Broccoli: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance

Prepared by the Economic Research Service, USDA
in cooperation with the University of California

for the Federal Crop Insurance Corporation

August 25, 1994

Contributors: Diane Bertelsen (202) 219-0887
Robert Dismukes (202) 219-0028
Joy Harwood (202) 501-8554
Fred Hoff (202) 219-1288
Hyunok Lee (916) 752-3508
John Love (202) 219-0388
Agapi Somwaru (202) 219-0812
Glenn Zepp, coordinator (202) 501-7703

Table of Contents

Executive Summary

The U.S. produced about 12 million cwt of broccoli annually between 1988 and 1993, of which 82 percent was destined for fresh-market use. Although the USDA reports acreage and production for only California, Arizona, Oregon, and Texas, broccoli is widely grown in the United States. The Census of Agriculture reported 46 states having farms with broccoli production in 1987, and ad hoc disaster assistance data indicate that payments were made for broccoli in 43 states between 1988 and 1993.

Broccoli is a relatively new vegetable for many Americans. The per capita use of fresh and frozen broccoli increased from an estimated 1.5 pounds (farm weight equivalent) in 1970 to 5.1 pounds in 1993. Per capita use has remained relatively constant or declined slightly since the peak per capita consumption of 6.2 pounds was reached in 1988.

Although broccoli prices follow a fairly well-defined seasonal pattern, they can vary substantially from month to month. They are generally lowest during May, June, and July, and highest during December. The lowest prices occur when supplies from central California are at a high level and states in the South, East, and Midwest are shipping broccoli. Prices rise throughout the Summer and Fall and usually peak during December.

The U.S. Census of Agriculture reported 2,821 farms with broccoli sales in 1987, an increase of more than 200 farms above the 1982 level. The relative stability in the number of farms, combined with a 25 percent increase in broccoli harvested acreage over that period, reflects the growing popularity of broccoli in the American diet.

Off-farm employment is not an important source of income diversification for farmers growing broccoli. According to the 1987 Census, more than three-fourths of the operators on farms growing broccoli reported that farming was their main occupation and over half reported no off-farm work in 1987. Of the 45 percent of the operators who reported at least one day of off-farm work, the majority operated small farms.

Broccoli is grown in at least one part of the U.S. at any given time of the year. California, for example, markets fresh broccoli throughout the year, and accounts for 90 percent of U.S. production. Arizona and Texas, also large broccoli-growing states, each produce during the Fall and Winter. Northern states, such as Oregon, Michigan, and Maine, produce for the fall market only. Some mid-latitude states, including Virginia and North Carolina, produce a spring crop and a fall crop, while several Midwestern states produce during the Summer and Fall.

Broccoli is a cool-season crop. Most cultivars produce the best-quality heads during cool weather, and only a few are productive at temperatures above 85° F. Broccoli grows best on well-drained soils with good moisture-holding capacity, with loams, clay loams, and muck soils ideal for production.

Broccoli is customarily direct-seeded in the field. However, young broccoli plants are increasingly transplanted in order for growers to harvest earlier in the season and to utilize land to the maximum. In California, for example, transplanting can cut at least 15 days off the field-growing period and allows some growers to harvest three crops per year.

Broccoli needs a steady moisture supply. The large leaves of the broccoli plant lose moisture at a fast rate, leading quickly to drought stress. The equivalent of 1 to 2 inches of rainfall per week is required for successful broccoli development. Nationally, 94 percent of U.S. broccoli harvested area was irrigated in 1987. Virtually all broccoli is irrigated in Arizona, California, and Texas; far less is irrigated in Michigan, New York, and Maine. Broccoli is normally ready for harvest 45 to 60 days after transplanting or 60 to 75 days after direct seeding. Broccoli is harvested by hand-cutting the heads from the stalk. Although mechanical harvesting is available, it is not used because the heads do not mature uniformly enough to cut all plants in one pass through the field. After the primary head has been cut from the plant, side shoots or secondary heads develop. These secondary heads are not usually harvested unless market prices are exceptionally high.

The natural perils that would be most likely to result in indemnities under a broccoli policy include excessive rain, excessive heat (which can cause heads to over-mature), extreme cold, and drought (in the generally non-irrigated Midwest and Eastern states). Growers generally report that they can cope with insect perils by following prudent pest management practices. Various diseases, particularly rots, can cause significant yield losses.

Ad hoc disaster data can be used to indicate which broccoli-producing areas received large payments relative to their acreage. NASS does not report broccoli acreage in Illinois and Wisconsin, although those states accounted for an average of 11 to 12 percent of U.S. ad hoc disaster payments made for broccoli between 1988 and 1993. Similarly, NASS data indicate that Texas accounted for a relatively large share of payments. In contrast, Arizona and California collected a small share of ad hoc payments.

Insurance issues addressed in this report include the setting of reference prices, estimating "appraised production," moral hazard, and the demand for insurance. Our research suggests that the demand for a broccoli policy would likely be higher in states in the Midwest and East, and in Texas, than in Arizona and California.

A limitation to offering broccoli insurance in the eastern states is the lack of sufficient acreage in any one county to justify offering a crop insurance policy. Except for Aroostook County in Maine and Cameron and Hidalgo counties in Texas, very few counties in the eastern states have 500 acres or more of broccoli. Most have less than 100 acres.

Broccoli: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance

Introduction

Broccoli belongs to the Cruciferae or mustard family and is commonly classified as a cole crop. It is a horticultural hybrid closely related to cauliflower (Nonnecke). Other closely-related vegetables include cabbage, brussels sprouts, kale, collards, kohlrabi, and Chinese cabbage.

Broccoli is classified as an annual that produces a large central head consisting of flower buds on a thick stem. The edible parts of the plant are the thick stalks and dark green clusters of unopened flower buds at the top of the plant.

Although broccoli is grown commercially in most states, the bulk of the production is located in California, Arizona, Oregon, and Texas. Ninety percent of U.S. production originated in California in 1993 (Table 1).

This report examines those aspects of the broccoli industry that relate to the demand for crop insurance and the feasibility of developing a broccoli policy. Many of the cultural practices and production perils relevant for broccoli are similar for cauliflower. However, there are enough differences in production locations, perils, and practices for the two crops that separate reports were deemed necessary.

The Broccoli Market

Supply

The United States produced about 12 million cwt (1.2 billion pounds) of broccoli annually between 1988 and 1993. Eighty-two percent of production went for fresh-market use. The remainder was processed, primarily as frozen product. Total U.S. broccoli production increased rapidly in the early- and mid-1980's, peaking at 13.5 million cwt in 1989. Output has dropped slightly since that time, however, due to a decline in harvested area.

Although the USDA reports acreage and production for only California, Arizona, Oregon, and Texas, broccoli is widely grown in the United States. The Census of Agriculture reported 46 states having farms with broccoli production in 1987, and ad hoc disaster assistance data indicate that payments were made for broccoli in 43 states between 1988 and 1993. However, less than 10 percent of U.S. acreage was outside the top five states--California, Texas, Arizona, Oregon, and Maine--according to the 1987 Census.

Imports of fresh and processed broccoli products provided 27 percent of the total U.S. supply in 1993. Almost all imports were frozen broccoli from Mexico (88 percent) and Guatemala (11 percent).

Table 1--U.S. broccoli acreage and production, 1988-93

State	1988	1989	1990	1991	1992	1993
			Acres harvested			
Fresh market and processing:						
Arizona	4,300	5,400	5,100	6,500	7,000	8,700
California	101,100	101,600	97,500	88,000	97,000	93,000
Oregon	2,800	3,100	3,100	3,100	3,200	2,200
Texas	6,200	6,700	5,100	3,400	4,200	3,300
U.S.	114,400	116,800	110,800	101,000	111,400	107,200
			1,000 Cwt production			
Fresh market and processing:						
Arizona	391	540	587	618	700	687
California	11,626	12,192	11,213	10,120	11,155	9,765
Oregon	260	285	264	248	256	189
Texas	515	496	281	204	336	158
U.S.	12,792	13,512	12,345	11,190	12,447	10,799
Fresh market:						
Arizona	391	540	587	618	700	687
California	9,166	9,792	9,113	8,560	9,625	8,515
Other	465	412	193	190	277	113
U.S.	10,022	10,744	9,893	9,368	10,602	9,315

Source: USDA, NASS.

The United States exported a quarter of its fresh-market broccoli production in 1993. Most exports went to Canada and Japan, but the United States also exports fresh broccoli to Korea, Mexico, the European Community, and other countries.

The long-term rise in U.S. broccoli production reflects producers' responses to growing consumer demand for broccoli. Of course, short-term variations in the quantity of fresh broccoli occasionally occur because of weather disruptions in major production areas. Examples include the hard December freezes in Texas in 1989 and in California in 1990.

Demand

Broccoli is a relatively new vegetable for many Americans. The per capita use of fresh and frozen broccoli increased from an estimated 1.5 pounds (farm weight equivalent) in 1970 to 5.1 pounds in 1993 (Tables 2 and 3). Per capita use has remained relatively constant or declined slightly since the peak per capita consumption of 6.2 pounds was reached in 1988.

Total U.S. broccoli use in 1993 was 1.3 billion pounds, up from 0.3 billion in 1970 (USDA, ERS). Between 55 and 60 percent of U.S. broccoli use in recent years has been in the fresh form and 40 to 45 percent has been processed, mostly into frozen product.

Consumer purchases of fresh broccoli are relatively uniform throughout the year. Fresh-market shipments peak during the Winter and early Spring, when most broccoli originates from the major producing states of California, Arizona, and Texas. Broccoli-growing areas in the East and Midwest ship during the Summer and Fall.[1]

The quantity of broccoli purchased by consumers is likely to be more price-sensitive than for certain other vegetables, such as celery or lettuce. Although broccoli is frequently consumed in combination with cauliflower, carrots, celery, and other vegetables, the largest quantity of fresh broccoli likely is served as a main vegetable dish. Consequently, a change in the price of broccoli has a greater effect on the total cost of a meal than a change in the price a vegetable such as lettuce, which is frequently used as a component in a salad or a sandwich. Consumers, therefore, are likely to place greater importance on price when purchasing broccoli than when purchasing a food such as lettuce.

One statistical study which examined the relationship between farm-level prices and quantities for fresh vegetables as a group shows prices rising (falling) about 2 percent for each one percent decline (increase) in quantity (Wohlgenant). In contrast, another study of the relationship between farm-level prices and quantities--this time, for lettuce--suggests that the price

[1] Shipment statistics are reported only for major broccoli-growing areas and for imports and do not, therefore, provide an accurate picture of total supply when the non-reported areas are marketing broccoli (USDA, AMS).

Table 2--U.S. fresh broccoli: Supply, utilization, and price, farm weight, 1970-94

	Supply			Utilization			
Year	Production 1/	Imports 2/	Total	Exports 2/	Total	Per capita use	Season average price 3/ Current dollars
							Constant 1987 dollars
	Million pounds					Pounds	$/cwt
1970	109.2	0.0	109.2	--	109.2	0.5	13.40	38.18
1971	149.6	0.0	149.6	--	149.6	0.7	14.80	40.00
1972	147.4	0.0	147.4	--	147.4	0.7	14.10	36.25
1973	160.7	0.0	160.7	--	160.7	0.8	15.70	38.01
1974	168.2	0.0	168.2	--	168.2	0.8	17.10	38.08
1975	213.9	0.0	213.9	--	213.9	1.0	17.40	35.37
1976	234.8	0.0	234.8	--	234.8	1.1	19.00	36.33
1977	270.3	0.0	270.3	--	270.3	1.2	19.70	35.24
1978	271.5	0.1	271.6	51.8	219.8	1.0	21.70	35.99
1979	329.7	0.6	330.3	60.3	270.0	1.2	22.20	33.84
1980	381.9	0.7	382.6	63.5	319.0	1.4	23.50	32.78
1981	453.1	0.9	454.0	73.0	380.9	1.7	26.30	33.33
1982	541.4	0.1	541.5	80.1	461.4	2.0	26.70	31.86
1983	558.2	0.3	558.5	82.7	475.8	2.0	28.20	32.34

1984	674.0	3.6	677.6	96.7	580.9	2.5	25.10	27.58
1985	715.4	4.5	719.9	104.9	614.9	2.6	24.20	25.64
1986	844.2	8.5	852.7	119.5	733.2	3.0	21.90	22.60
1987	855.9	22.7	878.6	128.9	749.7	3.1	21.90	21.90
1988	1,002.2	36.0	1,038.2	113.5	924.7	3.8	24.00	23.10
1989	1,074.4	27.8	1,102.2	161.2	941.0	3.8	21.00	19.35
1990	989.3	21.3	1,010.6	168.1	842.4	3.4	22.30	19.68
1991	936.8	20.1	956.9	185.6	771.3	3.1	22.00	18.69
1992	1,060.2	20.7	1,080.9	203.4	877.5	3.4	23.50	19.41
1993	931.5	31.8	963.3	232.9	730.4	2.8	26.90	21.66
1994f	980.0	24.9	1,004.9	207.6	797.3	3.1	--	--

-- = Not available. f = ERS forecast.

1/ Source: USDA, National Agricultural Statistics Service. Production was adjusted by ERS for 1970-81 to account for States not included in NASS estimates. 2/ Source: U.S. Dept. of Commerce, Bureau of the Census. From 1978-89, U.S. exports were adjusted using Canadian import data.

3/ Constant dollar prices were calculated using the GDP implicit price deflator, 1987=100.

Table 3--U.S. broccoli for processing: Supply, utilization, and price, farm weight, 1970-94

Year	Supply				Utilization			Season average price 3/	
	Production	Imports	Beginning stocks 1/	Total	Exports 2/	Ending stocks 1/	Total	Per capita use	Current dollars 1/	Constant 1987 dollars 1/
	Million pounds							Pounds	$/ton	
1970	216.1	--	51.5	267.6	--	63.4	204.2	1.0	161.00	458.69
1971	188.5	--	63.4	251.9	--	63.8	188.1	0.9	176.00	475.68
1972	226.9	--	63.8	290.7	--	86.8	203.9	1.0	176.00	452.44
1973	200.5	--	86.8	287.3	--	74.5	212.8	1.0	189.00	457.63
1974	234.3	11.8	74.5	320.6	--	95.9	224.6	1.1	245.00	545.66
1975	190.5	10.7	95.9	297.1	--	80.0	217.1	1.0	253.00	514.23
1976	205.5	8.0	80.0	293.6	--	51.7	241.8	1.1	250.00	478.01
1977	312.2	14.1	51.7	378.0	--	109.3	268.7	1.2	270.00	483.01
1978	275.2	20.6	109.3	405.1	--	94.5	310.6	1.4	293.00	485.90
1979	304.6	20.6	94.5	419.7	--	103.3	316.3	1.4	319.00	486.28
1980	295.8	30.1	103.3	429.2	--	99.2	330.1	1.4	374.00	521.62
1981	300.5	39.2	99.2	438.8	--	84.1	354.7	1.5	376.00	476.55
1982	340.4	42.4	84.1	466.9	--	107.2	359.7	1.5	390.00	465.39

1983	274.4	44.6	107.2	426.2	--	70.8	355.4	1.5
385.00	441.51							
1984	354.2	87.0	70.8	512.0	--	92.7	419.2	1.8
389.00	427.47							
1985	347.3	102.6	92.7	542.7	--	79.4	463.3	1.9
382.00	404.66							
1986	308.7	155.8	79.4	543.9	--	140.6	403.3	1.7
357.00	368.42							
1987	291.1	259.1	140.6	690.7	--	152.7	538.0	2.2
353.00	353.00							
1988	277.0	236.9	152.7	666.6	--	74.7	591.9	2.4
374.00	359.96							
1989	276.9	325.8	74.7	677.4	--	141.0	536.4	2.2
365.00	336.41							
1990	245.2	322.6	141.0	708.8	--	150.3	558.5	2.2
390.00	344.22							
1991	182.2	355.8	150.3	688.3	--	117.4	570.9	2.3
391.00	332.20							
1992	184.6	501.0	117.4	803.0	--	190.8	612.2	2.4
386.00	318.74							
1993	148.4	442.9	190.8	782.1	--	180.0	602.1	2.3
386.00	310.79							
1994f	170.0	429.3	180.0	779.4	--	184.9	594.4	2.3
--	--							

-- = Not available. f = ERS forecast.

1/ Source: USDA, National Agricultural Statistics Service. 2/ Source: U.S. Dept. of Commerce, Bureau of the Census. All product weight data was converted to a fresh basis using a factor of 1.33. 3/ Constant dollar prices were calculated using the GDP implicit price deflator, 1987=100.

of lettuce may change as much as ten percent for each one percent change in quantity (George and King). Because broccoli is frequently used as a main dish rather than in combination with other foods--such as lettuce is frequently used--its price-quantity relationship is probably more like the estimate for all fresh vegetables than the estimate for lettuce.

Prices

Month-to-month changes in broccoli prices are very substantial and create significant price risk, especially for producers of fresh-market broccoli (Figure 1). An exceptional example of month-to-month variation occurred in 1991, when the average grower price rose from $3.13 a carton in February to $11.45 in March. The unusually high prices in March were due to a supply shortfall in central California, where a severe freeze in December 1990 destroyed much of the broccoli intended for harvest the following March. When March arrived, production had declined seasonally in Arizona and the Imperial Valley, while the seasonal increase in output from the central California areas was much smaller than typical.

Broccoli prices follow a fairly well-defined seasonal pattern. They are lowest during May, June, and July, and highest during December (Figure 2 and Table 4). The lowest prices occur when supplies from central California are still at a relatively high level and states in the South, East, and Midwest are shipping broccoli. Prices rise throughout the Summer and Fall and usually peak during December, when the bulk of broccoli production is shifting from central California to the winter areas in the Arizona and southern California deserts, and production has declined in the East. Prices usually decline during January and February when the desert areas are in full production, but peak again in March when supplies from Arizona and southern California decline, and central California has not yet reached full output.

Industry Characteristics

Some of the more salient aspects of the broccoli industry which are significant in assessing the demand for crop insurance include:

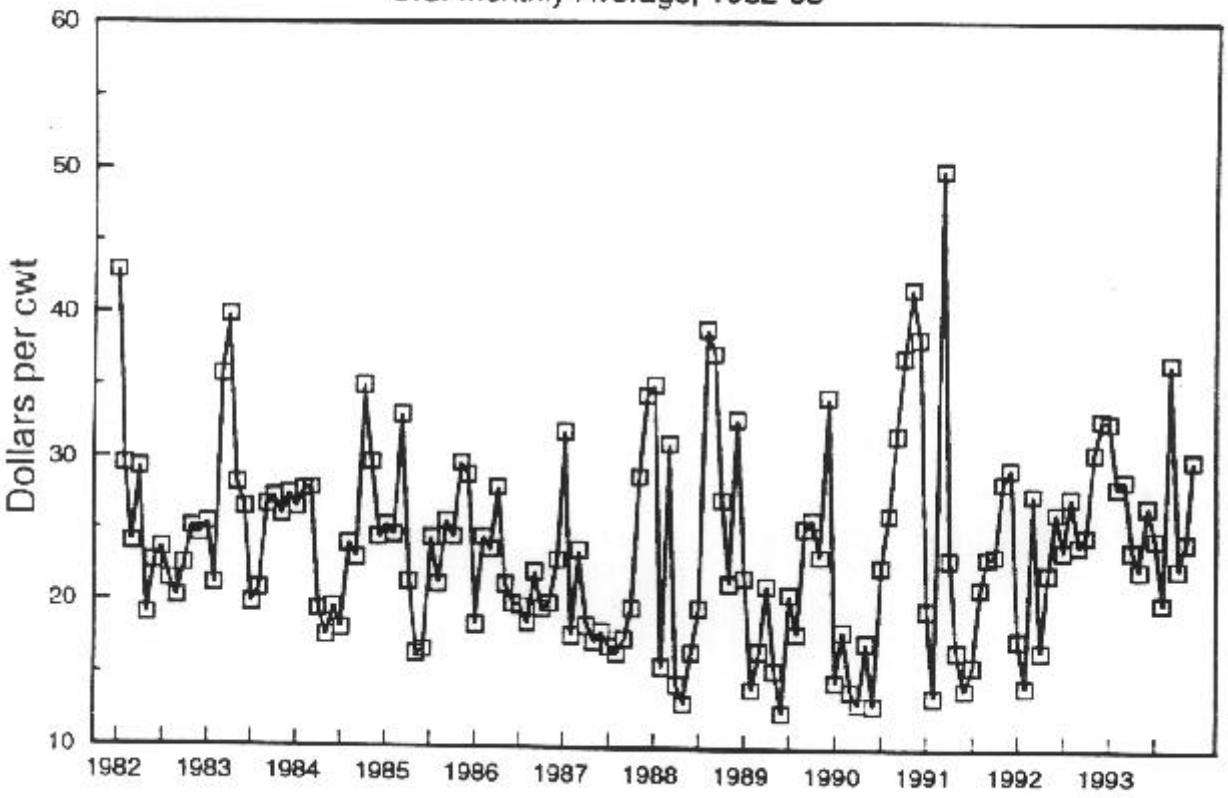
- Off-farm income is not an important source of diversification for farms with broccoli. More than three-fourths of the operators on farms growing broccoli reported to the Census that farming was their main occupation in 1987, and over half reported no off-farm work.

- Irrigation is used widely, especially in the major growing areas of Arizona, California, Oregon, and Texas, reducing the risk of drought. A relatively large share of broccoli acreage is also irrigated in the more humid areas of the country.

- Many broccoli producers are well-diversified between broccoli and other crops, especially other vegetable crops, helping growers manage price-related and weather-related risks.

Figure 1--Broccoli: Grower Prices,

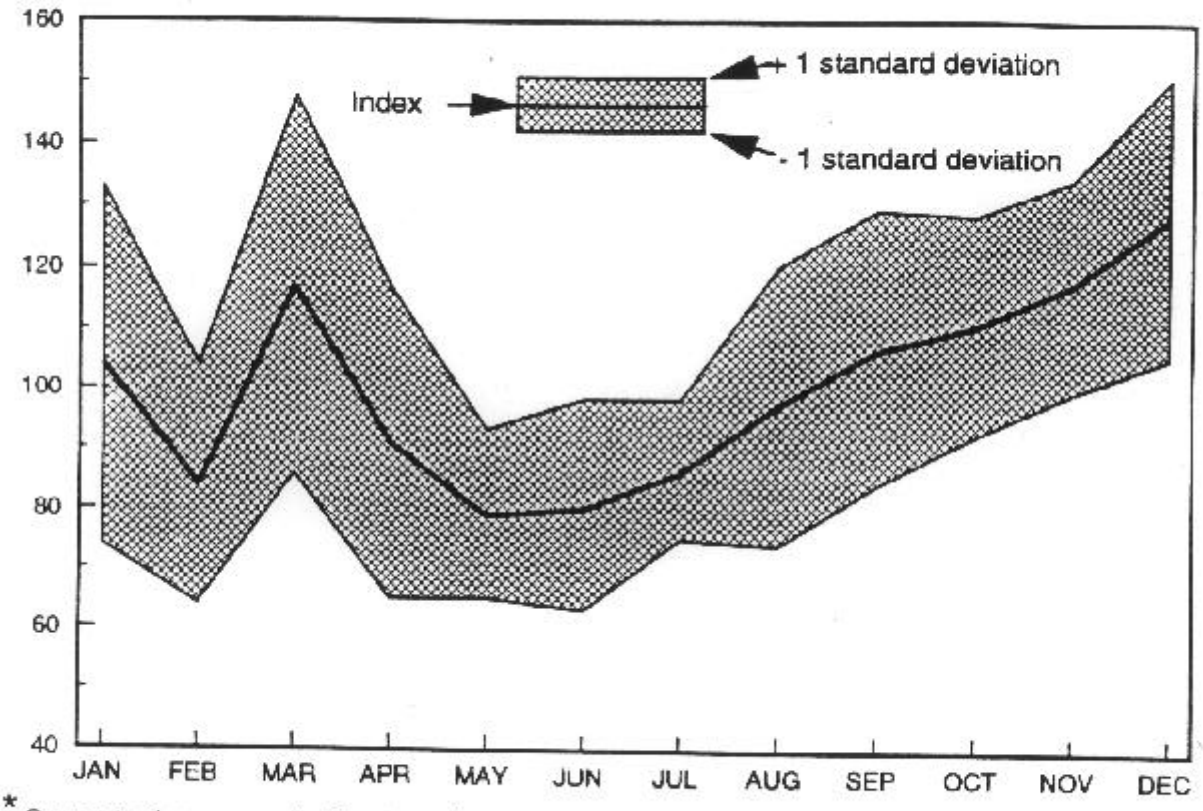
U.S. Monthly Average, 1982-93



Source: USDA, NASS.

Figure 2--Broccoli: Grower Prices

Average Seasonal Price Index, 1981-92*



* Current price, percent of centered 12-month moving average

Source: USDA, NASS.

Table 4--Broccoli: U.S. f.o.b. prices, monthly averages, 1989-93

Month	1989	1990	1991	1992	1993
	--------Dollars per 23-pound carton-------				
January	4.99	3.36	4.49	4.03	7.50
February	3.24	4.16	3.13	3.29	6.46
March	3.84	3.22	11.45	6.35	6.58
April	4.88	3.01	5.29	3.84	5.45
May	3.54	3.98	3.84	5.06	5.13
June	2.88	2.99	3.24	6.05	6.16
July	4.74	5.18	3.61	5.43	5.64
August	4.12	6.00	4.83	6.30	4.60
September	5.80	7.29	5.31	5.52	8.42
October	5.93	8.51	5.36	5.68	5.15
November	5.34	9.59	6.53	7.02	5.57
December	7.89	8.79	6.76	7.54	6.90

Source: Computed from USDA, NASS.

The primary source of available information on farms producing broccoli is USDA's 1992 Chemical Use Survey and the 1987 Census of Agriculture.[2]

Farms with Broccoli

The U.S. Census of Agriculture reported 2,821 farms with broccoli sales in 1987, an increase of more than 200 farms above the 1982 level (Appendix table 1). The relative stability in the number of farms, combined with a 25 percent increase in broccoli harvested acreage over that period, reflects the growing popularity of broccoli in the American diet.

Virtually all of the broccoli in Arizona, California, Oregon, and Texas was irrigated in 1987. Nationwide, nearly 94 percent of the broccoli acreage was irrigated in that year.

Except in Arizona, California, Oregon, and Texas, the largest share of farms with broccoli are relatively small operations, with less than $100,000 in crop sales (Appendix table 2). Many of the smaller farms with broccoli appear to grow a mixture of vegetables and sell primarily in local and regional markets.

Seventy-one percent of farms with broccoli were either individual- or family-owned operations in 1987 (Appendix table 3). Among the larger farms (those with $500,000 or more in sales), however, a partnership or corporate arrangement was the most common organizational structure. Many of the larger farms are located in California. In that state, 57 percent of the farms with broccoli had sales of $500,000 or more, and more than three-quarters of those farms were classified as partnerships or had a corporate ownership arrangement.

Income Diversification on Farms with Broccoli

Off-farm employment is not an important source of income diversification for farmers growing broccoli. More than three-fourths of the operators on farms growing broccoli reported that farming was their main occupation and over half reported no off-farm work in 1987 (Appendix table 4). Of the 45 percent of the operators who reported at least one day of off-farm work, the majority operated small farms. As evidence, more than three-quarters of those with off-farm work operated farms with $50,000 or less in crop sales.

Income from other crops, especially other vegetables, is a major source of revenue on farms with broccoli, accounting for the bulk of farm receipts. Of the $1,046 million in market sales reported by the Census for farms growing broccoli in Arizona, California, Oregon, and Texas in 1987, $794 million was from the sale of vegetables (including broccoli) and melons (Table 5). The USDA's Crop Reporting Board estimated the value of broccoli production in

[2] Results for the 1992 Census of Agriculture were not available for all states, most notably for Arizona, California, and Texas, at the time this report was prepared. Consequently, reference is sometimes made to the 1992 Census and sometimes to the 1987 Census.

Table 5--Market value of sales on farms producing broccoli, selected states, 1987

State	All Products	All Crops	Vegetables & melons	Broccoli	Broccoli, % of all products
	----------Million dollars----------				Percent
Arizona	63.6	62.9	47.9	8.3	13
California	841.6	835.7	631.7	212.6	25
Oregon	30.7	30.4	21.1	6.1	20
Texas	109.8	106.7	94.2	12.5	11
Four states	1,045.7	1,035.7	793.9	239.5	23

Sources: All data are from the 1987 Census of Agriculture, except for broccoli sales, which are from USDA, NASS, *Vegetables*.

these states at $240 million, or 23 percent of total sales reported by the Census. The greatest specialization was in California, where broccoli sales accounted for about one-quarter of the sales on farms with broccoli.

Vegetable acreage reported by growers in a 1992 survey of chemical use also indicates a greater amount of specialization among California broccoli growers than in other states. More than one-third of the total vegetable acreage on survey farms with broccoli in California was planted with broccoli (Table 6). Broccoli accounted for a substantially smaller percentage of the vegetable acreage in Arizona, Oregon, and Texas.

Cultivation and Management Practices

Broccoli is grown in at least one part of the U.S. at any given time of the year. California, for example, markets fresh broccoli throughout the year. Arizona and Texas each produce during the Fall and Winter. Northern states, such as Oregon, Michigan, and Maine, produce for the fall market only. Some mid-latitude states, including Virginia and North Carolina, produce a spring crop and a fall crop, while several Midwestern states produce during the Summer and Fall.

Climate

Broccoli is a cool-season crop. Most cultivars produce the best-quality heads during cool weather, and only a few are productive at temperatures above 85° F. Broccoli grows well at 70-80° F, although heads tend to soften and over-mature at temperatures above 80° F. Broccoli seeds germinate at as low as 40° F. However, germination is most successful at 70-75° F.

Soil Requirements

Broccoli grows best on well-drained soils with good moisture-holding capacity. Loams, clay loams, and muck soils are ideal for broccoli production, but lighter soils, if managed carefully, can also produce good crops. Excellent broccoli crops have been produced on soils ranging from dune sand to silty clay (University of California, 1993). Broccoli has greater salt tolerance than certain other cool-weather crops, such as lettuce.

Varieties

Most American-grown broccoli is the Italian type called Calabrese.[3] Popular varieties include Atlantic, Coastal, DeCicco, Green Sprouting Medium, Green Sprouting Late, Waltham 29, Spartan Early, Green Comet, Pirate, Emperor, Green Belt, and Green Duke. New cultivars are bred for disease resistance, heat tolerance, adaptability to freezing manufacture, and uniform growth. The latter is particularly important in reducing harvesting costs.

[3] Broccoli raab--or rappini--is a branching-type broccoli grown in small quantities in the United States.

Table 6--Enterprise diversification on farms growing broccoli, 1992

State	Farms sampled	Broccoli farms growing other vegetables	Broccoli, percent of total vegetable acreage
	---Number---	---Percent---	---Percent---
Arizona	16	100	10
California	132	92	35
Oregon	34	97	16
Texas	29	100	20

Source: USDA, *1992 Vegetable Chemical Use Survey*.

Planting

Planting dates are usually used as reference points in specifying insurance sign-up dates and policy closing dates. The planting and harvesting dates for broccoli in the U.S. depend largely on the location of production and the season of the year. Broccoli crops are harvested in the U.S. in the Winter, Spring, Summer, and Fall, depending on the location (Table 7).

Broccoli is customarily direct-seeded in the field. However, young broccoli plants may be transplanted in order for growers to harvest earlier in the season and to utilize land to the maximum. In California, for example, transplanting can cut at least 15 days off the field-growing period and allows some growers in the Santa Maria area to harvest three crops per year (Laemmlen).

For direct-seeding, precision planters are used to sow seeds at a depth of 1/8-1/4 inches on double-row, 42-inch beds. Precise sizing of seed is particularly important with direct-seeding in order to assure uniform growth. A smoother seedbed is prepared for direct-seeding than for transplant-planting to ensure uniform germination. Broccoli normally germinates and emerges easily from a well prepared soil unless driving rains cause the soil's surface to form a hard crust. When preparing a field for transplant-planting, a slightly rough surface helps reduce sand movement and blasting (damage caused by wind-blown sand) of the transplants.

Fertilization

Broccoli requires careful nutrient management to obtain good quality and maximum yields. Broccoli grows best when the soil pH is between 6.2 to 6.8 on mineral soils, and at 5.5 or higher on organic soils. Calcium intake is reduced in soils with a pH below 6.0, and young broccoli plants growing at a low pH often have poorly developed leaves with tipburn (the leaves have dead margins at the edge), especially during cool weather. Lime is applied to raise the pH to the desired level.

Broccoli requires moderate-to-large amounts of nitrogen (N), phosphorus (P), and potassium (K). For good nutrient management, soils should test for phosphate (P_2O_5) at 150 to 200 pounds per acre and for potash (K_2O) at 300 to 350 pounds per acre. Total nitrogen rates will vary with the cultivar, but all require at least 150 pounds N applied per acre per year. The nitrogen can be applied at 60 pounds preplant, with additional N applied at two 3-week intervals after initial growth begins. A minimum 120 pounds of phosphate and 120 pounds of potash are recommended annually, all applied as a preplant treatment.

Broccoli is very sensitive to boron deficiency, which can cause hollow stems and lead to browning of the florets. Most forms of boron are very soluble and leach from the soil rapidly. To avoid a deficiency, 3 to 4 pounds of boron per acre can be incorporated into the soil before planting. Boron requirements can be met by applying, during soil preparation, 30 to 40 pounds

Table 7--Usual planting and harvesting dates for broccoli

State	Planting date	Usual harvest date		
		Begin	Most active	End
Winter--				
Arizona	Sep. 15-Oct. 15	Jan. 1	Jan. 1-Feb 28	Mar. 20
California	See Table in California state analysis section.			
Texas	Oct. 1-Dec. 15	Jan. 1	Jan. 1-Feb. 28	Apr. 15
Spring--				
California	See Table in California state analysis section.			
Summer--				
California	See Table in California state analysis section.			
Oregon	May 1-July 31	July 15	Oct. 1-Nov. 31	Dec. 31
Fall--				
Arizona	Aug. 5-Sep. 15	Nov. 1	Dec. 1-Dec. 31	Dec. 31
California	See Table in California state analysis section.			
Texas	Aug. 15-Sep. 30	Nov. 15	Dec. 1-Dec. 15	Dec. 31

Source: USDA, Statistical Reporting Service.

Note: Dates reported in this table may differ slightly from those reported in the "State Analyses" section. Dates in that section largely reflect personal communication with extension specialists and ASCS county executive directors and may be more location-specific than the dates in this table.

of borax per acre mixed with the fertilizer. Alternatively, 15 to 20 pounds of a soluble form can be sprayed on the soil with the herbicide. Additional boron can be applied during the season, as needed, in a foliar spray.

Other nutrients required for proper broccoli development include calcium, magnesium, manganese, and molybdenum. Manganese and magnesium deficiencies cause the older leaves to lose their green color. Nutrient problems may occur at various soil pH levels. Manganese deficiency frequently occurs at soil pH levels of 7.0 and above, while at a pH below 5.5, manganese toxicity is a potential problem.

Irrigation

Broccoli needs a steady water supply. The large leaves of the broccoli plant lose moisture at a fast rate, leading quickly to drought stress, which reduces yields. The equivalent of 1 to 2 inches of rainfall per week, depending on plant size, stage of growth, air temperature, and soil type, is required for successful broccoli development.

Nationally, 94 percent of U.S. broccoli harvested area was irrigated in 1987 (1987 Census). Virtually all broccoli is irrigated in Arizona, California, and Texas. In contrast, about 60 percent of the harvested broccoli acreage was irrigated in Michigan and New York, and only 2 percent in Maine. Normally, broccoli is irrigated 6-10 times per season in California, depending on the time of year and the location.

Broccoli, however, is sensitive to waterlogged soil and if the roots are under water for an extended period, plants will die. Consequently, well-drained soils are preferable for dependable broccoli production.

Harvesting

Broccoli is normally ready for harvest 45 to 60 days after transplanting or 60 to 75 days after direct seeding, although the exact timing depends on the location and the time of year. For example, California broccoli is ready for harvest about 60 days after planting in the Summer and 80-110 days in the Winter. Preventing over-maturity, which occurs when the flower buds begin to open, is a major problem, especially during periods of warmer weather. Hybrid cultivars mature very uniformly and most heads in a planting can be harvested within 7 days with two passes through the field. Some older cultivars may require 3 or 4 harvests to cut 90 percent of the primary or main heads.

Broccoli is harvested by hand-cutting the heads from the stalk. Although mechanical harvesting is available, it is not used because the heads do not mature uniformly enough to cut all plants in one pass through the field. Heads are cut when they reach 3 to 6 inches in diameter and are of uniform color. The broccoli heads and a portion of the stem are cut at a length measuring 8 to 10 inches from the top of the head to the bottom of the stem. Leaves attached to the stem are stripped off at the time the head is cut.

After the primary head has been cut from the plant, side shoots or secondary heads develop. These secondary heads are not usually harvested unless market prices are exceptionally high. The size of the primary head is directly related to plant spacing--the closer the spacing, the smaller the heads.

Packing and Shipping Fresh Broccoli

After cutting, broccoli heads are field-packed into cartons or they may be placed in bulk bins and taken to a shed for packing. In packing, the broccoli heads are bunched (2-4 heads are trimmed to 6-8 inch lengths and secured by a rubber band), placed in 26-pound waxed-fiberboard cartons containing 14 or 18 bunches, and cooled to removed field heat.

A small amount of broccoli is sold as "florets" (or bud clusters), which are loose-packed in mesh bags. Some broccoli also is sold as "crown cut." For crown-cut broccoli, the top dome is cut from the stem at a 3-inch length rather than at 6-8 inches. This form is considered a premium cut, and commands a higher market price than regular-cut broccoli.

Although the total volume of crown cuts is still small, the crown-cut share of the fresh market is increasing. Crown-cut broccoli is supplied to domestic markets as well as exported to Japan. Crown cuts are more perishable than regular-cut broccoli and packaging may be required. Crown-cut broccoli is a form of "fresh processed" broccoli.

Broccoli florets are another form of fresh processed broccoli gaining in market share. Florets may be mixed with other fresh-cut vegetables, such as cauliflower and carrots.

Cut broccoli requires rapid cooling after harvest. Broccoli respires at a relatively high rate because the cut florets are immature flowers. High respiration is associated with high perishability. Cut broccoli florets, after a short time, will lose their green color and decay rapidly if not cooled quickly.

Liquid-icing is the standard cooling method. This process involves injecting an ice-water slush into the waxed cartons, providing immediate cooling of the product. The iced broccoli is then placed immediately in refrigerated storage. If broccoli is kept at 32^{o} F and 95 percent relative humidity, it can be stored for up to 2 weeks. Harvesting early in the morning, before field heat accumulates in the heads, helps maintain the best quality.

Broccoli is transported to wholesale and retail markets mainly by truck. In 1993, 91 percent of the broccoli shipped from major domestic suppliers went directly by truck and 9 percent went by piggyback rail. Piggyback rail transport involves truck semi-trailers loaded onto flatbed rail cars. Because of broccoli's high perishability, low-temperatures must be maintained during transportation and retail display.

Marketing

Most fresh-market broccoli is grown under a contractual arrangement between the grower and the fresh-market packer. With fresh-market broccoli, the packer typically furnishes seed and advances operating capital to the grower. The packer specifies planting dates, which effectively schedule the timing of harvest. Such scheduling assures the packer a supply of raw material to meet expected consumer demand. Although contracting remains the principal method for coordinating supply with packers' needs, one source indicated that some growers in California were operating without formal agreements, which gave them greater flexibility in selecting their markets.

Contract production is also the customary practice for processed broccoli, and involves an arrangement between the grower and a processor. Processors need a relatively constant supply of raw material to fully utilize their plants. However, growers sometimes are allowed to switch broccoli between the fresh and processing markets if the price differential between fresh and processing broccoli warrants the switch.

Costs of Production

Variable harvesting and marketing expenses account for over half of the total costs of producing fresh-market broccoli in Texas and in Imperial County, California (Table 8).[4] Although variable harvesting costs are a smaller proportion of total costs in Michigan, they may also be a major consideration in growers' harvesting decisions. Packing and selling constitute the largest share of total harvesting and marketing costs for fresh broccoli in all states.

For processing broccoli, harvesting and marketing expenses play less of a role in growers' harvesting decisions. Since processing broccoli involves minimal packing and selling expenses, variable harvesting and marketing expenses account for a smaller share of total costs than for fresh-market broccoli. In Oregon, variable harvesting and marketing expenses for processing broccoli accounted for about 28 percent of total costs in 1988.

As with other fresh-market vegetables, the market price for broccoli may play a role in growers' harvesting decisions and, thereby, affect yields. If market prices fall below expected variable harvesting and marketing expenses, growers may find it more profitable to abandon a portion of their harvestable production than to sell at less that the cost of harvesting and marketing.

Relatively low prices, therefore, may result in the grower cutting fewer times, reducing planted-acre yields to a lower level than if prices were higher. On the other hand, if prices are relatively high, growers may try to increase their yields by caring for the plants after the primary harvest and cutting side shoots and secondary heads.

---

[4] Detailed cost of production budgets are presented in Appendix table 6.

Table 8--Broccoli: Variable harvesting costs, selected states [1]

State	Yield	Variable harvest cost	Total cost	Variable harvest percent of total
	Pounds	$/acre		Percent
Fresh market:				
Imperial county, California	12,500	1,700	2,945	58
Michigan	7,000	1,303	2,887	45
Texas	10,000	1,905	2,693	71
Processing:				
Oregon	9,000	328	1,175	28

[1] Costs may not be comparable among states because budgets may be for different seasons and may not include the same cost items. California, Michigan, and Texas estimates are for fresh-market broccoli. Estimates for Oregon are for broccoli for processing.

Sources: Cross et.al.; Dainello, 1993; Shapley et. al., 1986; and University of California, 1993.

Production Perils

The natural perils that would be most likely to result in indemnities under a broccoli policy include excessive rain, excessive heat (which can cause heads to over-mature), extreme cold, and drought (in the generally non-irrigated Midwest and Eastern states). Growers generally report that they can cope with insect perils by following prudent pest management practices. Various diseases, particularly rots, can cause yield losses.

Excessive Rain

The roots of broccoli, like other vegetable plants, need free oxygen in order to breathe and to take up water. Broccoli plants will die if the soil becomes saturated for a period of time. If flooding is so severe that the broccoli head is submerged, rot-causing pathogens can become established, causing reduced yields or complete crop losses.

Heavy rains following direct-seeded planting were reported as a production peril in some areas. Heavy rains can wash away newly-planted seeds. In addition, heavy rains followed by sunny weather cause some soils, especially those with a high clay content, to form a hard surface (crust) which the seedlings cannot penetrate. Growers may have to replant in such situations, thereby losing their initial investment in seed and other planting expenses.

Excessive Heat

Excessively high temperatures can cause rapid growth in the broccoli plant, which results in "fragmenting" of the head. Fragmenting refers to the situation where the heads develop loosely, with spaces between the individual florets, rather than in a tight or compact manner. Excessive heat can also cause bolting, where the flower buds open and the plant begins its seed production phase. "Leafy head" is another condition caused by excessive heat, and is associated with the growth of small leaves from the surface of the head. Fragmenting, bolting, and leafy head all lower the quality of the broccoli and can cause it to be unsalable.

When accompanied by high humidity, excessive heat increases the incidence of bacterial soft rot. Bacterial soft rot was identified as the most serious broccoli disease in Oregon (Mansour, personal communication).

Excessive Cold

Broccoli can withstand a hard freeze (to as low as 25^{o} F) if the plant has had a period of relative cold prior to the freeze. Freezing temperatures, however, can kill broccoli if the cold temperatures follow a relatively warm period.

High Winds

High winds, such as those accompanying severe thunderstorms and hurricanes, may cause broccoli plants to lodge (topple to the ground), exposing the leaves and perhaps the broccoli head to the soil. Exposure to the soil increases the opportunity for decay pathogens to become established, which may lead to subsequent yield loss. Lodging is particularly serious when excessive rain accompanies high winds. This is because the soil becomes saturated, weakening the plant's anchoring and causing it to topple more easily.

Drought

Broccoli has large leaves and requires a relatively constant supply of water, especially during periods of warm temperatures. Most broccoli in the major production areas is grown on irrigated soils, so that drought is not a serious production peril. Some broccoli is also grown with irrigation in the South, East, and Midwest. For non-irrigated broccoli in these areas, however, extended periods of dry weather can stunt plant growth and reduce yields. Drought was the major source of crop loss throughout the Midwest in 1988.

Hail

Hail damage to broccoli heads can create wounds, which act as an entry way for rot-causing pathogens. Pathogens are pervasive in broccoli fields, and any wound, such as a nick or cut from falling hail, acts as an entry point for rots. Severe hail, of course, can physically destroy a broccoli plant.

Weeds

Excessive weed growth can reduce broccoli yields by competing for sunlight and water. Weeds also can host several disease organisms that infect broccoli.

Growers are advised to cultivate as often as necessary to control weeds when they are small. An alternative weed control practice is to develop a "stale" seedbed. This involves one of two methods. The first involves controlling the first flush of emerged weeds with herbicides. The second involves flaming (burning the weeds), either before planting or before emergence of the seedlings, followed by minimal soil disturbance. Minimizing soil disturbance reduces the number of weed seeds exposed to favorable germinating conditions and diminishes weed growth.

Insects

Broccoli is susceptible to the same pests that attack cabbage, namely aphids, cabbage maggots, caterpillars (cabbage worms and cabbage loopers), cutworms, flea beetles, thrips, and whiteflies. Insect control is more difficult for broccoli than for cabbage because the compound broccoli head provides partial protection from insecticide applications and is an ideal place for insects to escape detection. Insects can damage the leaves, roots, stems, and head of the broccoli plant.

Aphids

Aphids weaken the broccoli plant by sucking plant juices and are considered a food adulterant if contained in processed broccoli. Aphids also transmit viral diseases among plants. Control consists of applying insecticides starting with the first appearance of aphids and continuing at regular intervals if aphids reappear.

Cabbage maggots

Cabbage maggots are the larvae of small flies that resemble houseflies. The flies lay eggs on young plants or on weeds around the plants. These eggs hatch in several days and the maggots chew the stems and bore into the roots and lower part of the stalks. Young plants that are invaded by maggots usually wilt and die.

Caterpillars

Caterpillars attack broccoli by eating the leaves and buds and tunnelling into the heads of older plants. The most destructive species are the cabbage looper and the cabbage worm. Insecticides are used for control.

Cutworms

Cutworms damage young broccoli plants by feeding on the stem, sometimes severing the plant from its roots. Insecticides are used for cutworm control.

Flea beetles

Flea beetles are small, shiny, steel-blue, jumping insects that eat round holes in the leaves. They are most serious among young broccoli, but can be controlled with insecticides.

Whiteflies

Sweetpotato whiteflies have recently caused substantial damage to broccoli seedlings in the southern part of California. They sap strength from the plant and slow growth. Whitefly damage delays maturity of the crop by 2-3 weeks, causing growers to miss targeted market opportunities.

Nematodes

Broccoli hosts the sugarbeet cyst nematode and should not be planted after sugarbeets. In addition, broccoli should not be planted in the same field for more than three consecutive years due to the potential for infestation by sugarbeet cyst nematode.

Diseases

Club root

Club root, a fungal disease, causes broccoli roots to enlarge and form spindle-shaped galls or "clubs." The growth of the clubs inhibits development of a normal root system and blocks vascular activity. Infected plants eventually die, or may survive in a stunted condition.

Club root incidence can be reduced by using uninfected transplants and by avoiding movement of machinery from infected areas to clean fields. Raising the soil pH by the application of lime also assists in control. Crop rotation is not very effective because resting club root spores can survive in the soil for many years.

Black Rot

Black rot is caused by a bacteria that overwinters on crop debris, although infections most often develop from infected seed. Infected young plants usually wilt and die. Black rot infections in older plants cause stunting and small heads. The development of the disease is accelerated by warm temperatures (in the 80-86^{o} F range) and high humidity.

Control of black rot includes the use of seeds that have been hot water-treated or assayed and found to be completely free of black rot. Rotating fields out of cole crops at least 2 years helps avoid re-infestation in the field. Copper sprays applied with a boom sprayer may reduce spread of the black rot organism in the field (Zandstra).

Soft rot or head rot

Soft rot, a bacterial disease, causes a watery, soft, foul-smelling rot. Soft rot infections often occur after chemical, mechanical, pest, or other injury. The bacteria softens the cell walls, which results in the rapid collapse of the plant's tissue. Soft rot develops most rapidly during warm, humid weather.

Cultivars with domed heads that shed surface water are less susceptible to soft rot than those with flat heads. Growing broccoli on well-drained soils and maintaining adequate soil moisture also helps avoid soft rot.

Downy Mildew

Downy mildew, a fungal disease, results in irregularly-shaped grayish-purple spots on the stems and undersides of leaves. Heavily-infected leaves turn yellow, dry out, and eventually drop off. Advanced stages of the infection result in internal darkening of the broccoli head.

Downy mildew overwinters in roots or in old, diseased plant parts. Cool weather, high humidity, fog, drizzling rains, and heavy dew are conducive to

development and spread of the disease. Although downy mildew has been a major fungal disease in broccoli, most commercial varieties carry some resistance.

Physiological Disorders

Hollow stem

Hollow stem is primarily the result of a boron deficiency, but may be influenced by excessive nitrogen application. In serious cases, hollowing of the stem proceeds upward through the surface of the head, and the internal surfaces become brown or black. Bacterial soft rot may develop, causing a soft, odoriferous rot of the head surface and the internal cavity. The incidence of hollow stem can be reduced by the use of resistant cultivars, maintenance of correct soil pH, irrigation, maintenance of adequate levels of boron, and use of sufficient fertilizer.

Leafy head

The presence of leaves within the head reduces the market value of broccoli. Leafy heads are often due to high temperatures, coupled with lush growth due to excess water and nitrogen (Mansour, personal communication).

Coarse buds

Large, coarse buds reduce the quality of broccoli. Bud size is a function of variety, but all broccoli develops large buds as the heads become mature. High temperatures and delayed harvest can produce excessively-large or open buds (Mansour, personal communication).

State Analyses

Arizona

Arizona is the second-largest broccoli-producing state, accounting for 6 percent of U.S. output in 1993. Arizona's 1993 broccoli production had a farm value of $21.5 million.

The Census reported 21 farms in Arizona with broccoli sales in 1987, 81 percent of which had gross sales of $500,000 or more. Production is located in the counties of Yuma, Maricopa, Pinal, and La Paz, which are in the south central and southwestern parts of the state.

Arizona's broccoli is grown for fresh-market use. The state's market window is from November to April, with the heaviest volume of shipments occurring from December to February.

Production Perils

Broccoli production in Arizona is faced with relatively few weather-related perils. Hail was mentioned by one grower as an occasional cause of loss. The

relatively dry climate discourages the development of diseases, and growers generally consider insects to be manageable with current production practices and pesticides. The sweetpotato whitefly has been a problem in some recent years, but as with other insects, growers believe they can manage this pest.

Arizona received among the smallest total disaster payments for broccoli of any state between 1988 and 1993--only $17,000 over that period. More than $15,000 of this six-year total was the result of losses due to flooding that followed excessive rains in January 1993.

Demand for Insurance

Arizona growers would not likely be very interested in a broccoli insurance policy because weather-related perils are not a sizeable risk to broccoli production in that state. One grower indicated that Arizona producers would not be happy with a broccoli policy that "favored" producers in the more risky Eastern states. The greatest concern among Arizona broccoli growers seems to be uncertain returns caused by price variability.

California

California is by far the largest broccoli-producing state, accounting for 90 percent of total U.S. output in 1993. California's broccoli had a farm value of $250 million in 1993.

The Census of Agriculture reported 410 farms with broccoli sales in California in 1987. Many are large enterprises: fifty-seven percent of California farms with broccoli had a total value of crop sales of $500,000 or more in 1987.

The Salinas Valley (Monterey county) is the leading broccoli-growing area in the state, providing over half of California's output. The Santa Maria-Oceano area of Santa Barbara and San Luis Obispo counties ranks second in output, accounting for over 20 percent of California's production. The remainder of California's broccoli is grown in Fresno, Imperial, San Benito, Santa Clara, Stanislaus, Riverside, and Ventura counties (see Appendix table 5 and Appendix map).

The Salinas and Santa Maria valleys (central coastal areas) provide ideal weather conditions for broccoli production, and accounted for nearly 90 percent of California output in 1980. The development of new, more heat-tolerant varieties, however, has encouraged broccoli-growing in the warmer, desert areas of the Imperial and Coachella Valleys.

As a result, broccoli acreage and production in the desert areas increased four- to five-fold between 1980 and 1992, while acreage and production "only" doubled in the Salinas and Santa Maria Valleys. The Salinas and Santa Maria Valleys account for a smaller share of California's total output at the present than in 1980, even though they continue to dominate California broccoli production.

Planting and Harvesting Dates

Broccoli is grown year-round in one area or another in California. Cool summers and moderate winters permit production year-round in the Salinas and Santa Maria areas, although peak production occurs during the Spring and Summer. The warm winter temperatures in the southern California desert areas favor winter production. Typical planting and harvesting dates for major broccoli areas in California are shown in Table 9.

Broccoli Marketing in California

Fresh broccoli is shipped year-round from the Salinas and Santa Maria areas. Shipments from the Santa Maria area, however, are more stable from month-to-month than from the Salinas area. Shipments from the Salinas area generally decline during December and January, begin to rise in February, and peak during April, May, and June. The southern areas, including Imperial and Riverside counties, produce only in the Winter.

Although the total volume is still relatively small, more fresh broccoli is being harvested as crown cuts (a premium cut containing less stalk than is normally included with the broccoli head) than in the past (Laemmlen). Much of California's crown-cut broccoli is exported to Japan, although the domestic market is increasingly demanding this premium product.

As with lettuce, the broccoli industry is to a large extent vertically-integrated, with several large grower-shippers who grow, pack, and market their own broccoli. The three largest grower-shippers handling fresh vegetables in California are Tanamura & Antle, Dole, and Bruce Church. According to industry analysts, these three companies account for nearly 50 percent of the fresh broccoli grown in California.

A number of small- and medium-sized growers contract with a shipper or a grower-shipper to pack and sell their fresh-market broccoli. Fresh-market contracts consist of various arrangements, but usually stipulate that the shipper provide the seed and an advance for the grower to meet production expenses. Growers in San Luis Obispo county reportedly are moving away from contractual arrangements, operating only with informal grower-shipper agreements (Borg).

For processing broccoli, contracts between grower and processors are the norm. Processors contract with growers to ensure they have the constant supply of raw material needed to fully utilize their plants (Laemmlen). Broccoli grown for processing and that grown for the fresh market are essentially the same, and when prices for processing and fresh-market broccoli become too disparate, growers may switch some broccoli from the lower-priced use to the higher-priced use.

Many California broccoli farmers also grow and market other vegetables. Most growers rotate broccoli with other crops such as celery, lettuce, and sweet corn. The choice of rotation crops is mainly governed by the shippers'

Table 9--Usual planting and harvesting dates for broccoli in California

Region	Planting	Harvesting	Peak harvest
Salinas	Year round	Year round	April, May, June
Santa Maria	Year round	Year round	March, April, May
Imperial	Aug.25-Nov. 1	Nov. 25-Mar. 5	January, February

Source: *Marketing California Broccoli 1990*, Dot Map.

marketing needs. Shippers know approximately how much of each crop they can handle and arrange with growers to produce that amount (Laemmlen).

Production Perils

There are relatively few weather-related production perils affecting broccoli in California. The climate is relatively dry and all of the broccoli acreage is irrigated. However, excessive heat can lead to reduced quality. Further, extreme cold and excessive rain have caused some yield losses in the past.

The largest ad hoc disaster payments for broccoli in California were made for losses during 1990 and 1991, caused by extreme cold weather. California experienced a severe freeze during December 1990 which destroyed most crops in the central valley, including broccoli (Chambers). In 1993, relatively large disaster payments were made for broccoli in San Luis Obispo county due to losses caused by excessive rain from January-March (Borg).

Large sweetpotato whitefly populations have occasionally slowed the development of early-planted broccoli seedlings in the southern part of California. Damage occurs in the form of 2-3 week delays in the normal maturity of the crop, causing the grower to miss targeted market opportunities (University of California, 1993). A new pesticide called "Admire" appears to be providing satisfactory control of whiteflies at the present time (Mayberry).

Other pests of California broccoli include flea beetles, root maggots, cabbage worm, cabbage looper, thrips, and aphids. Approved management practices and currently-available pesticides provide adequate control for these pests. The major diseases problems in California are club root, black rot, and soft rot.

Grower Organizations

The Central California Vegetable Grower-Shipper Association and the Vegetable Grower-Shipper Association of Santa Barbara and San Luis Obispo Counties fund labor relations and legislative affairs activities with assessments from grower-shippers based on cartons shipped. Although the associations have fresh broccoli shipment records, these records may differ from actual grower production, which may include processing broccoli (Angstadt, Quandt).

Demand for Insurance

The demand for a potential broccoli insurance policy in California is most likely not very great. The president of the Central California Vegetable Grower-Shipper Association said he thought there would be no interest in a broccoli policy among growers in the Salinas Valley because growers in that area face very few production perils (Angstadt). The Salinas Valley has a relatively mild climate and all of the broccoli acreage is irrigated. Low broccoli prices are the greatest risk facing growers in the Salinas Valley.

A spokesman for the Vegetable Grower-Shipper Association of Santa Barbara and San Luis Obispo Counties also indicated that he thought there would not be

very much interest in crop insurance for broccoli, particularly for that grown during the Summer. He did indicate, however, that growers who raise broccoli during the Winter face more production perils (extreme cold and flooding) than those who grow during the Summer, and that they may have some interest in a broccoli policy.

In addition to the risk-diminishing effects of a mild climate and the use of irrigation, broccoli-growing in California tends to be substantially diversified with other crops, which further reduces growers' income risk. Any income loss due to reduced broccoli yields may be partly offset by income from other crops. Also, California growers tend to harvest broccoli over an extended season, and yield losses during one part of the season represent only a portion of their total crop.

Illinois

Illinois is a minor broccoli-growing state. Neither the USDA nor the Illinois Department of Agriculture report broccoli acreage or production data for the state. The Census of Agriculture reported 69 farms in Illinois with broccoli sales in 1992, the same number as in 1987. However, harvested acreage had dropped over the period, from 1,348 acres in 1987, to 618 acres in 1992. Broccoli in Illinois is grown by farmers who raise a number of vegetables for sale in local and regional markets.

Claims for ad hoc disaster payments for broccoli were made and approved in 24 Illinois counties between 1988 and 1993. McHenry county had the largest payments of any county in the state, with a total of $635,000 over the six-year period, all of which was paid for 1988 and 1989 losses caused by drought (Maraccini).

Maine

Commercial broccoli production in Maine is located in Aroostook county in the northern part of the state. Aroostook county is the "Maine Potato" growing area, and farmers initially turned to broccoli as an alternative crop in the 1980's when the potato economy declined in that area. Aroostook county farming was virtually a one-crop economy and farm income depended on the price of potatoes. It was hoped that broccoli would provide a measure of income diversification for potato farmers.

Commercial broccoli production began in Aroostook county in 1982, with about 20 growers initially. The 1992 Census showed 11 growers in Aroostook county, harvesting 3,184 acres of broccoli. For 1987, the Census reported 12 growers and 2,339 harvested acres. There were reportedly only 3 major growers in 1994, with a total of more than 3,000 acres (Ayre, Williams). Neither the USDA nor the New England Agricultural Statistics Office estimate broccoli acreage and production for Maine.

Although Maine broccoli growers sell during a market window with generally strong prices, they are faced with a substantial amount of price risk. Maine's broccoli is marketed mostly in supermarkets in New England from late

July through October, and a buildup of supplies in the Boston and New York terminal markets can cause prices to decline sharply, reducing grower returns. The largest grower in Maine reported that about one-third of his production goes to the processing market.

Broccoli is planted in Maine from the first week of May to the first week of July. Most broccoli is direct-seeded in Aroostook county, although a small amount may be transplanted in order for an early harvest. Harvest generally begins during the third week in July and continues to the end of October. Although there is a slight production peak in August and September, shipment volume is fairly uniform throughout the harvest season. Harvesting is done by contract with migrant labor crews. Typical yields are 8,000 to 8,500 pounds per acre.

Production Perils

The greatest production perils in Maine are excessive rainfall and cold weather during August and September, which causes losses due to rot. Early hard freezes, hail, drought, extreme hot weather, and diseases can also reduce yields in Maine (Williams). Aroostook county had $90,000 in disaster payments for broccoli in 1993, reflecting all of the disaster payments received by the county over the 1988-93 period. Multiple perils were the cause, and included drought during June, hot and humid conditions during July and August, cold and wet weather during September, and early heavy frost in October (Hanson).

Demand for Insurance

There appears to be interest in a broccoli insurance policy among commercial growers in Maine (Hanson). One of the three major growers in Aroostook County said that he is "extremely interested" in crop insurance and that the other two are "somewhat interested." Because broccoli may account for a larger share of total farm income among Maine's commercial producers than in other areas, they may have greater need for crop insurance as a risk management tool.

In addition, Maine broccoli appears to be exposed to a relatively high risk of yield loss due to weather-related perils. In 1993 alone, disaster payments were made due to drought, excessive rain, and early hard freeze at different times during the season. Because broccoli is not irrigated in Maine, drought is a greater production risk than in the western states.

Although there may be interest in having insurance for broccoli in Maine, the potential for crop insurance is limited because there are so few growers.

Michigan

The 1992 Census of Agriculture reported 160 farms with broccoli sales in Michigan, but only 289 harvested acres of broccoli. Most of the broccoli plantings in Michigan consist of less than an acre grown for roadside and local markets. Michigan's broccoli acreage has been declining in recent

years. Broccoli acreage in 1992, at about 290 acres, was down 44 percent from the 514 acres reported in 1987.

Nearly $400,000 in ad hoc disaster assistance was paid to Michigan farmers for broccoli losses between 1988 and 1993. A large portion of this amount was paid for the 1988 crop, when drought caused major losses to crops throughout the Midwest. Other broccoli production perils in Michigan include excessive rain, excessive heat, and hail.

New York

Broccoli production is declining in New York, as it is in a number of Eastern and Midwestern states. The Census reported 646 harvested acres of broccoli in New York in 1992, down from 1,262 in 1987. The number of farms reporting broccoli in 1992 increased, however, to 323, from 299 in 1987. New York's commercial production is concentrated on Long Island. Most of New York's broccoli is grown on small vegetable farms and is sold in local markets.

There were $146,000 in disaster payments made for broccoli in New York between 1988 and 1993, scattered widely throughout the state. Payments on Long Island in 1992 were for yield losses due to excessive heat (Bruno). Other weather-related production perils associated with growing broccoli in New York include excessive rain, drought, and hail.

Oregon

Oregon was the third-ranked state in broccoli production in 1993. Oregon's 1993 planted area totalled only 2,200 acres, however, down from about 3,100 to 3,200 over the 1989-92 period. Oregon's broccoli had a farm value of $4 million in 1993.

The Census of Agriculture reported 105 farms with broccoli sales in 1992, up from 98 farms in 1987. The largest acreage and the largest number of growers are located in Marion county, but Clackamas, Linn, Washington, and Yamhill counties all reported at least 100 acre of broccoli harvested in 1992. Virtually all of Oregon's broccoli is grown in the Willamette Valley, which extends south from Portland.

Although the USDA does not report separate estimates for fresh and processing broccoli in Oregon, one source estimated that about half the crop is destined for processing and half is sold as fresh-market broccoli (Mansour, unpublished material). The Oregon Processed Vegetable Commission reports that 47 growers delivered broccoli to processors in 1993 (McCulley).

Broccoli marketing in Oregon is handled through grower-processor contracting. Contracts specify the acreage and the time of planting. By specifying planting times, processors can schedule harvesting to correspond with plant capacity.

Production Perils

Oregon growers do not face a very serious set of production perils. Excessively high temperatures, heavy rains following planting, diseases, and insects are production problems, but ones which growers can generally manage (Mansour, personal communication). Yield losses due to hail or freeze damage are unusual in Oregon.

Heavy rains following planting may result in growers losing their investment in seed (about $100 and acre) and other planting expenses. Usually, growers replant and thereby recover their investment in fertilizer.

Bacterial soft rot is the most serious disease peril for Oregon broccoli (Mansour, personal communication). It usually occurs during warm, humid periods. Other diseases mentioned as perils for Oregon broccoli include downy mildew, black leg, black rot, and club root.

The principal insect perils, which generally can be controlled, include flea beetles, cabbage loopers, aphids, cabbage worms, slugs, wireworms, cutworms, and diamondback moth larvae.

Grower Organizations

The Oregon Processed Vegetable Commission supports research through grower assessments on six processing vegetables, including broccoli. The Commission has information on the amount of broccoli delivered to processors, but no information on the planted acreage nor on the amount sold for the fresh market.

Demand for Insurance

There may not be very much demand for crop insurance for broccoli in Oregon because most growers in the Willamette Valley are diversified with a number of other crops and the production perils are not serious production risks (Brewster). The Executive Secretary of the Oregon Processed Vegetable Commission indicated that he had never heard the need for crop insurance mentioned at any of the Commission's meetings and that it was his feeling that there would not be very much participation on the part of Oregon growers (McCulley). The small amount of disaster payments made to Oregon broccoli growers (0.03 percent of the value of broccoli sales) between 1988 and 1993 tend to support these judgements.

Texas

Texas ranked third among the states in broccoli acreage in 1993, harvesting 3,300 acres. Because of low average yields per acre, however, Texas ranked fourth behind Oregon in production. The farm value of broccoli in Texas, at $4 million in 1993, was down substantially from $8 million in 1992 and $6 million in 1991. The Census of Agriculture reported 113 farms with broccoli sales in 1987.

Most commercial broccoli in Texas is grown in Hidalgo and Cameron counties in the far southern tip of the state (the lower Rio Grande Valley). A small amount is grown in Bexar, Uvalde and other counties west of San Antonio, in a part of the state known as the "Winter Garden" area. Broccoli in Texas is marketed for both fresh and processing uses.

Production Perils

Hard winter freezes are the biggest cause of production losses in the Rio Grande Valley area. A freeze in late December of 1989 killed all broccoli in the field at that time. State production for 1990 dropped 43 percent from the previous year, although the same amount of acres had been planted.[5] Of the 7,000 acres of broccoli planted for the 1990 season, 1,900 were not harvested. During most years, only 200-400 acres are not harvested. Growers' returns from broccoli sales dropped to $6.3 million in 1990, down from $14.7 million the previous year (Texas Agricultural Statistics Service). Eighty percent of all ad hoc disaster payments for broccoli in Texas between 1988 and 1993 were made to growers in the Rio Grande Valley for losses during 1990. Early freezes can also cause yield losses in the Winter Garden area (Dainello).

Other production risks in Texas include excessive heat, excessive rain, wind, hail, and flooding, which can accompany severe thunderstorms and hurricanes (Brandenberger).

Grower Organizations

The Texas Vegetable Association supports research and promotion for Texas vegetables through assessments on growers. Although it does not have information on individual grower's broccoli acreage, Association personnel indicated that they would work with FCIC and Texas growers to provide the yield data needed to offer a broccoli policy (Sellman).

Demand for Insurance

The insurance coordinator for the Texas Vegetable Association indicated that there was a strong demand in Texas for crop insurance for vegetables, including broccoli (Sellman). Relatively large ad hoc disaster assistance payments made for Texas broccoli provides further evidence that participation in crop insurance for broccoli may be relatively high among Texas producers. Disaster assistance averaged 2.1 percent of the value of Texas broccoli between 1988 and 1993, compared with payments of less than 0.05 percent in the other major broccoli states.

[5] The production shortfall due to the 1989 freeze appears in the 1990 statistics because acreage and production are reported for the year of intended harvest. Broccoli in the field at the end of 1989 was for 1990 harvest.

Wisconsin

Wisconsin is a minor broccoli-producing state in which a substantial decline in broccoli acreage occurred between the 1987 and 1992 Census. The 1992 Census reported 78 farms with broccoli sales in Wisconsin and 312 harvested acres in 1992; in 1987, the Census reported 82 farms and 1,023 acres. Much of the broccoli in Wisconsin is grown on small vegetable farms, and is destined for sale in local markets. The majority of the broccoli in Wisconsin is grown without the benefit of irrigation. Only 66 of the 312 acres reported by the Census in 1992 was on irrigated land.

Wisconsin producers received near $634,000 in ad hoc disaster payments for broccoli between 1988 and 1993, the bulk of which occurred in 1988 when drought caused widespread crop losses throughout the Midwest. Other weather-related perils include excessive rain, hail, and excessive heat.

Ad Hoc Disaster Assistance for Broccoli

Ad hoc disaster assistance legislation was made available for losses of commercially-grown crops in each of the years 1988-93. Ad hoc payments provide an indication of high-loss areas during that period, and may indicate states and counties that would face relatively high risk under a potential FCIC broccoli policy. These data may also suggest the areas where the demand for a broccoli crop insurance policy would be relatively high.

Under the 1988-93 legislation, payments were made under the categories of participating program crops, nonparticipating program crops, sugar, tobacco, peanuts, soybeans, sunflowers, nonprogram crops, ornamentals, and at times, aquaculture. Producers without crop insurance--the case for broccoli--were eligible for payments for losses greater than 40 percent of expected production. If a producer had no individual yield data to use in calculating "expected production," county-level or other data were used as a proxy. Payment rates for broccoli were based on 65 percent of a 5-year average price, dropping the high and low years.

Disaster assistance payments for broccoli (fresh, processed, and broccoli raab) totalled about $5.7 million over the 1988-93 period. Payments for fresh broccoli accounted for 91.8 percent of the total. Payments for processed broccoli accounted for 7.7 percent of the total, and for broccoli raab, 0.5 percent. Payments for losses in all broccoli categories peaked at nearly $1.9 million in 1988, and were about $1.75 million in 1989. Payments in all other years totalled less than $800,000. Payments made for broccoli accounted for about 0.2 percent of all ad hoc assistance for non-program crops (that is, non-price and income support crops) over the 1988-93 period.

Ad hoc disaster payments for broccoli were scattered over a geographically broad area. For fresh broccoli, 43 states received payments in at least one of the six years, with twelve states collecting payments in all years. For processed broccoli, 8 states collected payments in one of the 6 years; no

states received payments in all years. Broccoli raab payments were made only in New Jersey and New York.

In an ordering of counties, McHenry county, Illinois ranked first in fresh broccoli payments, receiving $635,280 over the 6-year period. The next three counties were: Hidalgo county, Texas ($589,006); Racine county, Wisconsin ($358,439); and Cameron county, Texas ($216,447). A total of 478 counties received payments in at least one of the 6 years for fresh broccoli yield losses. By state, the largest payments were made to Illinois growers ($705,583) and Indiana growers ($267,092).

For processed broccoli, the top-ranked counties in ad hoc payments include Hidalgo county, Texas ($114,784); Washara county, Wisconsin ($100,060); Oconto county, Wisconsin ($48,825); and Rapides parish, Louisiana ($45,551). A total of 27 counties received payments in at least one of the 6 years for processed broccoli losses. By state, the largest payments were made to growers in Wisconsin ($191,287) and Texas ($138,133).

Ad hoc disaster data can be used to indicate which broccoli-producing areas received large payments relative to their acreage (Table 10). The National Agricultural Statistics Service (NASS) does not report broccoli acreage in Illinois and Wisconsin, although those states accounted for an average of 11 to 12 percent of U.S. ad hoc disaster payments made for broccoli between 1988 and 1993. Similarly, NASS data indicate that Texas accounted for about 4 percent of U.S. broccoli acreage over the 6-year period, but accounted for 18 percent of the U.S. ad hoc payments made for broccoli.

In contrast, Arizona and California collected smaller shares of ad hoc payments relative to their acreage. Arizona accounted for 5.6 percent of U.S. broccoli acreage over the 1988-93 period and 0.3 percent of broccoli payments, while California accounted for 87.4 percent of U.S. acreage--and only 13.8 percent of the ad hoc payments for that crop.

Disaster payments for the four NASS broccoli states averaged 0.1 percent of the total U.S. broccoli crop value over the six years (Table 11). Disaster payments as a percent of crop value were highest in Texas (2.1 percent) and lowest in Arizona, California, and Oregon (less than 0.05 percent). The low payments in these latter states reflect the relative absence of weather-related production perils in these states. Virtually all of the broccoli in Arizona, California, and Oregon is irrigated so drought is not a production peril in these areas. Although yield losses have occurred in central California due to severe freeze or excessive rain, such losses have been relatively infrequent.

Broccoli Insurance Implementation Issues

Adverse Selection

Adverse selection is always a potential problem in providing crop insurance because of differences in micro-climates, soil types, and typography among

Table 10--Disaster assistance payments for broccoli (fresh and processed), 1988-93

State	Average broccoli harvested acreage, 1988-93	Share of U.S. acreage	Total broccoli disaster payments, 1988-93	Share of U.S. broccoli disaster payments
	--Acres--	--Percent--	Thousand --Dollars--	--Percent--
Arizona	6,167	5.6	17.5	0.3
California	96,367	87.4	788.0	13.8
Illinois	NR	NR	705.6	12.3
Oregon	2,917	2.6	10.8	0.2
Texas	4,817	4.4	1,054.2	18.4
Virginia	NR	NR	221.3	3.9
Wisconsin	NR	NR	633.8	11.1
U.S.	110,267	100.0	5,730.0	100.0

NR = not reported.

Sources: USDA, NASS, and ASCS data files, compiled by the General Accounting Office.

Table 11--Broccoli: Crop value and disaster assistance, selected states, 1988-93

State	Total crop value	Total broccoli disaster payments	Disaster payments, percent of crop value
	---Thousand dollars---		Percent
Arizona	83,150	17	*
California	1,475,498	788	*
Oregon	33,801	11	*
Texas	50,128	1,054	2.1
Four states	1,642,577	1,870	0.1

* Less than 0.05 percent.

Source: ASCS data files, compiled by the General Accounting Office and USDA, NASS.

fields. Insuring broccoli would not appear to present any unusual problems with respect to the incidence of adverse selection.

Setting Reference Prices

FCIC provides a reference price (price election) for the insured crop which becomes the basis for assigning value to yield losses. The insured grower elects a price guarantee, normally between 30 and 100 percent of the reference price.

A reference price for broccoli should represent the in-field value of the crop, because growers would generally not incur harvesting and marketing expenses on that portion of the yield that was lost. Variable harvesting and marketing expenses account for a relatively large share of total costs for broccoli (as much as 70 percent for fresh-market broccoli, although less for processing broccoli). Using a fresh-market f.o.b. price or a season average price for processing broccoli could create the situation where growers would realize a higher return from indemnity payments than the market value of the crop. Such a situation may provide undue incentive for moral hazard.

There are two approaches for deriving an "in-field" reference price. One is to deduct the estimated harvesting costs from a market price. The second is to estimate the cost of production and use it as a proxy for the in-field price. The market price here refers to the grower price and not the retail price.

Market Prices and Actual Production History (APH) Distortion

A grower's APH is established, where possible, from his or her own production records over the past 4-10 years. For a number of fresh-market vegetables such as broccoli, variations in past yields may have been due partly to market conditions. If market prices fall below the costs for harvesting and marketing at harvest time, for example, yields may be lower than normal because the grower only partially harvested or even completely abandoned the crop for economic reasons.[6] Or, if prices are unusually high at harvest-time, the grower may raise the yield above its normal level following management practices that extend the number of harvests. One contact expressed the opinion that "broccoli yields can go up 40 percent if the price is right" (Dillon). If an average yield does not indicate farming ability, APH yields may not provide a satisfactory method for screening a farmer's productivity.

Estimating "Appraised Production"

Appraised production for broccoli (unharvested, but potential yield at the time of the appraisal) could be estimated by counting and weighting marketable

[6] Economic abandonment occurs because the grower incurs a smaller loss by abandoning the crop than by incurring the expenses for harvesting and marketing and selling at a low price.

broccoli heads in a sample of plots and expanding the plot yields to a per-acre basis. For broccoli in which the heads have not yet reached marketable size, the yields per plot could be estimated by counting stalks and multiplying by an average or typical yield per stalk. Yields per stalk may need to be adjusted to reflect the number of stalks per plot. Broccoli plants in fields with higher plant populations tend to develop smaller heads than plants in fields with lower plant populations.

Insuring Price Risk

Several growers cited market risks as the greatest peril. Growers in the western areas (Arizona, California, and Oregon) have relatively few weather-related production perils and can generally cope with insects and diseases using currently available pesticides and management practices. Their major peril, especially for fresh-market broccoli, is market risk caused by price variability.

To make crop insurance attractive to broccoli producers in the major growing areas, crop insurance may have to contain an element of protection against the risks of low market prices. A revenue insurance plan may protect broccoli growers against income falling below some guaranteed minimum, regardless of whether the cause was low yield, low prices, or a combination of both. Such a plan could provide a measure of market-risk protection, while at the same time avoiding indemnity payments to growers who, despite low yields, had a good return because of high market prices.

Market Prices and Moral Hazard

There is potentially a moral hazard concern in insuring broccoli since the situation sometimes arises where, because of low market prices, an indemnity payment would be higher than the net return from harvesting a crop. In order for moral hazard to arise, a yield loss would need to occur due to some contributing action or lack of action (such as neglecting pest control practices) on the part of the grower.

As a practical matter, however, moral hazard does not appear likely to be a problem in areas having a processing market so long as the price election is based on an in-field price. Grower-induced losses are not likely to occur among growers who have access to the processing market because marketing costs for processing broccoli are much lower than for the fresh market and economic abandonment may not be the best alternative for these growers. Neither is moral hazard likely to be a problem with growers who market over an extended season because usually only a small part of the season-total crop is abandonment and yield losses during that part of the season may not lower average yields enough to qualify such growers for indemnity payments.

Yield losses due to insects and diseases could occur if a grower neglected to follow prudent pest management practices. It is unlikely that a grower would neglect proper pest management in order to collect an insurance indemnity, however, because a pest buildup may be difficult to eradicate, and could

create a peril for future crops when market prices may be higher. In addition, FCIC may not wish to include indemnification for insect and disease losses in a broccoli policy because growers generally view these perils as manageable problems with currently available control methods.

Availability of Individual Yield Data

There does not appear to be any readily available source of yield data for the two largest production areas (California and Arizona). In neither state is there a grower organization that collects production and acreage statistics for individual growers. In Texas, the Texas Vegetable Association indicated that it could work with growers to obtain historical acreage and production data. In Oregon, the Oregon Processed Vegetable Commission has information on the amount of broccoli delivered to processors, but no information on the planted acreage nor on the amount of broccoli sold for fresh-market use.

Demand for Insurance

It is our assessment that the demand for multi-peril crop insurance for broccoli would be greatest in Texas and in production areas in the East, Midwest, and South. Demand would likely be lowest in the western states (California, Arizona, and Oregon), where the majority of the crop is grown.

Growers in the East face a greater array of weather-related perils (drought, excessive rain, excessive heat, flooding, and hail) than in the West, which increases their need for a risk management tool such as crop insurance. In addition, growers in the East generally face a shorter market window than growers in the West. Consequently, a yield loss at one point in the season represents a larger proportion of total income for eastern growers than for western growers who may grow and market broccoli over a number of months, or perhaps year-round.

Other Implementation Issues

There does not appear to be any particularly intractable implementation obstacles in developing a policy for broccoli insurance. The problems encountered in offering a broccoli policy would be about the same as those confronted in offering insurance for fresh-market tomatoes or that would be confronted in developing insurance for lettuce or celery. All are treated as an annual crop in commercial production and present problems such as market-price distortion of yields, extended harvest seasons, and highly variable market prices.

However, a limitation to offering broccoli insurance in the eastern states is the lack of sufficient acreage in any one county to justify offering a crop insurance policy. Except for Aroostook County in Maine and Cameron and Hidalgo counties in Texas, very few counties in the eastern states have 500 acres or more of broccoli. Most have less than 100 acres.

References

Angstadt, Ed. President. Central California Vegetable Grower-Shipper Association. Salinas, California. Personal Communication. August 1994.

Arnold, Rita. Program Assistant for Disaster Assistance. ASCS office. Racine County, Wisconsin. Personal Communication. August 1994.

Ayre, Andy. President. Maine Farms, Inc. Caribou, Maine. Personal Communication. August 1994.

Borg, Catherine. Program Assistant for Disaster Assistance. ASCS office. San Luis Obispo County, California. Personal Communication. August 1994.

Brandenberger, Lynn. Extension Horticulturalist. Texas A&M University, Weslaco, TX. Personal Communication. August 1994.

Brewster, Thomas. County Executive Director. ASCS office. Marion County, Oregon. Personal Communication. August 1994.

Bruno, Sue. County Executive Director. ASCS office. Suffolk county, New York. Personal Communication. August 1994.

Chambers, Catherine. Program Assistant for Disaster Assistance. ASCS office. Kings County, California. Personal Communication. August 1994.

Cross, Tim, John Burt, and Dan McGrath. *Enterprise Budget for Broccoli, Willamette Valley Region*. EM-8378. Oregon State University Extension Service. April 1988.

Dainello, Frank. Extension Horticulturalist. Texas A&M University. College Station, TX. Personal Communication. August 1994.

Dainello, Frank, J. *1993-1994 Texas Commercial Vegetable Production Guide*. Department of Horticultural Sciences. Texas A&M University. 1993.

Dillon, Richard. Vegetable Analyst. County Agriculture Commissioners office. Imperial County, California. Personal Communication. August 1994.

Fuqua, Shirley. Program Assistant. ASCS office. Hidalgo County, Texas. Personal Communication. August 1994.

George, P.S. and G.A. King. *Consumer Demand for Food Commodities in the United States With Projections for 1980*. Giannini Foundation Monograph Number 26. University of California. March 1971.

Hanson, Brad. Program Assistant. ASCS county office. Aroostook County, Maine. Personal Communication. August 1994.

Hine, Richard, Fred Harper, and Dave Langston. *Cultural Guidelines and Pest Management Recommendations for Cole Crops in Arizona*. University of Arizona Cooperative Extension. September 1990.

Laemmlen, Frank. Farm Advisor. Santa Barbara County, California. Personal Communication. July 1994.

Mansour, William. "Broccoli for Processing." Unpublished material. 1994.

Mansour, William. Extension Horticulturalist. Oregon State University. Corvallis, Oregon. Personal Communication. August 1994.

Maraccini, Sue. County Executive Director. ASCS office. McHenry County, Illinois. Personal Communication. August 1994.

Marketing California Broccoli, 1993. Dot map.

Mayberry, Keith. Farm Advisor. Imperial County, California. Personal Communication. August 1994.

McCulley, John. Executive Secretary. Oregon Processed Vegetable Association. Personal Communication. August 1994.

Nonnecke, Ib Libner. *Vegetable Production*. New York: Van Nostrand Reinhold, 1989.

Quandt, Rick. Vegetable Grower-Shipper Association of Santa Barbara and San Luis Obispo Counties. Personal Communication. August 1994.

Seelig, R.A. *Vegetable Facts and Pointers, Broccoli*. United Fresh Fruit and Vegetable Association. March 1971.

Sellman, Charles. Insurance Coordinator. Texas Vegetable Association. Personal Communication. August 1994.

Shapley, Allen, E., Edgar L. Strong, and Thomas A. Dudek. *Cost of Producing Broccoli in Western Michigan*. Agricultural Economics Staff Paper No. 86-47. Michigan State University. June 1986.

Texas Agricultural Statistics Service. *1991 Texas Crop Statistics*. Bulletin 250(1). September 1992.

U.S. Department of Agriculture. Agricultural Marketing Service. *Fresh Fruit and Vegetable Shipments*. FVAS-4. Various issues.

U.S. Department of Agriculture. Agricultural Stabilization and Conservation Service. Disaster Assistance Data Files, 1988-93. Compiled by the General Accounting Office.

U.S. Department of Agriculture. *1992 Vegetable Chemical Use Survey.*

U.S. Department of Agriculture. Economic Research Service. *Vegetables and Specialties Situation and Outlook Report*. VGS-263 (Yearbook issue). July 1994.

U.S. Department of Agriculture. National Agricultural Statistics Service. *Vegetables*. Annual summaries.

U.S. Department of Agriculture. Statistical Reporting Service. *Usual Planting and Harvesting Dates for Fresh Market and Processing Vegetables.* Agricultural Handbook No. 507. February 1977.

U.S. Department of Commerce. Bureau of the Census. *Census of Agriculture, 1987*. (Including special runs requested by USDA, ERS.)

U.S. Department of Commerce. Bureau of the Census. *Census of Agriculture, 1992*.

University of California. Cooperative Extension Service. Division of Agriculture and Natural Resources. "Broccoli Projected Production Costs, Imperial County 1992-93." 1993.

Williams, Matthew. Aroostook County Cooperative Extension Agent. Personal Communication. July 1994.

Wohlgenant, Michael. "Demand for Farm Output in a Complete System of Demand Functions." *American Journal of Agricultural Economics*. Vol. 71. pp. 241-252. 1989.

Zandstra, Bernard, H. *Commercial Vegetable Recommendations, Cole Crops, Broccoli, Brussels Sprouts, Cabbage, Cauliflower*. Extension Bulletin E-1591. Michigan State University. June 1988.