# VEGETABLES

## Characteristics, Production, and Marketing

Lincoln C. Peirce

# VEGETABLES

## Characteristics, Production, and Marketing

**Lincoln C. Peirce**
*University of New Hampshire*

**John Wiley and Sons**
*New York* *Chichester* *Brisbane* *Toronto* *Singapore*

***Library of Congress Cataloging in Publication Data:***

Peirce, Lincoln C.
Vegetable: characteristics, production, and
marketing.

1. Vegetables. 2. Truck farming. 3. Vegetable
trade. 4. Vegetables—United States. 5. Truck
farming—United States. 6. Vegetable trade—United
States. I. Title.
SB320.9.P45 1987 635 86-32625
ISBN 0-471-85022-5

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

# VEGETABLES

## Characteristics, Production, and Marketing

# Preface

Over 85 distinct taxonomic groups constitute the majority of vegetables grown in the United States. On a global basis, the number is much higher, including many plants indigenous to tropical and subtropical regions, but relatively unknown in temperate areas. The focus of this book is on those crops that contribute to the commercial vitality of the vegetable industry in the western hemisphere, particularly in North America. These crops include some of major importance to world food supplies (such as potato, beans, cole crops) and others of relatively local significance (okra, taro).

The vegetable industry is a dynamic one. Cropping practices, regardless of commodity, change continually, incorporating innovations by growers and new technology supplied by biochemists, physiologists, geneticists, engineers, economists, and others at an accelerating rate. It is difficult to partition these technologies within a textbook, for they represent inputs within highly integrated vegetable production systems. A given technology also may have a different purpose for different crops in different production areas.

Students interested in vegetable production or marketing must recognize that techniques and skills alone are insufficient to maintain a progressive business. A broad understanding of basic sciences and of the economics of the marketplace is essential if one is to remain progressive. This text is directed toward the sophomore or junior level student who has acquired an understanding of basic sciences. The first portion of this book is devoted to resources—natural, biological, and economic—that are fundamental to successful vegetable production and to the general vegetable management systems that have evolved to integrate those resources. The remaining chapters include the importance, history, botany, cultural methods, and handling of specific vegetable crops and descriptions and general control methods for the common insect and disease pests.

It is not feasible to describe each variant of

a production system: growers often develop modifications that succeed within their specific environments and market structure. An understanding of the plant and its response to stress and to growing and marketing practices is most important as is a full awareness of the kinds of environmental pressures that may affect growth or market quality. The choice of specific application rate of fertilizers or pesticides or, in many instances, of specific materials will differ according to soil, climate, and legal restrictions within a state or county. Local extension services should be consulted for specific recommendations and for proper application methods within the existing regulatory framework. Specific practices presented in the text are intended as illustrative of systems developed to produce and protect a crop, not as general recommendations to be applied regardless of local circumstances.

Many people have contributed to this book—growers and extension specialists who demonstrate the practicability of different production and marketing systems, scientists who have published their research and otherwise shared their understanding of production problems and opportunities, and those in industry who have created new products that enhance production skills or improve production volume and quality. Particular thanks are extended to Lincoln C. Peirce III and Amy Bartlett Wright for their artwork, to those who offered critique and suggestions for improving each chapter, and to those who allowed their data and photographs to supplement the text.

**Lincoln C. Peirce**

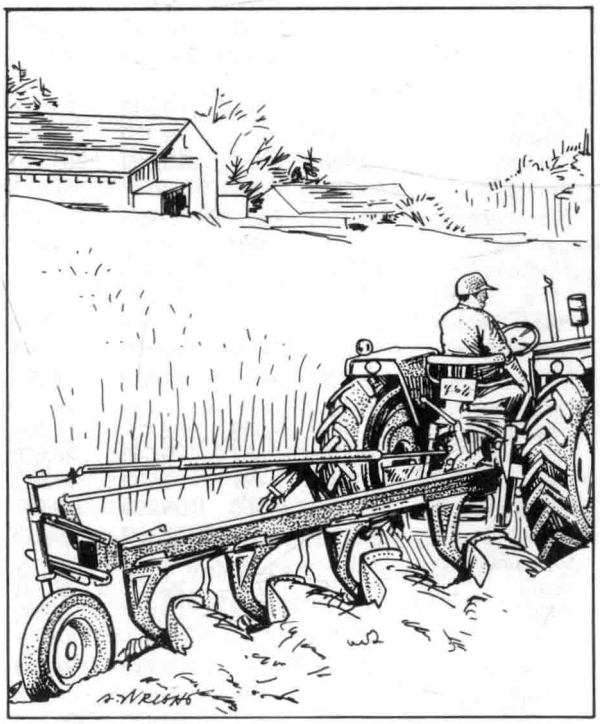
# VEGETABLES

## Characteristics, Production, and Marketing

# Contents

# 1

# The Vegetable Industry



In the 1940s, American policy was guided by the Jeffersonian ideal that our society would be served best by traditional family-size, owner-operated farms. Substantial change has occurred in the vegetable industry since World War II. Until that time, small family farms did predominate, relying heavily on local labor, suppliers, and consumers to sustain their business. After 1945, the rapid transition to volume marketing systems, the improvements in technology of food handling systems, including refrigeration, developed during wartime, and the changing economic structure of American agriculture, spurred by the federal highway expansion of the 1950s, all favored those growers who could supply the market with a large volume over a prolonged time period. Small production units were inefficient in that setting and either failed or enlarged to meet the new challenges. They enlarged through purchases of additional land or through production/marketing cooperatives. They maintained competitiveness by adopting new technology and by stressing high quality in vegetable production and handling.

Today's vegetable industry is a highly interdependent network of producers, suppliers, processors, seed growers and dealers, brokers, wholesalers, retailers, and service industries. Income attributed to farm sales is substantial, over $3.9 billion, but the significance of these dollars is the value they generate within sectors of the economy supporting vegetable production and within sectors supported by this production. Because of the efficient food production and distribution system and the competitive nature of the industry, the share of the consumer dollar devoted to food purchases is among the lowest in the world (Figure 1.1).

## COMPONENTS OF THE VEGETABLE INDUSTRY

### Field Production for Fresh Market

The total vegetable industry includes commercial farms and greenhouses and many small units not included in agricultural marketing statistics. Table 1.1 provides an estimate of the total area in vegetables by state. Both the number of farms and the area cultivated have declined steadily since the 1940s as productivity per farm has increased. The average vegetable farm is small by comparison to grain

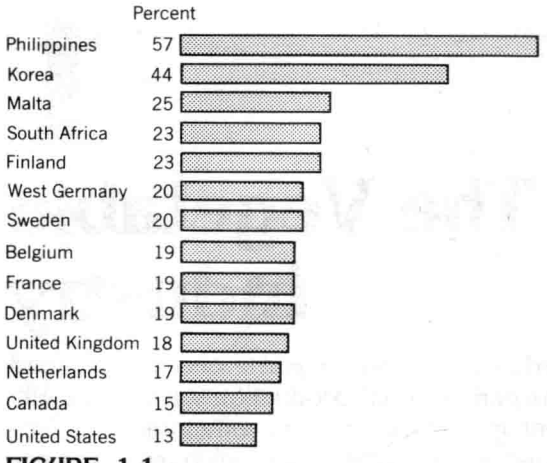



**FIGURE 1.1**
**Share of consumer expenditures for food. 1978 data; UN National Accounts of Statistics and National Sources, 1979. (*Source*: *Handbook of Agricultural Charts*, USDA Agric. Handb. 609 (1982).)**

farms, but the productivity and value per acre are much higher. This high value supports the substantial labor and marketing costs inherent in vegetable production.

In the past, vegetable farming was compartmentalized into distinct kinds of production systems. **Truck farms** were defined as arising adjacent to transportation systems, dealing with only one or two crops on a substantial acreage for distant marketing. **Market gardens** tended to develop near population centers and supplied a wide array of homegrown produce (typical of today's roadside

**TABLE 1.1**
**Distribution of farms and vegetable acreage by state and region, 1954 and 1982[a]**

| Region and state | Farm (number) | | Acreage harvested | |
|---|---|---|---|---|
| | 1954 | 1982 | 1954 | 1982 |
| Northeast | | | | |
| Connecticut | 1,185 | 511 | 12,727 | 8,244 |
| Delaware | 1,446 | 367 | 40,033 | 40,421 |
| Maine | 2,307 | 535 | 18,926 | 11,278 |
| Maryland | 5,345 | 1,403 | 94,078 | 38,331 |
| Massachusetts | 2,347 | 1,011 | 20,324 | 15,307 |
| New Hampshire | 620 | 278 | 3,729 | 2,974 |
| New Jersey | 5,102 | 1,970 | 145,879 | 70,746 |
| Pennsylvania | 11,862 | 3,876 | 96,154 | 46,194 |
| Rhode Island | 238 | 120 | 1,810 | 1,908 |
| Vermont | 577 | 228 | 3,804 | 1,633 |
| West Virginia | 1,934 | 421 | 3,804 | 1,288 |

**TABLE 1.1 (*Continued*)**

| Region and state | Farm (number) | | Acreage harvested | |
|---|---|---|---|---|
| | 1954 | 1982 | 1954 | 1982 |
| Midwest | | | | |
| Illinois | 4,570 | 1,585 | 125,437 | 81,916 |
| Indiana | 5,935 | 1,429 | 76,415 | 30,830 |
| Iowa | 2,565 | 429 | 36,261 | 8,363 |
| Kansas | 852 | 362 | 5,330 | 4,808 |
| Michigan | 13,931 | 3,634 | 105,358 | 126,248 |
| Minnesota | 7,598 | 3,152 | 158,040 | 177,242 |
| Missouri | 2,001 | 696 | 12,831 | 13,797 |
| Nebraska | 621 | 186 | 2,901 | 1,677 |
| Ohio | 7,897 | 2,442 | 63,042 | 53,594 |
| Wisconsin | 21,497 | 4,262 | 241,766 | 280,326 |
| South | | | | |
| Alabama | 11,894 | 2,341 | 64,942 | 24,047 |
| Arkansas | 6,397 | 917 | 29,220 | 12,938 |
| Florida | 9,766 | 2,455 | 323,909 | 283,780 |
| Georgia | 23,384 | 2,801 | 167,317 | 61,973 |
| Kentucky | 3,278 | 1,549 | 6,882 | 4,919 |
| Louisiana | 6,458 | 999 | 34,931 | 8,597 |
| Mississippi | 10,508 | 1,363 | 36,025 | 11,530 |
| North Carolina | 22,723 | 3,938 | 77,325 | 54,650 |
| South Carolina | 11,125 | 1,645 | 86,948 | 31,538 |
| Tennessee | 9,147 | 2,070 | 33,203 | 30,708 |
| Virginia | 7,001 | 1,510 | 72,716 | 27,498 |
| Southwest | | | | |
| Arizona | 494 | 339 | 69,190 | 69,864 |
| Colorado | 2,139 | 657 | 29,640 | 28,686 |
| New Mexico | 1,282 | 497 | 9,973 | 23,502 |
| Oklahoma | 2,364 | 556 | 26,239 | 13,987 |
| Texas | 21,391 | 3,434 | 403,197 | 210,873 |
| Intermountain | | | | |
| Idaho | 1,635 | 766 | 29,237 | 42,291 |
| Utah | 2,429 | 432 | 19,488 | 6,982 |
| West | | | | |
| California | 7,161 | 4,053 | 560,116 | 894,573 |
| Hawaii | — | 746 | — | 4,673 |
| Oregon | 2,926 | 1,554 | 95,490 | 134,814 |
| Washington | 3,789 | 2,031 | 106,787 | 169,170 |
| Other states[b] | 994 | 431 | 5,785 | 3,908 |

*Source:* Bureau of the Census, Department of Commerce.

[a] Excludes white potato; vegetable data include all vegetable farms growing for sale.

[b] Alaska, Montana, Nevada, North Dakota, South Dakota, Wyoming.

market operations). The differences among farms today are less distinct than in past years; transportation and market proximity, although important, place few restraints on location of a farm. It is the environment that is the major consideration in locating a successful farm: proximity to water, availability of fertile and well-drained land, length and climatic features of the growing season. These factors have been responsible for development of most major production centers. For small diversified farms, location near a suitable market is still an important advantage.

Fresh market vegetables are produced to some extent in every geographical area of the United States. Of the total acreage and production, the amounts devoted to commercial production of the principal fresh market vegetables by state and their value by year are presented in Tables 1.2 and 1.3. The intensity, size, and objectives of the different production units differ according to climate, demographics (population density, labor supply), and economic pressures resulting from industrial and population growth. Six states, California, Florida, Texas, Arizona, New York, and Michigan, constitute over 70 percent of the harvested acreage and 80 percent of the total U.S. production and value of principal fresh market vegetables. Of these six, the first four produce winter vegetables, thereby inflating percentage domination of the market. California and Florida account for over 50 percent of the nation's fresh vegetable production. During spring, summer, and fall, many areas of the country have substantial acreages in vegetables, both for local and for long-distance marketing.

The trend toward increased farm size, begun after World War II, has persisted. In the major vegetable production areas, corporate purchases of agricultural enterprises, not only of substantial numbers of farming units but also of seed production and distribution enterprises, and other agricultural suppliers and services have provided the capital for rapid development and use of technology. Although bigness has dominated several sectors of the fresh market vegetable industry, the family farm also has thrived, especially in areas with substantial urban populations. Grower-operated roadside markets, pick-your-own systems, and farmer's markets, featuring fresh, high-quality produce, are especially appealing to those unable to enjoy such produce from a home garden. Such operations often are characterized by intensive cropping practices, including intercropping, succession cropping, high plant populations per acre, plastic mulching, and temperature modification to maximize income, particularly within restricted acreages.

### Processing Vegetables

Freezing, canning, and dehydration are the major mechanisms by which food is preserved. Growers who supply the raw product to processors do so through contracts that specify, among other conditions of production and sale, some of the production techniques, price per ton at a given level of quality, and standards for acceptance of the harvest (percentage weed seed, foreign matter). The price usually does not approach that of fresh produce in a free market, but the stability of price is attractive to many growers. Production of many processing crops is highly mechanized (Figure 1.2), and cultivars often reflect specific quality components dictated by the type of processing. Processing acreage has become concentrated predominantly in several states. California now accounts for almost 50 percent of the total volume of raw vegetables for processing, and of the four major processing crops, sweet corn, peas, snap beans, and tomatoes, Wisconsin, California, and Minnesota have the largest production (Table 1.2). The value has approximately doubled since 1969 (Table 1.3).

### Vegetable Forcing

The greenhouse industry has declined substantially over the past 30 years because of competition from winter production areas and because of high maintenance and energy

**TABLE 1.2**
**Commercial production of principal vegetable crops[a] in the United States by state: Annual average for the period 1981 to 1983**

| State | Fresh market[b] | | Processing[b,c] | | Total | |
|---|---|---|---|---|---|---|
| | Acres | Tons | Acres | Tons | Acres | Tons |
| Alabama | 8,250 | 26,350 | 1,300 | 2,690 | 9,550 | 29,040 |
| Arizona | 45,160 | 625,470 | — | — | 45,160 | 625,470 |
| Arkansas | 2,130 | 10,070 | 3,670 | 10,000 | 5,800 | 20,070 |
| California | 415,500 | 5,126,470 | 232,530 | 5,694,710 | 648,030 | 10,821,180 |
| Colorado | 16,700 | 223,250 | 1,390 | 15,740 | 18,090 | 238,990 |
| Connecticut | 3,600 | 11,750 | — | — | 3,600 | 11,750 |
| Delaware | — | — | 15,910 | 48,420 | 15,910 | 48,420 |
| Florida | 119,930 | 1,162,250 | 3,130 | 23,170 | 123,060 | 1,185,420 |
| Georgia | 2,100 | 9,870 | 930 | 1,750 | 3,030 | 11,620 |
| Hawaii | 900 | 9,400 | — | — | 990 | 9,400 |
| Idaho | 4,870 | 124,170 | 27,000 | 167,920 | 31,870 | 292,090 |
| Illinois | 3,730 | 15,320 | 58,970 | 254,270 | 62,700 | 269,590 |
| Indiana | 1,270 | 8,050 | 9,700 | 131,160 | 10,970 | 139,210 |
| Iowa | — | — | 4,890 | 28,850 | 4,890 | 28,850 |
| Louisiana | 360 | 1,970 | — | — | 36 | 1,970 |
| Maine | — | — | 8,540 | 11,230 | 8,540 | 11,230 |
| Maryland | 2,600 | 12,480 | 18,300 | 97,140 | 20,900 | 109,620 |
| Massachusetts | 9,060 | 43,800 | — | — | 9,060 | 43,800 |
| Michigan | 34,900 | 343,980 | 25,470 | 210,700 | 60,370 | 554,680 |
| Minnesota | 2,150 | 32,300 | 176,170 | 687,600 | 178,320 | 719,900 |
| Missouri | — | — | 610 | 2,090 | 610 | 2,090 |
| New Jersey | 19,880 | 115,020 | 12,770 | 109,790 | 32,650 | 224,810 |
| New Mexico | 8,500 | 124,150 | 200 | 2,310 | 8,700 | 126,460 |
| New York | 48,010 | 387,970 | 70,270 | 256,220 | 118,280 | 644,190 |
| North Carolina | 6,700 | 29,720 | 2,400 | 13,160 | 9,100 | 42,880 |
| Ohio | 19,290 | 105,600 | 17,490 | 343,630 | 36,780 | 449,230 |
| Oklahoma | — | — | 1,300 | 4,350 | 1,300 | 4,350 |
| Oregon | 17,900 | 323,000 | 100,100 | 529,390 | 118,000 | 852,390 |
| Pennsylvania | 19,470 | 69,370 | 16,070 | 108,660 | 35,540 | 178,030 |
| South Carolina | 7,300 | 67,920 | 300 | 410 | 7,600 | 68,330 |
| Tennessee | 4,270 | 24,570 | 6,470 | 15,360 | 10,740 | 39,930 |
| Texas | 64,100 | 522,020 | 4,570 | 22,660 | 68,680 | 544,680 |
| Utah | 2,000 | 34,620 | 3,240 | 12,500 | 5,240 | 47,120 |
| Virginia | 5,130 | 36,700 | 2,970 | 22,760 | 8,100 | 59,460 |
| Washington | 12,780 | 203,270 | 107,130 | 479,060 | 119,910 | 682,330 |
| West Virginia | — | — | 27 | 373 | 27 | 373 |
| Wisconsin | 6,310 | 120,170 | 268,300 | 907,740 | 274,610 | 1,027,910 |
| U.S. total | 915,000 | 9,951,000 | 1,202,133 | 10,215,800 | 2,117,133 | 20,166,800 |

*Source: Agricultural Statistics* (1984).

[a] Including broccoli, carrot, cauliflower, celery, sweet corn, honeydew melon, lettuce, onion, and tomato.

[b] Area for fresh market is area for harvest; area for processing is area harvested.

[c] Data for the following crops in all states: snap bean, sweet corn, green pea, and tomato. Other vegetables processed are included in fresh market data.

**TABLE 1.3**
**Area, production, and value of principal vegetable crops[a] in the United States, 1970 to 1984**

| | Area[b] (1000 acres) | | Production (1000 tons) | | Value[c] ($1000) | |
|---|---|---|---|---|---|---|
| | Fresh market | Processing | Fresh market | Processing | Fresh market | Processing |
| 1970 | 1,674 | 1,581 | 11,358 | 9,297 | 1,233,222 | 410,189 |
| 1971 | 1,610 | 1,558 | 11,361 | 9,923 | 1,438,946 | 439,980 |
| 1972 | 1,648 | 1,584 | 11,578 | 10,242 | 1,607,022 | 466,633 |
| 1973 | 1,637 | 1,727 | 11,907 | 10,662 | 1,857,859 | 550,632 |
| 1974 | 1,558 | 1,776 | 12,017 | 11,794 | 1,885,149 | 929,785 |
| 1975 | 1,542 | 1,874 | 11,994 | 13,533 | 2,159,168 | 1,036,635 |
| 1976 | 1,577 | 1,625 | 12,510 | 11,049 | 2,260,078 | 786,606 |
| 1977 | 1,579 | 1,638 | 12,741 | 12,612 | 2,351,737 | 945,180 |
| 1978 | 1,644 | 1,612 | 13,140 | 11,323 | 2,786,530 | 874,768 |
| 1979 | 1,637 | 1,652 | 13,422 | 12,576 | 2,919,656 | 1,030,239 |
| 1980 | 1,610 | 1,429 | 13,248 | 10,807 | 3,182,975 | 864,451 |
| 1981[d] | 865 | 1,166 | 9,643 | 9,222 | 2,613,119 | 746,130 |
| 1982 | 922 | 1,250 | 10,281 | 11,180 | 2,626,319 | 909,738 |
| 1983 | 928 | 1,190 | 9,930 | 10,246 | 2,804,157 | 791,843 |
| 1984 | 1,083 | 1,371 | 10,835 | 11,980 | 3,089,382 | 1,007,066 |

*Source: Agricultural Statistics* (1985), USDA.

[a] Fresh market data include artichoke, asparagus, lima bean, snap bean, beet, broccoli, brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, celery, sweet corn, cucumber, eggplant, escarole/endive, garlic, honeydew melon, kale, lettuce, onion, green pea, green pepper, shallot, spinach, tomato, and watermelon. Processing data include lima bean, beet, cabbage, sweet corn, cucumber, green pea, spinach, and tomato. Data for other vegetables processed included in fresh market estimates.

[b] Area for fresh market is for harvest; area for processing is area harvested.

[c] Value for all fresh market vegetables (except garlic) on f.o.b. basis; for processing vegetables, value at processing plant door.

[d] Beginning in 1981, statistics discontinued for the following crops: fresh market—artichoke, asparagus, snap bean, brussels sprouts, cabbage, cantaloupe, cucumber, eggplant, escarole/endive, garlic, green pepper, spinach, and watermelon; processing—lima bean, beet, cabbage, cucumber, spinach, and asparagus.

costs. However, greenhouse production has, at times, been a very significant segment of vegetable production, particularly in the eastern United States. It is not a new industry; transparent coverings were used in Roman times for cucumber production. Today, however, it is a highly intensive industry, focused largely on production of tomato, cucumber, and lettuce or on production of transplants for field or home use. Increases in fuel costs accelerated changes in greenhouse production in the 1970s. The glasshouses gradually are being replaced with those constructed of double-layered polyethylene (Figure 1.3) or rigid insulated plexiglass. Many utilize such technologies as nutrient film technique (soilless production using a shallow reservoir of complete nutrient solution) or sand-hydroponic culture and carbon dioxide enrichment to maximize yields per square foot. The quality of the greenhouse product must be high to meet competition from winter production areas and from imported produce and to justify the costs of production. An extension of greenhouse forcing, "factory" production, has developed in which the basic needs for plant growth are supplied automatically in controlled atmospheres under artificial light. Plant growth un-

der these conditions is rapid and uniform, but the cost of inputs, particularly of energy, can be substantial.

### Specialty Crops

In addition to standard production systems, there are specialties that can be profitable for careful and intelligent growers. These specialties include such enterprises as cellar forcing of rhubarb or witloof chicory, or mushroom culture. Proper environmental controls are critical to the success of any of these specialties. The market for such commodities is sufficiently strong to support a high price; however, many of the suppliers are well established, and gaining access to the market is difficult.

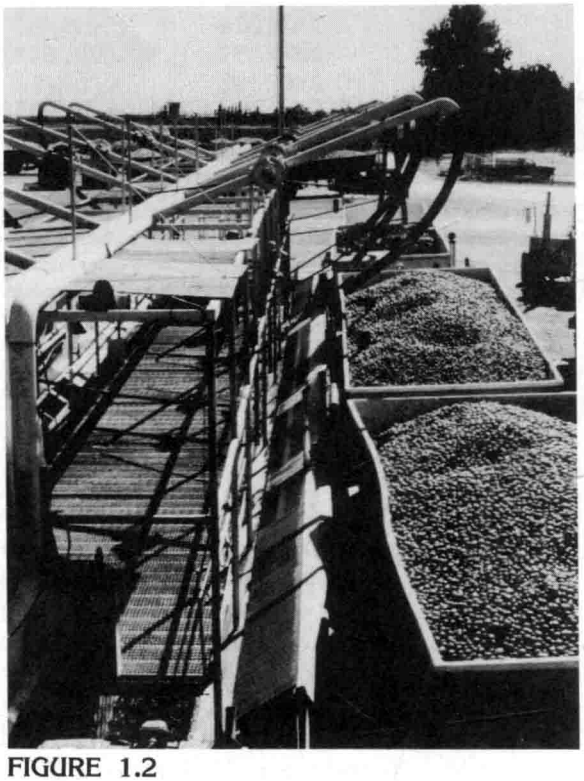


**FIGURE 1.2**
**Mechanically harvested tomatoes arriving at a processing plant. Water added to each car flushes the fruit into a sluice that conveys them to the plant. (Photo courtesy of University of New Hampshire.)**

**FIGURE 1.3**
**Typical twin-layer plastic greenhouse. Greenhouse vegetable production is confined largely to tomato, cucumber, and lettuce, mainly because of economic feasibility. (Photo courtesy of O. S. Wells, University of New Hampshire.)**

## TRENDS IN VEGETABLE PRODUCTION AND MARKETING

Only 3.1 percent of the U.S. population is directly responsible for our total agricultural production. This statistic largely reflects the mechanization and efficiency in growing feed and fiber crops and in handling livestock. Relative to these enterprises, vegetable production is substantially more labor intensive; yet the productivity of the average vegetable grower, through assimilation of new cultivars and production and marketing technology, has increased dramatically. Total production of vegetables has remained relatively stable since 1969, whereas acreage devoted to vegetable production has declined. Since the early 1950s, total acreage devoted to vegetable production has declined by 11 percent (Table 1.4). The increased production efficiency in the past 15 years has been focused largely on several major crops, most notably tomato, sweet corn, and lettuce. Prior to 1969, efficiency had been improved for beans, peas, and other easily mechanized crops.