38

SOURCE: USDA Fresh Fruit and Vegetable Prices, 1977-1988.

TABLE 25. SEASONAL PRICE CHANGES FOR CARROTS, CHICAGO, 1977-1988

Year	January to May	May to August	August to October	October to January
	$/48 lb. Film Bag			
1977	-4.64	-1.32	1.02	.91
1978	-.91	2.65	-1.75	1.80
1979	-1.95	-.12	-.78	1.00
1980	-.66	1.69	1.79	-.42
1981	.58	-.33	-1.32	2.57
1982	-2.37	-1.58	-.42	3.68
1983	-3.37	5.11	-2.93	1.73
1984	-1.85	-.31	-.94	.88
1985	-1.63	1.00	-.19	1.88
1986	-1.94	2.81	.44	-1.06
1987	-1.81	-1.43	.24	2.94
1988	-.82	1.89	-1.75	
10-year average (1978-1987)	-1.59	.95	-.59	1.50
5-year average (1983-1987)	-2.12	1.44	-.68	1.27

SOURCE: USDA, Fresh Fruit and Vegetable Prices, 1977-1988.

Market Competitiveness

The market competitiveness of North Dakota depends upon the ability to deliver product to a market at equal or less cost than other suppliers, assuming acceptable quality standards. Production and shipping costs are the major components in determining final cost. Published data were not available on production costs for major producing regions in the U.S. However, North Dakota's advantage (disadvantage) in shipping costs can be estimated. North Dakota, assuming a standard product, can be a competitive supplier provided the differential in production cost does not exceed the shipping cost advantage.

Because primary production of fresh carrots is in the Southwest, primarily California, potential market areas for North Dakota would be population centers near North Dakota and those to the east. This would include the states of North Dakota, South Dakota, Minnesota, Wisconsin, Illinois, Indiana, Michigan, and Ohio.

Although many of these states also produce carrots for the fresh market, they remain net importers; exceptions are Minnesota and Michigan. The eight-state region accounts for 19.5 percent of the population but only 9 percent of the fresh carrot production (Table 26). However, because carrots from Michigan, Minnesota, and Wisconsin are marketed during the late summer, fall, and early winter, this region may remain a net importer. Since some of Michigan's production would likely move east, limited market potential may exist for this region.

In estimating North Dakota's transportation advantage (disadvantage) in supplying specific markets, transportation costs were estimated for six markets and four supply points. The markets selected were Fargo, Minneapolis, Chicago, New York, Atlanta, and

TABLE 26. POPULATION AND CARROT PRODUCTION FOR SELECTED STATES

State	U.S. Population	U.S. Carrot Production
	----------%----------	
Illinois	4.76	--
Indiana	2.27	--
Michigan	3.78	6.7
Minnesota	1.74	1.1
North Dakota	.28	--
South Dakota	.29	--
Ohio	4.43	1.2[a]
Wisconsin	1.97	--
Total	19.52	9.0

[a]Wisconsin and Ohio combined.
SOURCE: U.S. Census 1980 and Table 17.

Sioux Falls to represent local, regional, and national markets. Major competing supply regions would be California, Minnesota, and Michigan. Estimated transportation advantage (disadvantage) for the Red River Valley (RRV) is presented in Tables 27 and 28. The RRV has a transportation advantage over California in supplying all markets and an advantage over Michigan in supplying Fargo, Minneapolis, and Sioux Falls. Both Minnesota and Michigan have an advantage in supplying the Chicago, New York, and Atlanta markets. Additionally, Minnesota has an advantage in supplying the Minneapolis and Sioux Falls Markets.

TABLE 27. ESTIMATED TRANSPORTATION COSTS FOR CARROTS FROM SELECTED ORIGINS TO SELECTED MARKETS[a], 1989

Destinations	Origins			
	Grand Forks[b]	California	Michigan	MN
Minnesota				
	----------	$/50 lb.	----------	
Fargo	.23	2.61	1.15	.59
Minneapolis	.57	2.69	.82	.25
Chicago	1.15	2.95	.25	.66
New York	2.28	4.00	1.38	1.78
Atlanta	2.09	3.15	1.26	1.67
Sioux Falls	.58	2.32	1.03	.36

[a]Rates estimated by following formula: Rate/50 lb. unit = (100 + 1.25 * miles)/880 units.
[b]Represents Red River Valley of North Dakota.

SOURCE: Based on Tariffs derived from industry sources.

TABLE 28. ESTIMATED RED RIVER VALLEY'S TRANSPORTATION COST ADVANTAGE (DISADVANTAGE) IN SUPPLY SELECTED MARKETS, 1989

Destinations	Origins		
	California	Michigan	Minnesota
	----------	$/50 lb.	----------
Fargo	2.38	.92	.36
Minneapolis	2.12	.25	(.32)
Chicago	1.80	(.90)	(.49)
New York	1.72	(.90)	(.50)
Atlanta	1.06	(.83)	(.42)
Sioux Falls	1.74	.45	(.22)

SOURCE: Adapted from Table 27.

Case Study for the Red River Valley of North Dakota, 1987-1988

A case study of vegetable production and marketing in the Red River Valley of North Dakota was used to develop an expanded model of a commercial operation. A description of the farm and size of the operation is covered first followed by production costs and marketing results.

A case study of a small vegetable production and marketing operation in the central Red River Valley was made to assess practical difficulties and profitability of a beginning enterprise. The operation was carried out on an existing farm, using traditional farm equipment when possible and specialized production and handling equipment when required (Table 29). A potato warehouse and used potato production and handling equipment were utilized for production, storage, and packaging of the product to the extent possible.

The soil is classified as "Beardon loam" and is representative of the type of soil used for the production of potatoes, sugarbeets, dry beans, small grains, and other crops in the Red River Valley. Average yearly rainfall in the area is 21 inches. No irrigation was available.

The operation began in 1987 with the planting of 20 acres of several varieties of carrots and 1.5 acres of a broad range of other vegetables. Included were winter squash, summer squash, melons, cabbage, broccoli, and tomatoes. Most of the 1.5 acres of sundry vegetables were successfully harvested, and about 15 acres of carrots were harvested although the carrot yield was low due to poor seed emergence. The 1987 harvest was encouraging because high quality products were produced and successfully marketed. It was discouraging from the viewpoint of profitability. Net returns were below variable production costs due to producer inexperience and lack of preparation which resulted in a series of production, storage, and marketing difficulties. Products were marketed locally, primarily in Fargo and Grand Forks. Total product sales for 1987 were only around

TABLE 29. UTILIZATION OF EQUIPMENT BY A CENTRAL RED RIVER VALLEY VEGETABLE OPERATION, NORTH DAKOTA, 1988

Specialized Production Equipment	Carrots	Transplant Onions	Seeded Onions	Greentop Onions	Potatoes	Broccoli
4-row Planet Jr. planters (used)	x		x	x		
4-row beet cultivator (used)	x	x	x	x		x
4-row transplanter (used)						
1-row onion digger with gas engine (used)			x			
FMC one row carrot harvester (used)	x					
Other equipment:						
Pickup with insulated topper to deliver product (used)	x	x	x	x	x	x
18 Hp. tractor for planting (used)			x		x	x
18 Hp. tractor for cultivating (used)[a]	x	x	x	x		x
30 Hp. tractor with side-mount tanks; transplanting (used)[a]		x				x
30 Hp. tractor for pulling harvester (used)[a]	x					
Spraycoupe sprayer for insect control/fertility program[a]					x	
PTO driven duster for insect control (used)[a]					x	x
80 Hp. tractor with cultivator for spring and fall till[a]		x	x	x	x	x
Single-axle truck with tank for hauling water (used)[a]						
Flatbed trailer for hauling (used)[a]	x	x	x			
Processing/packaging equipment:						
Two-wheel conveyor bottom trailer (used)	x					
Baskets (65 @ $5.00) (used)	x			x		x
Burlap sacks (900 @ $.50) (new)	x	x	x		x	x
Potato conveyor for offloading with gearhead (used)	x		x			
Large drum carrot washer (used)	x					
Small carrot washer (used)	x					
Conveyor from washer to packing belt (used)	x					x
Packing belt conveyor (used)	x	x	x			
Round collection table (used)	x		x			
Over/under packaging scales (used)	x		x			x
100 wooden pallets (used)		x	x			
Basket fans for circulating air (used)		x	x			
Platform scale, sackholders, tables (used)	x	x	x	x	x	x
Forklift (used)[a]	x	x	x			
Storage Equipment:						
Cooler, approx 20/10 ft installed (used)	x			x		x
Insulated bin built by cooler approx 25/15 ft (new)	x	x	x			
Refrigeration unit installed (new)	x			x		x

[a]Equipment rented or borrowed from other operations.

Source: Case study, central Red River Valley, North Dakota 1988.

$5,000. The two major accomplishments in 1987 were gaining production and marketing experience and opening market channels for a short, sweet, locally grown carrot product.

Production in 1988 was considerably better, with returns, in most cases, above variable production costs. However, returns were negative when operator labor and fixed costs were considered. The scale of operations was larger with 33 acres planted and 20.7 acres harvested. The product mix during 1988 changed with a major shift toward onions. All products harvested in 1988 were organically grown, and most of the products were certified and marketed as organically grown. The major accomplishments for 1988 were achieving organic certification and opening market channels for organic products on local, regional, and national levels.

Carrots

The following will discuss the carrot crop produced in 1987 and 1988, with emphasis on production techniques and problems encountered with the carrot crop. A discussion regarding the yields and returns for carrots is also presented as well as an evaluation of the carrot crop.

Carrot Crop of 1987

Carrots were the primary crop in 1987 and were grown on three fields without the use of chemical fertilizers. Weed control and seedling emergence were the primary obstacles to overcome.

An application of pre-emergent herbicide (treflan) was used on a 12.5 acre field, but due to its granular form and lack of rainfall, the herbicide was only partially effective in preventing weed growth. Due to slow carrot germination, weeds gained a head start on carrots, making use of postemergence herbicides questionable. As a result, hand weeding of the entire field was required, and 2.5 acres were abandoned due to excessive weed problems.

A second planting of carrots was attempted on 3 acres of certified organic land. Slow emergence and weed competition, especially foxtail, was so severe the entire field had to be abandoned.

A third field of carrots was planted on 4.5 acres with no prior herbicide application. Weeds again emerged ahead of the carrots and became so advanced a postemergence herbicide was deemed unfeasible. The weed density was low permitting hand weeding, which was an enormous task. The entire field was harvested.

Due to late planting and continued drought conditions, carrot seedlings failed to germinate, and those that did germinate after a short rain were trapped beneath crusted soil until they withered. The crop was watered extensively with tanks mounted on a tractor, applying one eighth to one quarter inch of water per pass. Watering this large acreage with tanks was tedious and proved to be inadequate in coping with drought and early summer heat. The soil surface quickly became hardened by the baking summer sun after each watering. For the most part, only the seedlings that penetrated through cracks in the earth managed to survive. Carrot seedlings which reached their third leaf stage became well rooted and survived the drought. Successful germination ranged between one and 50 percent, depending upon field and location. Larger seeds appeared to emerge more readily than smaller seeds.

An extended period of rain around July 1 germinated the balance of the seedlings in the soil, many of which successfully penetrated the soil surface. Despite their late emergence, most of these seedlings developed adequate sized roots for the fresh market prior to the late fall harvest.

The product was harvested with a mechanical harvester late in the fall and stored on trucks until a cooling bin and wash line could be installed in the potato warehouse. Prior to unloading, mold developed so part of the product never reached storage. The balance of the product on the trucks was unloaded and stored in a cooler and adjacent storage bin set up for this purpose.

Despite the fact carrots were stored in a temperature and humidity controlled environment, the temperature could not be kept cool enough to prevent the continued growth of mold on the stored product. Approximately one-half of the stored product was discarded early in the spring with the balance of the product marketed through mid-April.

Although quantity of the product was limited, quality was good. However, sales were slow, since the carrots were washed and sold in bulk 50 pound sacks. It became apparent in late November that consumer sized packaging would be required to move the product faster. Packaging scales were purchased and paper labels produced to meet legal marketing requirements (i.e. net weight, name of packer, and place of origin). The product was packaged in standard freezer bags and accepted by local supermarkets, and sales volume increased considerably as local consumers discovered the products homegrown flavor.

Carrot Crop of 1988

In 1988 a 3.2 acre field of carrots was planted in late April on certified organic land. Several later plantings were carried out on 11 acres of land using chemicals. Only the first planting was successful. The later plantings either did not germinate or the seedlings failed to penetrate the crusted soil surface. Drought was a major problem in 1988. Watering the germinated seedling was unsuccessful. Carrots on the 3.2 acres weathered the drought well. Weed growth on the field was moderate, so hand weeding was done, albeit with considerable expense.

Since the carrots were planted early, they reached saleable size for harvest around August 1. Over one-half of the carrots were dug and sold prior to final harvest. Sales were primarily in Fargo and Grand Forks. After organic certification was obtained they were promoted as organically grown, with negligible impact. A portion of the product was sold to regional organic markets where flavor is of prime concern. Because of limited acreage, supplies began to run low by the end of November. Some local sales

were curtailed in an effort to supply organic markets. By the end of January nearly all of the product had been sold.

Carrot Grade and Packout Percentages, 1988

Carrots were washed and packaged in several different package sizes to satisfy consumer demand. After carrots came out of the washer, they were lifted by a conveyor belt to a packaging belt where jumbos were manually taken off for 25 and 50 pound bulk packages. Smaller carrots were removed by workers and placed on packaging weigh-scales and put into 1.5 or 3-pound packages. The packages were consolidated into master[6] containers or bales. Each master contained packages of 24 or 32 oz. or 16 or 48 oz. Mini-carrots were packaged at 16 ounces per bag and sold in master containers or bales of 20 bags per bale. Greentop carrots were mostly mini-carrot size and were sold in bunches, with anywhere from six to 20 carrots per bunch, depending on carrot size. No. 2 grade product, which consists of broken and crooked but otherwise sound product, was normally sold at half price or delivered to charitable organizations for packaging costs. Waste product, too inferior for human food, was returned to the field as organic matter. Carrot packout and grade percentages are shown in Figure 6.

The carrot operation yielded gross returns sufficient to cover all variable growing, harvesting, packaging, marketing, and delivery costs, but not enough to cover fixed costs (Tables 30 and 31). Therefore, the operation at this scale could not be considered profitable.

Carrot growing costs on a per master basis came to $1.55 per master, which is not unlike growing costs reported in Michigan or other areas (Table 30). Variable post-production costs including harvesting, grading, packaging, marketing, and delivery came to $11.72 per master, which is extremely high when compared to other large scale operations.

[6]A master weighs 50 pounds.

Total harvesting costs, considering mechanically harvesting, handpicking, and hauling product to the warehouse, came to $2 per cwt. This high cost is due largely to the small scale of the operation which required weekly digging for only a few carrots. It is also the result of harvester misses which resulted in hand picking 25 percent of the product.

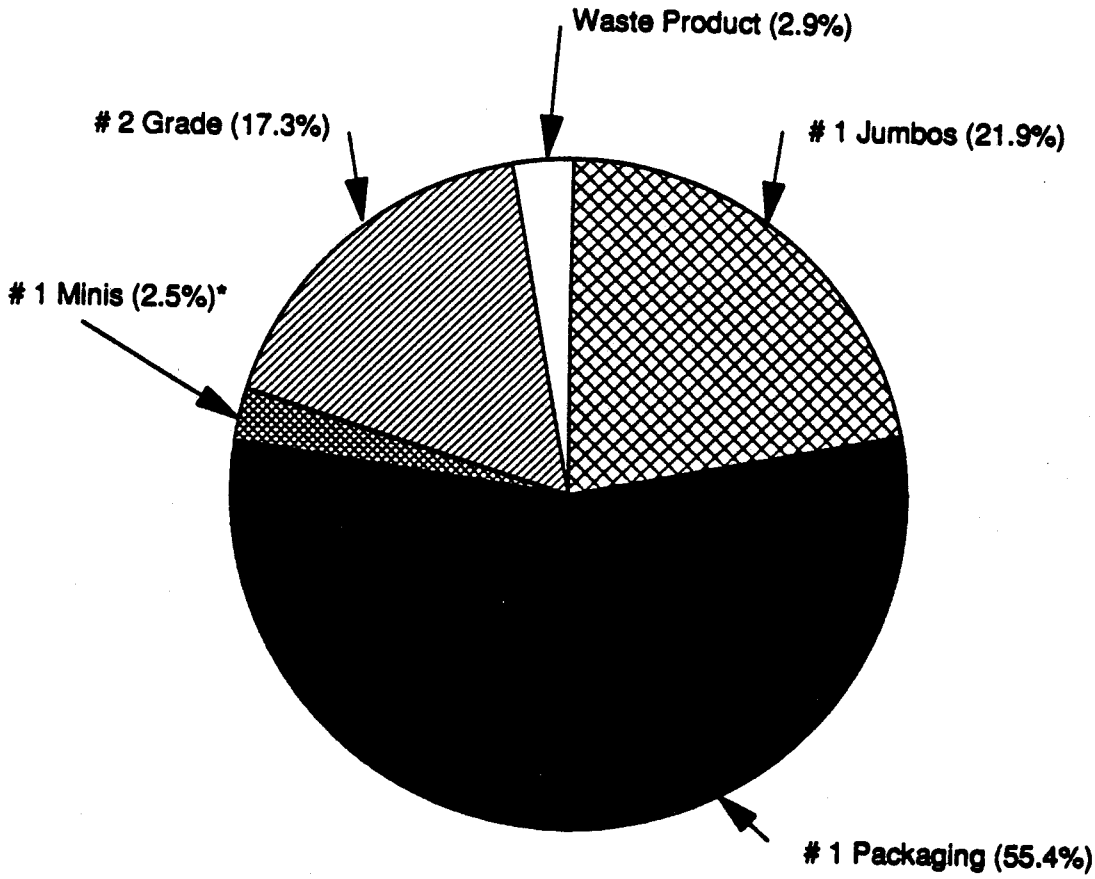


Figure 6. Carrot Grade and Packout Percentages From Case Study in Central Red River Valley, North Dakota, 1988.

*Includes Product Harvested Early With Greentops.

TABLE 30. CARROT OPERATION COSTS FOR THE CENTRAL RED RIVER VALLEY CASE STUDY, 1988[a]

Variable, Fixed, and Total Costs	Total Costs	Cost Per Acre	Cost Per Master[b]
		$	
Variable Costs			
Growing Costs			
Seed (3 lbs @ $13.67/lb)	131	41	0.19
Cultural Operations			
Fall till	16	5	0.02
Planting	28	9	0.04
Cultivating			
1st	55	17	0.08
2nd	22	7	0.03
3rd	12	4	0.02
Handweeding			
1st	480	150	0.71
2nd	240	75	0.36
Interest on operating capital			
6 mo. @ 12%	59	18	0.09
Subtotal	1,043	326	1.55
Harvesting, Packaging, and Marketing Costs			
Mechanically harvest (75%)	689	215	1.02
Hand pick (25%)	600	188	0.89
Hauling to warehouse	160	50	0.24
Grading/packing	1,769	553	2.62
Packing materials	962	301	1.43
Warehouse utilities			
Water	150	47	0.22
Heat	120	38	0.18
Electric	200	63	0.30
Repairs/maintenance	400	125	0.59
Telephone/marketing	700	219	1.04
Delivery	2,150	672	3.19
Subtotal	7,900	2,471	11.72
Total Variable Costs	8,943	2,797	13.27
Fixed Costs			
Land rental	320	100	0.47
Warehouse rental	1,200	375	1.78
Fixed ownership charges			
Specialized production equipment	934	292	1.39
Other unspecialized equipment	376	118	0.56
Processing/packing equipment	667	208	0.99
Storage equipment	946	296	1.40
Office supplies, subscriptions	54	17	0.08
Vehicle insurance/taxes/licenses	100	31	0.15
Membership and professional fees	87	27	0.13
Total Fixed Costs	4,684	1,464	6.95
TOTAL VARIABLE AND FIXED COSTS	13,627	4,261	20.22

[a]Based on 3.2 acres and 674 masters of production.
[b]A master weighs 50 pounds.

SOURCE: Case Study Central Red River Valley, North Dakota, 1988.

TABLE 31. CARROT PACKOUT AND PRICE RECEIVED FOR CENTRAL RED RIVER VALLEY CASE STUDY, 1988

Description	Packout	Value	Average Price/master	Weight	Average Price/lb.
	masters	—$—	——$——	—lbs—	—$—
#1 Packaging	481	7,156	14.88	23,088	0.31
#1 Bulk jumbo	191	2,654	13.90	9,525	0.28
#1 Minicarrot	55	657	11.95	1,105	0.60
#2 Bulk	151	379	2.51	7,525	0.05
Culls and waste	25	0	0.00	1,245	0.00
Total	903	10,846	12.01	42,488	0.26

SOURCE: Case study, 3.2 Acres in Central Red River Valley, North Dakota, 1988

Grading, packaging and packaging materials were $3.75 per master. This high rate is largely due to the physical constraints of the simplistic washing and packaging line which requires a high amount of labor. Warehouse utilities were $.90 per bale. This is rather high due to the low volume of product in the warehouse.

Telephone/marketing and delivery were $4.00 per cwt. This rate is high, not only because product volumes are low, but also because the product was often marketed and delivered directly to local retail markets, bypassing wholesale houses which might have taken large volumes at lower prices. Regular large deliveries of product would result in lower per unit prices.

Based on field experiments, the production and marketing of sweet carrots in North Dakota appears feasible, but a larger scale operation is required to make this venture profitable. One of the most serious constraints in producing carrots in North Dakota is the problem of spring seedling emergence. This problem can best be solved by early spring planting, irrigation, or through application of an anti-crust substance to the row's surface.

Marketing of sweet short carrots as a packaged product may represent a serious problem in terms of market acceptance. Although flavor is excellent, product appearance may be unacceptable for a clientele accustomed to a long carrot. The future of producing carrots for packaging seems to hinge upon market acceptance of a short but sweet carrot.

Onions

Transplant onions, winter storage onions, and greentop onions will be discussed along with production and cost data for each type of onion crop. The problems and benefits of each type of onion will also be presented.

Transplant Onions

Spanish onion transplants from Georgia were air-freighted to Minneapolis and hauled by pickup truck to North Dakota in 1988. The plants were transplanted using a four row transplanter requiring six workers, one worker for each row, a tractor driver, and a worker to monitor planting depth and reset plants.

Onion plants were set 5 1/2 to 6 inches apart in 20-inch rows, for a total of about 50,000 plants per acre. A tractor planting speed of 1/4th to 1/5th mile per hour was required to permit workers sufficient time to feed the transplanter. Water from tanks mounted on the tractor was applied as the plants were transplanted. Drought conditions required an additional two or three waterings to enable transplants to set roots. The transplanted crop was organically grown with no application of chemical fertilizers, herbicides, or insecticides. Inoculants were used on onion roots to ensure abundant bacterial life in the soil. Liquid fish emulsion was applied with water as a source of nitrogen.

Planting began in late May and continued through the third week of June, despite the drought. A transplant catch of around 90 percent was obtained with the help of irrigation. The onion transplants were cultivated and hand weeded twice. The seedlings developed large bulbs, most of which were hand-harvested into burlap sacks in September.

Harvest began when about 75 percent of the tops had weakened and fallen over. Workers with knives or scissors gathered onion tops in handfuls, pulled the entire plant, and cut the bulbs from the tops, allowing the bulbs to fall into pails or baskets. The onions were then dumped into burlap sacks and allowed to dry in the field for up to one week. When the onion leaves were dusty and rustled in the bags, they were transported to a warehouse where they were air stacked on rows of pallets. Ventilation was allowed to penetrate the sides and center of each pallet. Fans were used to circulate air around

the onions to facilitate the evaporation of transpired moisture. The onions were then hand graded into five sizes and marketed in 50 pound mesh bags. Packout percentages are shown in Figure 7.

The variable cost of growing transplant onions in 1988 came to $4.81 per 50 pound master, which is about equal to an FOB price of commercial onions grown in Western states (Table 32). The transplants alone cost nearly $2.00 per master. Variable harvest and packaging costs came to $3.90 per master, which was double most commercial rates.

Despite high growing costs, which consisted primarily of seedling purchase and transplanting, the transplant onion operation was profitable (Tables 32 and 33). This was largely because fixed costs were low ($1.70 per master). The onions were shipped early, requiring only temporary indoor storage.

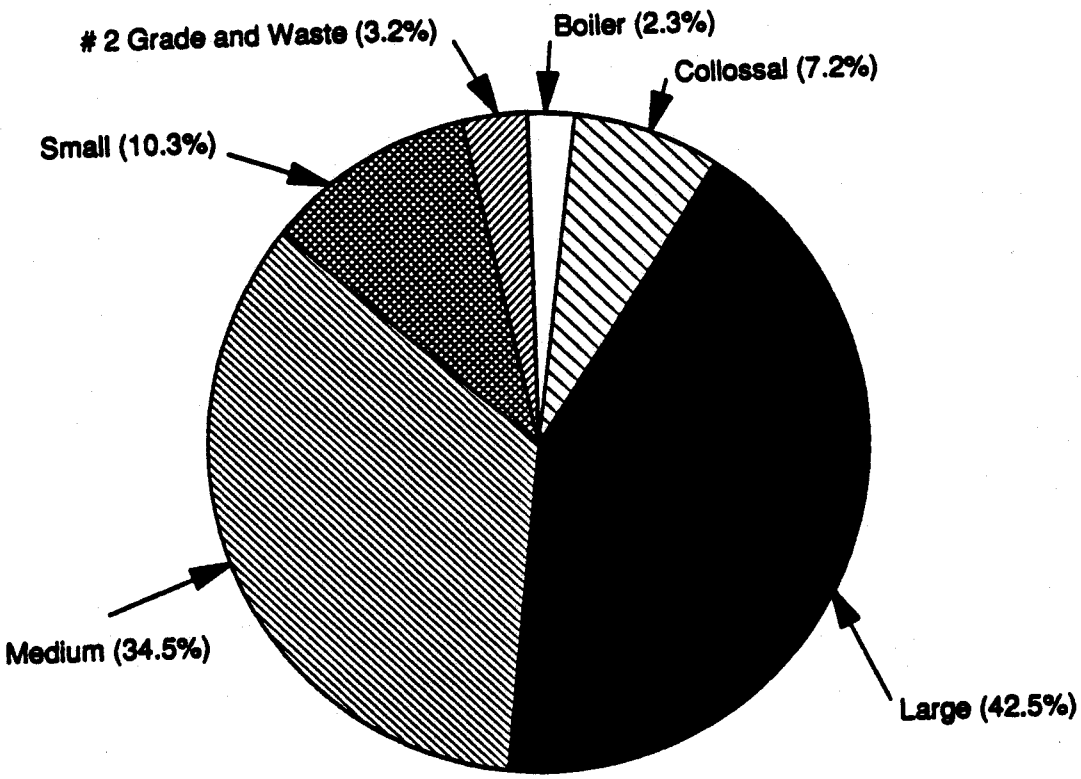


Figure 7. Transplant Yellow Spanish Onion Packout From Case Study in Central Red River Valley, North Dakota, 1988.

TABLE 32. TRANSPLANT ONION OPERATION COSTS FOR CENTRAL RED RIVER VALLEY CASE STUDY, NORTH DAKOTA, 1988[a]

Variable, Fixed and Total Costs	Total Costs	Cost/Acre	Cost/Master
		$	
Variable Costs			
Growing Costs			
Transplants (50,000/acre @ .0078 ea)	2,715	388	1.90
Fish/molasses	35	5	0.03
Inoculant	42	6	0.03
Water (irrigation)	93	13	0.07
Cultural operations			
Fall till	35	5	0.03
Transplanting	2,089	298	1.46
Watering	175	25	0.12
Cultivating			
1st	121	17	0.09
2nd	47	7	0.03
Hand Weeding			
1st	1,050	150	0.74
2nd	47	7	0.03
Interest on operating capital			
6 mo. @ 12%	416	59	0.29
Subtotal	6,865	980	4.81
Harvesting, Packaging, and Marketing Costs			
Hand pick	994	142	0.70
Hauling to warehouse	420	60	0.29
Grading/packing	2,612	373	1.83
Packing materials	411	59	0.29
Warehouse utilities Electric	25	4	0.02
Repairs/maintenance	100	14	0.07
Telephone/marketing	800	114	0.56
Delivery	200	29	0.14
Subtotal	5,562	795	3.90
Total Variable Costs	12,427	1,775	8.71
Fixed Costs			
Land rental	700	100	0.49
Warehouse rental	500	71	0.35
Fixed ownership charges			
Specialized production equipment	301	43	0.21
Other unspecialized equipment	125	18	0.09
Processing/packing equipment	190	27	0.13
Storage equipment	278	40	0.20
Office supplies, subscriptions	110	16	0.08
Vehicle insurance/taxes/licenses	40	6	0.03
Memberships and professional fees	176	25	0.12
Total Fixed Costs	2,420	346	1.70
TOTAL VARIABLE AND FIXED COSTS	14,847	2,121	10.41

[a]Based on seven acres and 1,428 masters of product sold.

SOURCE: Case study, Central Red River Valley, North Dakota, 1988.

TABLE 33. ONION TRANSPLANTS, PRODUCTION, AND PRICE RECEIVED FOR CENTRAL RED RIVER VALLEY, CASE STUDY, NORTH DAKOTA, 1988

Description	Units Sold	Invoice Amount	Amount Received	Amount/ Master	Weight	Price/ Pound
	masters		$		lbs.	$
Red Onions						
Unsized 50 lb.	30	780	402	13.40	1,500	0.27
Culls	6	0	0	0.00	300	0.00
Subtotal	36	780	402	11.17	1,800	0.22
White Onions						
Boilers 20/2 lb.	1	12	12	12.00	40	0.30
Small 16/3 lb.	3	60	60	20.00	144	0.42
Medium 50 lb.	18	360	360	20.00	900	0.40
Large 50 lb.	23	460	460	20.00	1,150	0.40
Colossal 50 lb.	32	480	480	15.00	1,600	0.30
Unsized 50 lb.	44	880	583	13.40	2,175	0.27
Culls	4	0	0	0	200	0.00
Subtotal	125	2,252	1,955	15.64	6,209	0.32
Yellow Onions						
Boilers 20/2 lb.	35	448	448	12.80	1,400	0.32
Small 20/2	1	14	14	14.00	29	0.50
Small 16/3 lb.	133	2,275	2,117	15.92	6,384	0.33
Medium 20/2 lb.	2	40	40	20.00	64	0.63
Medium 12/3 lb.	20	400	400	20.00	720	0.56
Medium 16/3 lb.	10	200	200	20.00	480	0.42
Medium 10/5 lb.	25	500	500	20.00	1,250	0.40
Medium 50 lb.	379	6,431	5,967	15.74	18,925	0.32
Large 50 lb.	528	8,850	8,409	15.93	26,400	0.32
Colossal 50 lb.	90	1,450	1,296	14.40	4,500	0.29
Unsized 50 lb.	4	78	78	19.50	208	0.38
#2 grade 50 lb.	20	208	204	10.20	1,020	0.20
Culls	20	0	0	0.00	1,000	0.00
Subtotal	1,267	20,894	19,673	15.54	62,380	0.32
TOTAL	1,428	23,922	22,030	15.43	70,389	0.31

SOURCE: Case study, approximately 7 acres central Red River Valley, North Dakota, 1988.

The major advantages of transplant onions over direct seeded onions are:

a) they permit an early harvest of late maturing varieties (eg. spanish type) which normally implies higher prices.

b) they facilitate weed control in an organic production system where chemical weed control cannot be used.

The major disadvantages are the increased cost of seedlings over seed and the slow transplanting process.

Direct Seeded Winter Storage Onions

These onions were planted in 20-inch rows at a rate of 3.2 pounds per acre (slightly above the 2.5 pounds per acre recommended for 20 inch row spacing) on 5.3 acres of certified organic land in mid April 1988. The major concerns in planting the crop were emergence and weed control in an organic production system.

Seedling emergence was good, resulting in optimal plant density, causing onions to remain small in size. Weed control using a beet cultivator and hand-weeding within the rows was manageable. The unavailability of migrant labor during weeding season resulted in some weeds going to seed before they were pulled. Variable growing costs were $427 per acre, with seed and hand weeding accounting for 85 percent of this amount.

Due to high plant density, 1.3 acres of the field was harvested as table onions when the plants reached pencil size. The remaining four acres of onions were hand harvested in early October before a hard frost. Half of the onions were picked by the tops. A small home made one row onion digger was used to lift the balance of the onions. A pull type rod weeder was effective to lift the onions in some parts of the field, but where the ground was packed and hard, it skimmed over the soil surface.

Inadequate moisture resulted in a large percenatge of small or "prepack" onions (Figure 8). Variable harvesting, packaging, and marketing costs were exceptionally high due to inadequate harvest equipment and unavailabilty of grading equipment. As a result, this operation had a net loss (Tables 34 and 35). The production of quality winter storage onions in North Dakota is feasible; however, and has been proven by area growers in the past and present.

The production of direct seeded onions using organic methods is troublesome in light of weed control. Onions are poor competitors against weeds. A heavy weed growth which might occur in normal years could make hand weeding economically infeasible and result in loss of the crop. Chemical herbicides are an effective means of weed control for the conventional grower and can be used effectively in North Dakota.

The major advantage of direct seeded onions over transplants is the considerably lower up-front cost required to establish a seedbed. In an organic system this advantage may be offset by the higher cost of hand weeding direct seeded onions during their longer life cycle. Since onion seedlings are extremely fragile after emergence, soil cannot be pushed against them during cultivation. They can be readily damaged or cut off by drifting soil on windy days.

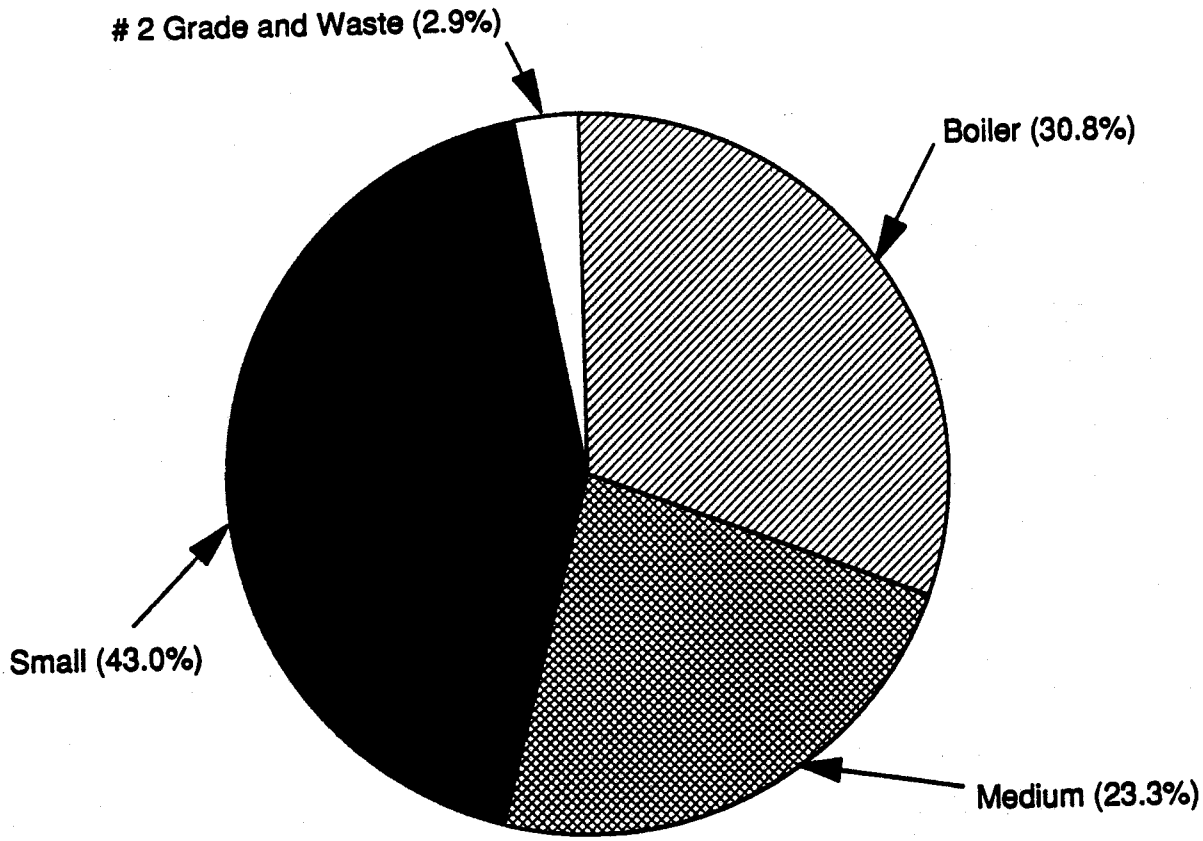


Figure 8. Direct Seeded Storage Onion Packout Percentages From Case Study in Central Red River Valley, North Dakota, 1988.

TABLE 34. DIRECT SEEDED ONION OPERATION COSTS FOR CENTRAL RED RIVER VALLEY CASE STUDY, NORTH DAKOTA, 1988[a]

Variable, Fixed, and Total Costs	Total Costs	Cost/Acre	Cost/Master
		$	
Variable Costs			
Growing Costs			
Seed (3 lb./acre @ $32/lb.	424	106	1.20
Cultural operations			
Fall till	20	5	0.06
Planting	35	9	0.10
Cultivating			
1st	69	17	0.20
2nd	27	7	0.08
3rd	15	4	0.04
Handweeding			
1st	600	150	1.70
2nd	300	75	0.85
3rd	120	30	0.34
Interest on operating capital			
6 mo. @ 12%	97	24	0.28
Subtotal	1,707	427	4.84
Harvesting, Packaging, and Marketing Costs			
Hand pick	1,784	446	5.05
Hauling to warehouse	104	26	0.30
Grading/packing	1,050	263	2.98
Packing materials	489	122	1.39
Warehouse utilities			
Heat	300	75	0.85
Electric	75	19	0.21
Repairs/maintenance	50	13	0.14
Telephone/marketing	300	75	0.85
Delivery	700	175	1.98
Subtotal	4,852	1,214	13.75
Total Variable Costs	6,559	1,641	18.58
Fixed Costs			
Land rental	400	100	1.13
Warehouse rental	600	150	1.70
Fixed ownership charges			
Specialized production equipment	143	36	0.41
Other unspecialized equipment	142	36	0.41
Processing/packing equipment	123	31	0.35
Storage equipment	149	37	0.42
Office supplies, subscriptions	28	7	0.08
Vehicle insur./taxes/licenses	20	5	0.06
Membership and professional fees	44	11	0.13
Total Fixed Costs	1,649	413	4.67
TOTAL VARIABLE AND FIXED COSTS	8,208	2,054	23.25

[a]Based on four acres and 353 masters of product sold.

SOURCE: Case study, Central Red River Valley, North Dakota, 1988.

TABLE 35. PRICE RECEIVED FOR SALES OF DIRECT SEEDED WINTER ONIONS FOR CENTRAL RED RIVER VALLEY CASE STUDY, NORTH DAKOTA, 1988

Description	Units Sold	Invoice Amount	Amount Received	Amount/ Master	Total Lbs.	Price/ Pound
	masters		$		lbs.	$
Boilers 50 lb.	90	1,440	1,440	16.00	4,500	0.32
Boilers 20/2 lb.	6	92	92	15.33	240	0.38
Boilers 25/2 lb.	15	283	283	18.87	750	0.38
Subtotal	111	1,815	1,815	16.35	5,490	0.33
Small 50 lb.	72	1,390	1,390	19.31	3,600	0.39
Small 12/3 lb.	13	260	260	20.00	468	0.56
Small 16/3 lb.	58	1,190	1,190	20.52	2,784	0.43
Small 10/5 lb.	16	300	300	18.75	800	0.38
Subtotal	159	3,140	3,140	19.75	7,652	0.41
Medium 50 lb.	77	1,940	1,940	25.19	3,850	0.50
Medium 10/5 lb.	6	120	120	20.00	300	0.40
Subtotal	83	2,060	2,060	24.82	4,150	0.50
TOTAL	353	7,015	7,015	19.87	17,292	0.41

SOURCE: Case study, 4 acres Central Red River Valley, North Dakota, 1988.

Greentop Table Onions

A winter storage variety of greentop table onions were planted and harvested from 1.3 acres. Due to high plant density, a decision was made to harvest the onions prior to bulbing for sale as table onions.

The greentop table onion operation consisted of hand-pulling, gathering onions into baskets, and transferring them to a warehouse where they were spray-washed with water. Washed plants were then bunched and tied with rubber bands with six to eight plants per bunch. Forty-eight bunches were packed in cartons lined with plastic coated paper for moisture resistance. The onions were marketed to supermarkets in Fargo and Grand Forks during July. Onion tops were left intact and no ice was applied due to lack of icing capability. Deliveries were made biweekly.

The major problem encountered was that onion tops quickly lost their fresh appearance, especially if held over from one delivery day to the next. Onions not sold quickly in supermarkets soon lost their market appeal. It was apparent only quality fresh

products were acceptable to consumers. Approximately one-third of the onions which had been hand harvested were discarded due to lack of freshness.

Revenue from the sale of greentop onions basically covered all variable costs but was insufficient to cover fixed costs (Table 36). Fixed costs, when allocated on the basis of equipment usage, were substantial, although the facilities were underutilized during mid-summer and alternative opportunity costs were therefore quite low.

Greentop onions have market potential for local fresh markets. Local demand for onions in the summer was strong, but varieties which retain their fresh appearance would need to be selected. The operation is labor intensive and labor demand is greatest in mid-summer when school-aged youth are available to work. Irrigation, while not essential, is desirable to ensure a mild onion product.

Potato Crop for 1988

Conventionally grown North Dakota red potatoes are currently produced on a large scale and marketed across the entire eastern half of the U.S. Certified organic production of red potatoes in North Dakota is as yet a novelty.

Red Pontiac potatoes were planted on 4.6 acres in late May at a rate of 16 cwt. of seed per acre. No chemical fertilizer was used and mechanical means of weed control were effective and adequate. Organic methods of insect control were only partially effective due to producer inexperience. As a result, considerable plant defoliation occurred.

Ten percent of the harvest was lifted and hand-picked for early marketing with the balance mechanically harvested. Due to drought and plant defoliation, yield was only about 80 cwt. per acre, compared to typical yields of 160 cwt. per acre for commercial growers. As a result a high percentage of the product was small. The mechanical harvester badly bruises the potatoes due to the presence of dirt chunks in the soil, so an unusually high percentage of potatoes were graded out as culls (Figure 9).

Given the high percentage of culls and #2 product, coupled with reduced yield and a small scale operation, revenues were only sufficient to cover variable costs.

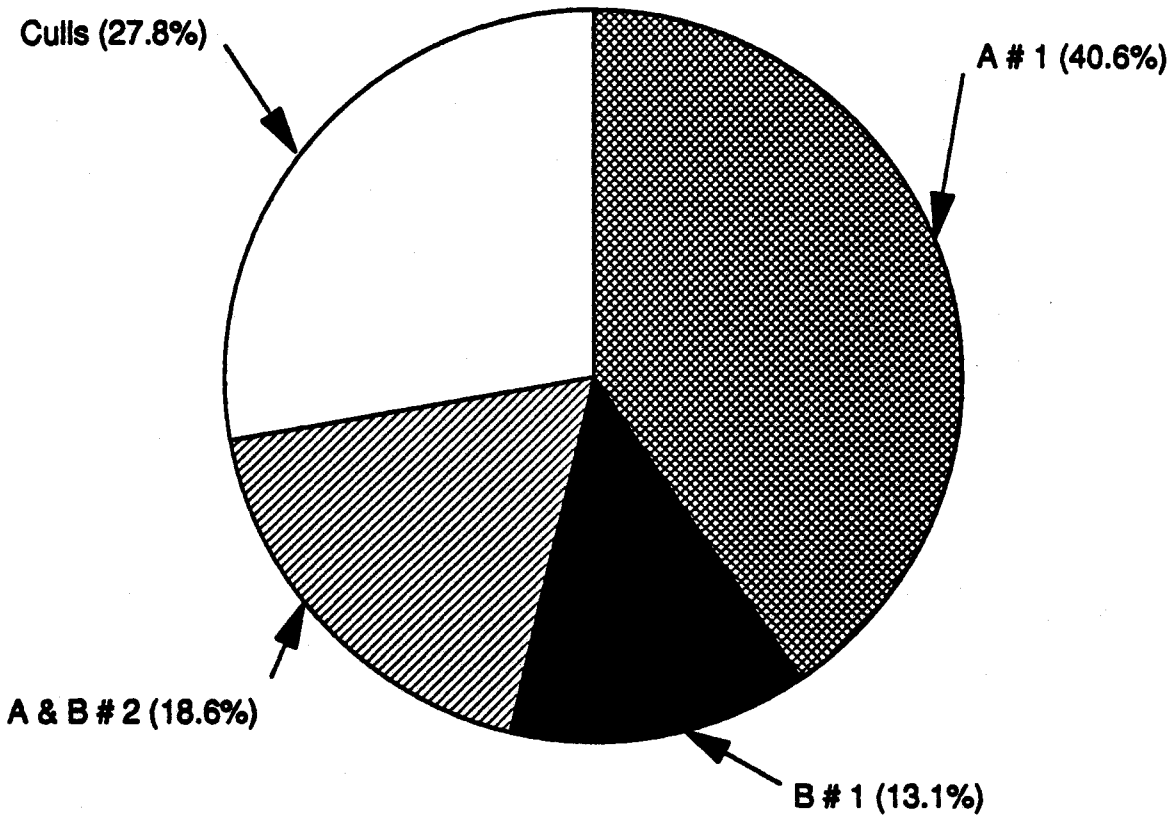


Figure 9. Red Potato Packout Percentage By Size and Grade From Case Study in Central Red River Valley, North Dakota 1988.

TABLE 36. TABLE ONION OPERATION COSTS FOR CENTRAL RED RIVER VALLEY CASE STUDY, NORTH DAKOTA, 1988[a]

Variable, Fixed and Total Costs	Total Cost	Cost/Acre	Cost/Master
	$		
Variable Costs			
Growing Costs			
Seed	138	106	1.15
Cultural operations			
Fall till	7	5	0.05
Planting	11	9	0.09
Cultivating			
1st	23	17	0.19
2nd	9	7	0.07
Handweeding			
1st	195	150	1.63
Interest on operating capital			
4 mo. @ 12%	15	12	0.13
Subtotal	398	306	3.39
Harvesting, Packaging, and Marketing Costs			
Hand pick	145	112	1.21
Hauling to warehouse	50	38	0.42
Grading/packing	260	200	2.17
Packing materials	60	46	0.50
Warehouse utilities			
Water	20	15	0.17
Electric	70	54	0.58
Repairs/maintenance	20	15	0.17
Telephone	150	115	1.25
Delivery	495	381	4.13
Subtotal	1,270	976	10.58
Total Variable Costs	1,668	1,287	13.96
Fixed Costs			
Land rental	130	100	1.08
Warehouse rental	400	308	3.33
Fixed ownership charges			
Specialized production equipment	24	18	0.20
Other unspecialized equipment	88	68	0.73
Processing/packing equipment	8	6	0.07
Storage equipment	117	90	0.98
Office supplies, subscriptions	10	7	0.80
Vehicle insur./taxes/licenses	20	15	0.17
Membership and professional fees	15	12	0.13
Total Fixed Costs	812	624	6.77
TOTAL VARIABLE AND FIXED COSTS	2,480	1,911	20.73

[a]Based on 1.3 acres and 120 masters of product sold.

SOURCE: Case study, Central Red River Valley, North Dakota, 1988.

However, prices for the product were favorable. Volume per shipment was generally small, resulting in high packaging, delivery, and marketing expense per master (Tables 37 and 38).

Potato production using organic production techniques is feasible, especially if mechanical methods of weed control are effective. Major problems associated with organic production are soil fertility to assure high yield and control of insects using organic methods. Temperature controlled storage is also a consideration, since sprout inhibitors used on conventional potatoes cannot be used on organic products.

Broccoli

This section presents case study data on broccoli. The production problems and cost data will be discussed and problems with the crop will also be presented.

Approximately 200 broccoli plants were transplanted around July 1, 1987, and harvested in mid-September. The crop established itself with some watering and was of excellent quality and flavor.

Based on the 1987 experience, approximately 8,000 Southern-grown transplants were set out in early June of 1988 and watered numerous times with a tractor mounted tank. Only 75-80 percent of the broccoli plants took root as a result of continued drought, hot temperatures, and strong southerly winds. Flea beetles, together with drought conditions, took a severe toll on the broccoli. Most of the plants were stunted and production was poor. Head flavor was strong, making the product nearly unsaleable. Adequate insect control using organic products was time consuming, as weekly spraying or dusting was required.

Broccoli heads were hand-harvested with knives in early morning hours and placed into vented baskets. The baskets were transported to a warehouse where they were placed in a cooler over flumes or air ducts in the floor. Thirty-six degree air was then forced through the product. After cooling, the broccoli was trimmed and bunched with two to three heads per bunch and packed 14 bunches per plastic paper coated box. Small spears of broccoli were packaged in plastic freezer bags, 1.5 pounds per bag. The broccoli was marketed in supermarkets in Fargo and Grand Forks.

TABLE 37. RED POTATO OPERATION COSTS FOR CENTRAL RED RIVER VALLEY CASE STUDY, 1988

Variable, Fixed, and Total Costs	Total Cost	Cost/Acre	Cost/Master
		$	
Variable Costs			
Growing Costs			
Seed	300	65	0.58
Organic Insecticide	100	22	0.19
Cultural operations			
Fall till	23	5	0.04
Planting	225	49	0.43
Cultivating/dragging			
1st	45	10	0.09
2nd	45	10	0.09
3rd	45	10	0.09
Spraying	46	10	0.09
Dusting	46	10	0.09
Interest on operating capital			
6 mo. @ 12%	53	11	0.10
Subtotal	928	202	1.79
Harvesting, Packaging, and Marketing Costs			
Mechanically harvest	300	65	0.58
Hauling to warehouse	50	11	0.10
Grading/packaging*	717	156	1.38
Packing materials	717	156	1.38
Repairs/maintenance	50	11	0.10
Telephone/marketing	300	65	0.58
Delivery	300	65	4.68
Subtotal	2,434	529	4.68
Total Variable Costs	3,362	731	6.47
Fixed Costs			
Land rental	460	100	0.88
Warehouse rental (on farm storage)	200	43	0.38
Fixed ownership charges			
Other specialized equipment	123	27	0.24
Office supplies, subscriptions	42	9	0.08
Vehicle insur./taxes/licenses	10	2	0.02
Membership and professional fee	67	15	0.13
Total Fixed Costs	902	196	1.73
TOTAL VARIABLE AND FIXED COSTS	**4,264**	**927**	**8.20**

*Washing/packaging/storage done at commercial warehouse.

SOURCE: Case study, Central Red River Valley, North Dakota, 1988.

TABLE 38. PRICES RECEIVED FOR SALE OF RED PONTIAC POTATOES FOR CENTRAL RED RIVER VALLEY CASE STUDY, 1988

Description	Units Sold	Invoice Amount	Amount Received	Amount/ Master	Total Lbs.	Price/ Pound
	masters		$		lbs.	$
Potato A#1	259	2,610	2,207	8.52	12,967	0.17
Potato A#1 5/10	33	386	386	11.81	1,633	0.24
Subtotal	292	2,996	2,593	8.88	14,600	0.18
Potato B#1	40	401	401	10.02	2,000	0.20
Potato B#1 10/5	54	673	581	10.75	2,700	0.21
Subtotal	94	1,074	982	10.45	4,700	0.21
Potato unwashed	42	364	364	8.68	2,100	0.17
Potato all #2	92	425	425	4.62	4,600	0.09
Subtotal	134	789	789	5.89	6,700	0.12
Culls	200	0	0	0.00	10,000	0.00
TOTAL	720	4,859	4,364	6.06	36,000	0.12

SOURCE: Case study, 4.6 Acres, Central Red River Valley, North Dakota, 1988.

The broccoli operation was the least profitable of all during 1988. Because of the product's strong flavor, broccoli harvest was suspended prematurely. Sales revenue was not enough to cover variable and fixed costs (Table 39).

Production of broccoli is very labor intensive and when done without irrigation is risky, especially during the summer when temperatures soar and southerly winds desiccate the succulent stems. A late fall crop may fare better if plants can be successfully established. Two year's experience indicates irrigation is required to reduce risk of crop failure and avoid strong product flavor resulting from drought and plant stress. With irrigation, broccoli production could be successful in North Dakota using organic or commercial production methods.

Summary of Red River Valley Case Study

Returns for each crop, except broccoli, and green table onions, covered variable production costs (Table 40). Overall profitability was, in most cases, negative when operator labor and fixed costs were considered. Only potatoes and transplant onions had

TABLE 39. BROCCOLI PRODUCTION AND MARKETING COSTS FOR CENTRAL RED RIVER VALLEY CASE STUDY, 1988

Variable, Fixed, and Total Costs	Total Cost	Cost/Acre	Cost/Master
		$	
Variable Costs			
Growing Costs			
Transplants	268	383	3.39
Fish/molasses	7	10	0.09
Inoculant	5	7	0.06
Water (irrigation)	18	26	0.23
Organic insecticide	32	45	0.40
Cultural operations			
Fall till	4	5	0.05
Transplanting	209	299	2.65
Cultivating			
1st	12	17	0.15
2nd	53	75	0.67
Spraying	7	10	0.09
Dusting	7	10	0.09
Interest on operating capital			
4 mo. @ 12%	31	44	0.39
Subtotal	653	931	8.26
Harvesting, Packaging, and Marketing Costs			
Hand pick	120	171	1.52
Hauling to warehouse	30	43	0.38
Grading/packing	65	93	0.82
Packing materials	65	93	0.82
Warehouse utilities			
Water	10	14	0.13
Electric	30	43	0.38
Repairs/maintenance	30	43	0.38
Telephone	100	143	1.27
Delivery	240	343	3.04
Subtotal	690	986	8.73
Total Variable Costs	1,343	1,917	17.00
Fixed Costs			
Land rental	70	100	0.89
Warehouse rental	100	143	1.27
Fixed ownership charges			
Specialized production equipment	20	29	0.25
Other unspecialized equipment	45	64	0.57
Processing/packing equipment	21	30	0.27
Storage equipment	111	159	1.41
Office supplies, subscriptions	6	9	0.08
Vehicle insur./taxes/licenses	10	14	0.13
Membership and professional fee	10	15	0.13
Total Fixed Costs	393	563	4.98
TOTAL VARIABLE AND FIXED COSTS	**1,736**	**2,480**	**21.97**

[a]Based on .70 acres and 79 masters of product sold.

SOURCE: Case Study, Central Red River Valley, North Dakota, 1988.

a return above variable and fixed costs. Carrots, green table and seeded onions were unprofitable because of high labor costs. Broccoli was not profitable due to poor production caused by flea beetles and drought conditions. Transplant onions were profitable because their shorter life-cycle reduced both weeding and storage costs. Potato yield was low, with a high percentage of potatoes graded as culls. Poor potato yield was a result of drought and ineffective organic control of insects. A small profit was achieved due to favorable product prices.

Expanded Model

The expanded model for this study is based on a study done by the Agricultural Economics Department of Michigan State University. The study entitled "Costs of Producing Carrots" addressed fixed and variable costs associated with a commercial sized carrot farm and profitability of carrots under alternative yield and price assumptions.

The same methodology used for the Michigan study was used to develop a commercial vegetable operation for North Dakota. Carrots and onions were selected for this study. These vegetables were selected because the case study and horticultural crop survey indicated North Dakota had favorable conditions for successfully producing the two crops. Although North Dakota does not have a commercial vegetable operation, this model presents the opportunities available to individuals interested in starting an operation specializing in the production of carrots and/or onions.

TABLE 40. VEGETABLE SALES, VARIABLE COSTS, FIXED COSTS, TOTAL COSTS, AND NET RETURNS (LOSS) FOR CENTRAL RED RIVER VALLEY CASE STUDY, NORTH DAKOTA 1988

Crop	Acres	Gross Sales	Variable Costs	Fixed Costs	Total Costs	Net Returns
				$		
Carrots	3.2	10,846	8,943	4,684	13,627	(2,781)
Onions, transplants	7.0	22,030	12,427	2,420	14,847	7,183
Onions, seeded	4.0	7,015	6,559	1,649	8,208	(1,193)
Onions, green table	1.3	1,224	1,668	812	2,480	(1,256)
Potatoes, red pontiac	4.6	4,364	3,364	901	4,265	99
Broccoli & all other	0.7	928	1,343	393	1,736	(808)
Total All Crops	20.8	46,407	34,304	10,859	45,163	1,244

SOURCE: Case Study Red River Valley, North Dakota, 1988.

The following assumptions were made for this model: 1) the farm would consist of 300 acres with 250 acres tillable, 2) 100 acres would be planted to either carrots or onions, 3) the remaining 150 acres were used for grain or other vegetable crops, 4) carrots would be irrigated to help alleviate the emergence problem, and 5) there would be wells available to provide sufficient water for irrigation of carrots.

Carrot Enterprise

This section addresses the profitability of growing 100 acres of carrots. Both fixed and variable costs for this operation were taken from the Michigan study. Price and yield used to determine gross receipts are from the case study presented in this paper. Various prices and yields are presented to illustrate how losses/returns vary with variations in price and yield.

Fixed Costs

Fixed costs do not vary with the acres planted or yield of the crop (once committed to the production of the crop). They include such items as depreciation, interest, repairs and maintenance, land rental, and insurance. Machinery and equipment are a considerable portion of fixed costs. General machinery and equipment costs needed to operate the 300 acre farm are provided in Table 41. The sum of general machinery and equipment costs amounted to $217,550 with an annual depreciation of $16,030. Specialized equipment costs amounted to $113,000 with annual depreciation of $10,800 (Table 42).

TABLE 42. ESTIMATED SPECIALIZED MACHINERY AND EQUIPMENT COSTS FOR A 100-ACRE CARROT ENTERPRISE IN THE RED RIVER VALLEY NORTH DAKOTA, 1988

Item	New Price	Salvage Value[a]	Average Value[b]	Annual Depreciation[c]
		$		
Irrigation equipment (to cover 50 A)	50,000	10,000	30,000	4,000
Carrot Drill	10,000	2,000	6,000	800
Carrot harvester (2-row self prop)	70,000	10,000	40,000	6,000
Carrot harvester (1-row pull type)(old)	–	–	7,000	–
Dump truck (old)	–	–	10,000	–
Semi tractor (old)	–	–	15,000	–
Semi trailer (old)	–	–	5,000	–
TOTALS	130,000	22,000	113,000	10,800

[a]A 10-year life is assigned to all machinery and equipment.

[b]Average Value is calculated to create a basis for determining interest on machinery and equipment investment (see Table 3).

[c]Annual depreciation = (new price - salvage value) / 10 years.

Table 41. General Machinery and Equipment Costs for A Typical Farm Producing Carrots in Central Red River Valley North Dakota, 1988[a]

Item	New Price	Salvage Value[b]	Average Value[c]	Annual Depreciation[d]
		$		
TRACTORS				
100 hp diesel (F.W. assist)	40,000	20,000	30,000	2,000
75 hp diesel (2) @ $28,000	56,000	30,000	43,000	2,600
75 hp diesel (F.W. assist) with bucket & backhoe (old)	--	--	12,500	
40 hp (2) @ $18,000	36,000	18,000	27,000	1,800
40 hp (old)(2) @ $5,000	--	--	5,000	--
Allis Challmers (old)	--	--	1,200	--
Small Crawler (old)	--	--	4,000	--
Bulldozer (old)	--	--	4,000	--
I. H. Model BN (forklift)	7,000	4,000	5,500	300
Forklift for indoor use (old)	--	--	6,000	--
TILLAGE				
4-18 in rollover plow	9,000	1,000	5,000	800
16 ft dis	7,000	1,000	4,000	600
Subsoiler	4,000	600	2,300	340
Springtooth drag (old)	--	--	1,000	--
Cultipacker (old)	--	--	2,500	--
CROP MAINTENANCE				
Fertilizer spreader (2)	4,500	700	2,600	380
Fertilizer wagon	4,000	1,000	2,500	300
Tiller	2,500	900	1,700	160
Rolling cultivator	1,500	500	1,000	100
6 row cultivator	3,000	1,000	2,000	200
300 gal sprayer (2) @ $4,000	8,000	2,000	5,000	600
Weed sprayer (3) @ $3,000	9,000	1,500	5,250	750
Drainage pump (3) @ $2,500	7,500	1,500	4,500	600
MISCELLANEOUS				
Pickup truck (4-wheel drive)	12,000	2,000	7,000	1,000
Pickup truck	10,000	1,000	5,500	900
Stake truck	18,000	2,000	10,000	1,600
Trailer	3,500	1,500	2,500	200
Wagons (2) @ $1,500	3,000	1,000	2,000	200
Ditch Mower	3,000	1,000	2,000	200
Shop tools	10,000	6,000	8,000	400
Office equipment	--	--	3,000	--
TOTALS	258,500	98,200	217,550	16,030

[a]The typical farm in this study consists of 300 acres total, with 250 acres of tillable land, of which 100 acres is in carrot production.

[b]A 10-year life is assigned to all machinery and equipment.

[c]Average value is calculated to create a basis for determining interest on machinery and equipment investment (see Table 31).

[d]Annual depreciation = (new price - salvage value) / 10 years.

Land, building, and improvement costs necessary for the 300-acre farm are listed in Table 43. Land cost is disregarded since it was assumed land would be rented.

Most vegetable operations use the percent of income producing acreage method to allocate costs. This method was used in the Michigan study and is used for this study. Since the carrot enterprise uses 40 percent of the income producing acreage, 40 percent of all fixed costs for operating the farm are charged to carrots. Fixed costs that occur specifically with the carrot enterprise are allocated at the rate of 100 percent. Fixed costs for carrots were estimated to be $489 per acre (Table 44).

TABLE 43. ESTIMATED LAND, GENERAL BUILDINGS AND IMPROVEMENT COSTS FOR A TYPICAL FARM PRODUCING CARROTS IN THE RED RIVER VALLEY, NORTH DAKOTA, 1988[a]

Item	New Price	Salvage Value[b]	Average Value[c]	Annual Depreciation[d]
			$	
Land[c] - 250 acres @ 573/A	143,520	--	143,250	--
50 Acres @ 200/A	10,000	--	10,000	--
Machinery Shop (40x80x16 ft)	20,000	5,000	12,500	600
Water Well (2) 150 ft 6 in @ 8,000	16,000	0	8,000	640
TOTALS (gen. bldgs. and improv. only)	36,000	5,000	20,500	1,240

[a]The typical farm consists of 300 acres with 250 acres of tillable 100 acres of carrot production.

[b]A 25-year life and assigned to all buildings and improvements.

[c]Land values were computed from North Dakota Farm Research Vol. 46, No. 4 January-February 1989.

[d]Annual depreciation = (new price - salvage value) / 10 years.

Variable Costs

The variable costs are those which vary with production of the crop. These include seed, fertilizer, the various chemicals used for the crop, labor, and other costs. The variable costs incurred in a typical carrot operation were $2,079 (Table 45). The variable inputs are presented on a per acre basis for both the amount used and cost.

TABLE 44. FIXED COSTS CHARGED TO THE CARROT ENTERPRISE TYPICAL FARM RED RIVER VALLEY, NORTH DAKOTA

Item	Cost	Percent Charged to Carrots[a]	Cost Charged to Carrots
	—$—	—%—	—$—
Depreciation			
Gen. mach. and equip. (Table 41)	16,030	40	6,412
Spec. equip. (Table 42)	10,800	100	10,800
Gen. bldgs. and improv. (Table 43)	1,240	40	496
Total Depreciation			17,708
Interest			
Gen. mach. and equip. (Table 41) ($217,550 x 10%)	21,755	40	8,702
Spec.equip. (Table 42) ($113,000 x 10%)	11,300	100	11,300
Gen. bldgs. and improv. (Table 43) ($20,500 x 10%)	2,050	40	820
Total Interest			20,822
Repairs and Maintenance			
Gen. bldgs. and improv. ($20,500 x 3%)	615	40	246
Tilling	1,250	40	500
Total Repairs and Maintenance			746
Land Rental			
Real estate [($70/acre) x (300 acres)]	21,000	40	8,400
Insurance			
Prop., mach., and equip.	2,500	40	1,000
Vehicles (incl. licenses)	550	40	220
Total Insurance			1,220
TOTAL FIXED COSTS (carrot enterprise)			48,896
TOTAL FIXED COSTS PER ACRE OF CARROTS ($48,896/100 Acres)			489

[a]Calculated by dividing acres used for carrots by a total of 250 tillable acres.

Total Costs and Net Returns

Gross receipts, variable and fixed costs, and net returns for both a per acre and per master basis were provided (Table 46). The carrot operation was profitable at a yield of 350 masters per acre and a price of $7.00 per master (Table 46). This was assumed to be a possible price and yield given conditions presented in the case study. The price received for carrots can vary depending on the targeted market and regional location of markets. Price can also vary depending on whether the farmer uses irrigation. The price used for computing gross receipts in Table 46 was the price received for organically grown carrots in the Red River Valley case study. It should be noted the price of carrots would be less if not organically grown.

TABLE 45. ESTIMATED VARIABLE COSTS PER ACRE FOR CARROT PRODUCTION RED RIVER VALLEY, NORTH DAKOTA, 1988

Item	Amount/ Acre	Price	Cost/ Acre
		$	
Growing and Interest Costs			
Seed	3.0 lbs.	37.00	111.00
Fertilizer			
- N	100 lbs.	0.15	15.00
- P	100 lbs.	0.16	16.00
- K	240 lbs.	0.05	12.00
Lime, micronutrients			30.00
Fungicide			
- Mancozeb (4X)	2 lbs.	1.60	12.80
- Bravo (3X)	1 qt.	6.60	19.80
- Flowable Copper (4X)	1 qt.	3.05	12.20
Insecticides			
- Diazinon (5X)	0.125 gal.	25.50	15.95
- Sevin (5X)	1 lb.	3.00	15.00
- Parathion ((5X)	0.0625 gal.	22.50	7.05
Herbicides			
- Lorox (2X)	1 qt.	12.50	25.00
- Fusilade (2X)	1.5 qt.	10.60	31.80
- Solvent	30 gal.	1.00	30.00
Nematicides			
- Vydate 2 L	2 gal.	45.00	90.00
Cultural Labor			
- Preparation	2 hr	5.50	11.00
- Planting	1 hr	5.50	5.50
- Irrigation (3X)	2 hr	3.50	21.00
- Weeding	1 hr	3.50	3.50
- Cultivation (3X)	0.25 hr	5.50	4.13
- Spraying (12X)	0.25 hr	5.50	16.56
- Side-dressing	0.25 hr	5.50	1.38
- Fringe benefits (20% of payroll:63.07)			12.61
Fuel, Oil[a]			67.00
Machinery repair (including all field equipment)			102.00
Machine hire			2.50
Utilities			18.00
Miscellaneous (travel, etc.)			15.00
Interest on operating capital (723.78x10%x0.5 yr)			36.18
Subtotal			759.96
Harvest and Marketing[b]			
Labor			
- Harvest	6.0 hr	5.50	33.00
- Fringe benefits (20% of payroll:33.00)			6.60
Packing	450 mst.	2.70	1,215.00
Transportation	600 mst.	0.10	60.00
Promotion	450 mst.	0.01	4.50
Subtotal			1,319.10
TOTAL VARIABLE COSTS PER ACRE			2,079.06

[a]Includes irrigation fuel.

[b]The typical farm has a field yield of 600 masters (mst) and a pack out of 450 masters. A master weighs 50 pounds.

TABLE 46. ESTIMATED PER ACRE AND PER MASTER COSTS AND RETURNS FOR CARROT PRODUCTION CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988[a]

Item	Per Acre	Per Master
	$	
Gross Receipts - 350 msts. reg.	2,450.00	7.00
- 100 msts. jumbos	400.00	4.00
Total Gross Receipts	2,850.00	6.33
Variable Costs		
Growing		
- Seed	111.00	0.25
- Fertilizer	43.00	0.10
- Lime, micronutrients	30.00	0.07
- Fungicide	44.80	0.10
- Insecticides	38.00	0.08
- Herbicides	86.80	0.19
- Nematicides	90.00	0.20
- Cultural labor	75.68	0.17
- Fuel, oil	67.00	0.15
- Machinery repair	102.00	0.23
- Machine hire	2.50	0.01
- Utilities	18.00	0.04
- Miscellaneous (travel, etc.)	15.00	0.03
- Interest on operating capital	36.18	0.08
Subtotal	759.96	1.69
Harvest and Marketing		
- Labor	39.60	0.09
- Packing	1,215.00	2.70
- Transportation	60.00	0.13
- Promotion	4.50	0.01
Subtotal	1,319.10	2.93
TOTAL VARIABLE COSTS	2,079.06	4.62
Fixed Costs		
- Depreciation	177.08	0.39
- Interest on investment	208.22	0.46
- Repairs and Maintenance	7.46	0.02
- Rent	84.00	0.19
- Insurance	12.20	0.03
TOTAL FIXED COSTS	488.96	1.09
TOTAL VARIABLE AND FIXED COSTS	2,568.02	5.71
Net return (loss)	281.98	0.62

[a]The typical farm in this study consists of 300 acres total, with 250 acres of tillable land of which 100 acres is in carrot production.

Net returns per acre for various prices and yields are provided in Table 47. A wide range of prices were used to represent both organically and non-organically grown carrots. Organically grown carrots generally command a higher price in the marketplace. Organically grown carrots were represented in Table 47 by prices of $9, $11, and $13 while non-organically grown prices were represented by prices of $5 and $7. Net returns (Table 47) were determined using the following assumptions. First, variable costs expended to prepare the land and grow carrots would not vary with yield. However, it

TABLE 47. NET INCOME (LOSS) PER ACRE AT VARIOUS PRICES AND YIELDS CARROT PRODUCTION, CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988[a]

	Average Price Received/Master (dollars)				
Yield	5	7	9	11	13
(Masters Sold/Acre)	$/acre				
150	(938)	(638)	(338)	(38)	(262)
250	(731)	(231)	269	769	1,269
350	(524)	176	876	1,576	2,276
450	(317)	583	1,483	2,383	3,283

[a]Jumbo's not included.

was assumed harvesting, packaging, and promotion costs would vary directly with yield. Active vegetable producers should compute their costs of operatrion using cost and yield estimates pertaining to their enterprise.

Onion Enterprise

Like the carrot enterprise, both fixed and variable costs of onions were used from the Michigan study. Some fixed and variable inputs used differ between the carrot and onion enterprises. Some additional inputs were added which specifically pertain to the production of onions. Price and yield used to determine gross receipts are from the case study presented in this paper. Various price and yield scenarios are presented to illustrate how losses/returns vary with price and yield.

Fixed Costs

General machinery and equipment costs totaled $206,400 with an annual depreciation of $16,820 (Table 48). Costs for specialized equipment are listed in Table 49. Specialized equipment costs totaled $24,000 with annual depreciation of $3,400.

Land, building, and improvement costs necessary for a typical 300-acre farm are provided in Table 50. Again land was rented rather than purchased. Specialized building and improvement costs amounted to $77,500 with annual depreciation of $3,800 (Table 51).

Table 48. General Machinery and Equipment Costs for A Typical Farm Producing Onions in Central Red River Valley North Dakota, 1988[a]

Item	New Price	Salvage Value[b]	Average Value[c]	Annual Depreciation[d]
		$		
TRACTORS				
- 100 hp diesel	40,000	20,000	30,000	2,000
- 75 hp diesel (2) @ 28,000	56,000	30,000	43,000	2,600
- 40 hp Gas (2) @ 18,000	36,000	18,000	27,000	1,800
- Small Crawler (old)	4,000	4,000	4,000	–
- Bulldozer (old)	4,000	4,000	4,000	–
- I. H. Model BN (forklift)	7,000	4,000	5,500	300
TILLAGE				
- 4-18 in rollover plow	9,000	1,000	5,000	800
- Land Leveler	5,000	1,000	3,000	400
- 16 ft disk	7,000	1,000	4,000	600
- Subsoiler	4,000	600	2,300	340
- Springtooth drag (old)	1,000	1,000	1,000	–
- Cultipacker (old)	2,500	500	1,500	200
CROP MAINTENANCE				
- Fertilizer spreader (2)	4,500	700	2,600	380
- Fertilizer wagon	5,000	1,000	3,000	400
- Tiller	2,500	900	1,700	160
- Rolling cultivator	1,500	500	1,000	100
- 6 row cultivator	3,000	1,000	2,000	200
- 300 gal sprayer	7,000	1,000	4,000	600
- Weed sprayer	3,500	500	2,000	300
- Drainage pump	2,500	500	1,500	200
MISCELLANEOUS				
- Field Trucks (3 old)	15,000	15,000	15,000	–
- Pickup truck (4-wheel drive)	10,000	1,000	5,500	900
- Pickup truck	8,000	600	4,300	740
- Stake truck	18,000	2,000	10,000	1,600
- Trailer	3,500	1,500	2,500	200
- Wagons (2) @ 1,500	3,000	1,000	2,000	200
- Skid loader	13,000	3,000	8,000	1,000
- Shop tools	10,000	6,000	8,000	400
- Elevator	5,000	1,000	3,000	400
TOTALS	290,500	122,300	206,400	16,820

[a]The typical farm in this study consists of 300 acres total, with 250 acres of tillable land, of which 100 acres is in onion production.

[b]A 10-year life is assigned to all machinery and equipment.

[c]Average value is calculated to create a basis for determining interest on machinery and equipment investment (see Table 3).

[d]Annual depreciation = (new price - salvage value)/10 years.

TABLE 49. ESTIMATED SPECIALIZED MACHINERY AND EQUIPMENT COSTS FOR A 100-ACRE ONION ENTERPRISE IN THE RED RIVER VALLEY, NORTH DAKOTA, 1988

Item	New Price	Salvage Value[a]	Average Value[b]	Annual Depreciation[c]
		$		
Onion Drill	14,000	2,000	8,000	1,200
Onion harvester	27,000	5,000	16,000	2,200
TOTALS	41,000	--	24,000	3,400

[a]A 10-year life is assigned to all machinery and equipment.
[b]Average Value is calculated to create a basis for determining interest on machinery and equipment Investment (see Table 33).
[c]Annual depreciation = (new price - salvage value)/10 years.

Basically, this consists of a drying building for onions which is not needed for carrots. Fixed costs were allocated to the onion enterprise using the percent of income producing acreage method (Table 52).

TABLE 50. ESTIMATED LAND, GENERAL BUILDINGS AND IMPROVEMENT COSTS FOR A TYPICAL FARM PRODUCING ONIONS, RED RIVER VALLEY, NORTH DAKOTA, 1988[a]

Item	New Price	Salvage Value	Average Value[b]	Annual Depreciation[c]
		$		
Land[c] - 250 acres @ 573/A	143,250	--	143,250	--
50 Acres @ 200/A	10,000	--	10,000	--
Machinery Shop (40x80x16 ft)	20,000	5,000	12,500	600
TOTALS (gen. bldgs. and improv. only)	20,000	5,000	12,500	600

[a]The typical farm in this study consists of 300 acres total with 250 acres of tillable land of which 100 acres are in onion production.
[b]A 25-year life is assigned to all buildings and improvements.
[c]Land values are computed from North Dakota Farm Research Vol. 46, No. 4 January-February 1989.

TABLE 51. ESTIMATED SPECIALIZED BUILDINGS AND IMPROVEMENT COSTS FOR A 100 ACRE ONION FARM, CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988

Item	New Price	Salvage Value[a]	Average Value	Annual Depreciation
		$		
Storage Facility Plus drying equip.	125,000	30,000	77,500	3,800

[a]A 25 year life is assigned to all buildings and improvements.

TABLE 52. ESTIMATED FIXED COSTS CHARGED TO COMMERCIAL-SIZED ONION FARM, CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988

Item	Cost	Percent Charged to Onions[a]	Cost Charged to Onions
	$	%	$
Depreciation			
- Gen. mach. and equip. (Table 48)	16,820	40	6,728
- Spec. equip. (Table 49)	3,400	100	3,400
- Gen. bldgs. and improv. (Table 50)	920	40	240
- Specialized bldgs. Equip. (Table 51)	3,800	100	3,800
Total Depreciation			14,168
Interest			
- Gen. mach. and equip. (Table 48) ($206,400 x 10%)	20,640	40	8,256
- Spec.equip. (Table 49) ($24,000 x 10%)	2,400	100	2,400
- Gen. bldgs. and improv. (Table 50) ($16,500 x 10%)	1,650	40	660
- Specialized bldgs., Improv. (Table 51) ($77,500 x 10%)	7,750	100	7,750
Total Interest			19,066
Repairs and Maintenance			
- Gen. bldgs. and improv. ($16,500 x 3%)	495	40	198
- Specialized bldgs.,improv. ($77,500 x 3%)	2,325	40	2,325
Total Repairs and Maintenance			2,523
Land Rental			
- Real estate ($70/acre x 300 acres)	21,000	40	8,400
Insurance			
- Prop., mach., and equip.	1,000	40	400
- Vehicles (incl. licenses)	550	40	220
Total Insurance			620
TOTAL FIXED COSTS (onion enterprise)			44,777
TOTAL FIXED COSTS PER ACRE OF ONIONS ($44,777/100 Acres)			448

[a]Calculated by dividing acres used for onions by a total of 250 tillable acres.

Variable Costs

Variable inputs for the onion enterprise are presented on a per acre basis for both amount used and cost. Variable costs for raising onions amounted to $2,305.72 per acre (Table 53).

TABLE 53. ESTIMATED VARIABLE COSTS PER ACRE FOR ONION PRODUCTION CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988

Item	Amount/ Acre	Price	Cost/ Acre
		$	
Growing and Interest Costs			
Seed	3.25 lb.	30.00	97.50
Fertilizer			
- N	200 lb.	0.18	36.00
- P	175 lb.	0.23	40.25
- K	300 lb.	0.08	24.00
Manganese	10 lb.	0.04	4.00
Zinc	1 lb.	0.35	0.35
Fungicide			
- Thiram (see treat.)	1 lb.	2.20	2.20
- Bravo (2X)	1.5 qt.	6.40	19.20
- Ridomil	2.0 lb.	7.10	14.20
- Manex (4X)	1 qt.	9.30	37.20
- Miscellaneous			31.50
Insecticides			
- Diazinon (4X)	1.0 qt.	6.50	26.00
- Lorsban	12.0 lb.	1.65	19.80
- Miscellaneous			10.00
Herbicides			
- Dual (3X)	1.0 qt.	12.50	37.50
- Furloe (2X)	1.0 gal.	23.00	46.00
- Fusilade 2000 (3X)[a]	1.0 pt.	28.00	84.00
- Goal (5X)	6.0 oz.	0.48	14.30
- Miscellaneous			20.00
Cultural Labor			
- Preparation[b]	3.0 hr	5.50	16.50
- Planting	1.0 hr	5.50	5.50
- Weeding (3X)	9.0 hr	3.50	94.50
- Cultivation (3X)	0.5 hr	5.50	8.25
- Spraying (15X)	0.13 hr	5.50	10.75
- Fringe benefits (15% of payroll:135.50)			20.35
Fuel,Oil			85.00
Machinery repair (including all field equipment)			102.00
Machine hire			9.00
Utilities			18.00
Supplies			10.00
Miscellaneous (travel, etc.)			11.00
Interest on operating capital (926.95x10%x0.5 yr)			46.35
Subtotal			1,001.20
Harvest and Marketing Costs			
Labor			
- Harvest	9.0 hr	5.50	49.50
- Storage	2.5 hr	5.50	13.75
- Fringe benefits (15% of payroll:63.25)			9.50
Storage Fuel and elec. 1,000 bag		0.10	40.00
Transportation 1,000 bag		0.20	80.00
Packing 700 bag		1.25	500.00
Promotion 700 bag		0.02	14.00
Brokerage Fee 15% of gross (700 bags@ 2.50=1,000)			150.00
Subtotal			856.75
TOTAL VARIABLE COSTS PER ACRE			1,857.95

[a]These two FIFRa Section 18, Emergency Exemptions expired on September 1, 1986. Therefore, these products cannot be used during 1987 unless the U.S. EPA again grants Section 18 status for these pesticide products.

[b]Does not include the cost of producing a cover crop but a cover crop planted the previous fall is recommended.

Total Costs and Net Returns

Variable and fixed costs were subtracted from gross receipts to arrive at per acre and per master net returns for onion production (Table 54). The onion operation was profitable at a price of $7.00 per bag and a yield of 400 bags per acre. This was perceived to be a possible price and yield given conditions presented in the case study. The price received could possibly be higher, depending upon targeted markets and regional location of markets. Price can also vary depending on whether the farmer uses irrigation.

TABLE 54. ESTIMATED PER ACRE AND PER BAG COSTS AND RETURNS FOR ONION PRODUCTION CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988

Item	Per Acre	Per Master
	$	
Price	7.00	–
GROSS RECEIPTS (400 bags)	2,800.00	–
Variable Costs		
Growing		
- Seed	97.50	0.24
- Fertilizer	104.60	0.26
- Spray and Additives	361.90	0.90
- Cultural labor	155.85	0.39
- Fuel, oil	85.00	0.32
- Machinery repair	102.00	0.26
- Machine hire	9.00	0.02
- Utilities	18.00	0.05
- Supplies	10.00	0.03
- Miscellaneous (travel, etc.)	11.00	0.03
- Interest on operating capital	46.35	0.12
Subtotal	1,001.20	2.50
Harvesting and Marketing Costs		
- Labor	72.75	0.18
- Fuel and Electricity	40.00	0.10
- Transportation	80.00	0.20
- Packing	500.00	1.25
- Promotion and brokerage	164.00	0.41
Subtotal	856.75	2.14
TOTAL VARIABLE COSTS	1,857.95	4.65
Fixed Costs		
- Depreciation	141.68	0.35
- Interest on investment	190.66	0.48
- Repairs and Maintenance	25.23	0.06
- Rent	84.00	0.21
- Insurance	6.20	0.02
TOTAL FIXED COSTS	447.77	1.12
TOTAL VARIABLE AND FIXED COSTS	2,305.72	5.77
Net return (loss)	494.28	1.24

Net returns for a range of possible prices and yields are presented in Table 55. These values were computed assuming only harvesting, packaging, and promotion costs varied directly with yields. A yield of 300 bags and a price between $6 and $7 would have to be received to just break even (Table 55). The results presented are hypothetical and will vary depending on a producers' situation.

Summary and Conclusions

The potential for competitive commercial production of vegetables in North Dakota was examined in this study. Production and marketing aspects were reviewed for 53 vegetables. Vegetable crops having the most agronomic potential were: rhubarb, asparagus, horseradish, red beets, carrots, garlic, onions, cabbage (excluding chinese), muskmelon, winter squash, summer squash, pumpkins, sweetcorn, cucumbers, green peas, and green beans. Root crops such as red beets, onions, and carrots had the most production and marketing potential.

Potential for North Dakota onion and carrot production was examined. First, total and seasonal U.S. production and foreign trade statistics were presented. Onions and carrots were divided by type (spring, summer non-storage, summer storage, and California for onions; fresh and processed for carrots). Market shares, seasonal prices, monthly shipments and returns to storage were presented. Regional market share (production) and population along with per capita consumption were used to determine regional demand. Results indicate North Dakota lies in a net import region for both crops. This would suggest production potential exists for North Dakota production of carrots and onions. Transportation costs from North Dakota and competing regions were introduced. North Dakota's advantage (disadvantage) in transportation costs versus other production regions were determined for the Fargo, Minneapolis, Chicago, New York, Atlanta, and Sioux Falls markets.

North Dakota onions have a transportation advantage over the Pacific Northwest and Denver origins for all the markets. Michigan onions enjoy a transportation advantage over North Dakota for the Chicago, New York, and Atlanta Markets.

TABLE 55. NET INCOME (LOSS) PER ACRE AT VARIOUS PRICES AND YIELDS, ONION PRODUCTION, CENTRAL RED RIVER VALLEY, NORTH DAKOTA, 1988

	Average Price Received/Bag				
Yield	5	6	7	8	9
(Bags Sold/Acre)	$				
100	(1,163)	(1,063)	(963)	(863)	(763)
200	(877)	(677)	(477)	(277)	(77)
300	(591)	(291)	9	309	609
400	(305)	95	495	895	1,295

North Dakota carrots have a transportation advantage over California for all the destination markets studied. A transportation advantage also exists for North Dakota carrots over Michigan and Minnesota carrots for the Fargo market and over Michigan for the Minneapolis and Sioux Falls markets.

North Dakota's competitiveness in any market is determined by production and transportation costs relative to production and transportation costs for other originating regions. However, since production costs for each region were not available, competitiveness comparisons were unobtainable.

A case study of a small vegetable production/marketing operation was analyzed. A vegetable operation was started in the central Red River Valley in 1987 and continued in 1988. Production in 1987 concentrated on carrots while 1988 production shifted in favor of onions. Red potatoes, broccoli, winter squash, summer squash, melons, cabbage, and tomatoes were also grown. Results of the operation including machinery utilization, production, sales, variable and fixed costs, packout, prices and net return data were analyzed for each enterprise. Operational problems encountered were made an integral part of the analysis.

An expanded model was developed from case study data and followed the methodology of a study done by Michigan State University. The expanded model evaluated economic feasibility of a commercial-sized operation producing either carrots or onions. Assumptions used in the expanded model included a 300 acre farm with 250 tillable acres (100 acres of either carrots or onions). Carrot acreage was irrigated while onion acreage was not. Carrot yields were estimated at 350 masters per acre and priced at $7.00 per master (based on case study data). Onion yields were estimated at 400 bags per acre using a $7.00 per bag market price.

Carrots were estimated to have positive net returns. Carrot production in the central Red River Valley of North Dakota was estimated to have per acre fixed and variable costs of $489 and $2,079, respectively. Carrot receipts were estimated to be $2,850 per acre. Net return for carrots was $282 per acre. Various price and yield scenarios presented indicate net returns for carrots. Under the assumed cost structure, carrots were profitable at a yield of 250 masters per acre and a price of $9 per master.

Onions were also estimated to have positive net returns. Onion production in the central Red River Valley of North Dakota was estimated to have per acre fixed and variable costs of $448 and $857, respectively. Onion receipts were estimated at $2,800 per acre and estimated net returns of $494 per acre. Net returns under various price and yield scenarios were also presented. Positive net returns were indicated for yields of 300 bags per acre and $7 per bag.

Feasibility studies can estimate costs and returns, but, anyone considering vegetable enterprises should use the estimates in this study as a guide, remembering that his/her costs and returns may differ.

Areas Needing Further Study

This study has focused on the fresh vegetable market with little attention given to the vegetable processing market. Interviewing vegetable processors of the Upper Midwest could be valuable in identifying constraints and opportunities for expanded vegetable production and marketing in North Dakota.

References

Edward E. Judge and Sons, Inc. The Almanac of the Canning, Freezing, Preserving, Industries, Maryland, U.S., 1988.

Lorenz, Oscar A., and D.N. Maynard. Knotts Handbook for Vegetable Growers, 2nd edition, p. 56.

Lutz, J.M., and R.E. Hardenburg. "The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks." USDA Handbook No. 66; p. 20 and pp. 37-53, 1968.

Romkey, Bud. Onion Grower and Packager of Moorhead, Minnesota, Interview, Spring 1989.

Shapley, Allen E. and Thomas A. Dudek. January 1989. "Costs of Producing Carrots." Agr. Econ. Rpt. No. 520, Dept. of Agr. Econ., Michigan State University, East Lansing, MI.

USDA, Agricultural Marketing Services, *Fresh Fruit and Vegetable Prices, 1978-1988*, Washington, D.C.

USDA, Agricultural Marketing Services, *Fresh Fruit and Vegetable Shipments*, Washington, D.C., 1988.

USDA Agricultural Statistics Board, *Vegetables*, Various Annual Summaries, Washington, D.C., 1970-1988.

USDA, Economic Research Service, *Food Consumption, Prices, and Expenditures, 1966-1987.* Statistical Bulletin No. 773, Washington, D.C., January 1989.

USDA, Economic Research Service, *Vegetables and Specialties*, Situation and Outlook Yearbook, Washington, D.C., November 1988.

Voyles, Jerry. Agricultural Manager for United Foods Company, Fairmont, Minnesota, Interview, March 25, 1988.