

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

Prepared by the Economic Research Service,
U.S. Department of Agriculture

for the
Office of Risk Management

May 20, 1996

Contributors:

Glenn Zepp, Coordinator (202) 219-0771
Joy Harwood (202) 219-0770
Agapi Somwaru (202) 219-0395

Table of Contents

Introduction	6
Types of Garlic	6
Hardneck Types	7
Elephant Garlic	7
The Garlic Industry	8
Farm Characteristics	10
The U.S. Garlic Market	12
Supply	12
Demand	12
Prices	16
Environmental Requirements and Cultural Practices	18
Climate	18
Soil	20
Water and Irrigation	20
Seed Garlic	21
Propagation and Planting	21
Fertilization	22
Rotations	22
Harvesting and Handling	22
Storage and Packing	23
Marketing Garlic	23
Costs of Production	24
Production Perils	25
Untimely or Excessive Rains	25
Flooding	27
Extreme Cold	27
Drought	27
Excessive Heat	28
Hail	28
Insects	28
Diseases	29
Nematodes	31
Weeds	32
Grower Organizations	32
Ad Hoc Disaster Assistance for Garlic	33

Insurance Implementation Issues	33
Demand for Insurance	33
Moral Hazard	36
Adverse Selection	37
Reference Prices	37
Yield Data	37
References	38

Executive Summary

Garlic, *Allium sativum*, is a bulbous plant closely related to the onion. Garlic is produced commercially for its composite bulb, which consists of several individual bulblets, known as 'cloves.' These individual bulblets are enclosed in a membranous bag that is whitish or purplish in color. In its fresh form, garlic is usually sold as a composite bulb.

California produces 80-90 percent of the garlic grown in the United States and virtually all of the commercial production intended for consumption. Oregon, Nevada, and Arizona also have commercial garlic production.

Although garlic is grown throughout California, the industry is concentrated in the central part of the state. The largest acreage is grown in the western San Joaquin Valley. The second major production area lies west of the Diablo mountain range, and centers around the towns of Gilroy and Hollister. This area was the original garlic-growing center in California, and most of the fresh-market shippers and dehydrators still have their facilities located in this area.

Lassen and Siskiyou counties in northern California produce a small amount of garlic, which is used mainly for seed. Northern California's climate is more similar to the climate in eastern Oregon and in Nevada than it is to the central California garlic areas. As in northern California, production in eastern Oregon and Nevada is intended mostly for seed garlic. The dry, cool high-desert climates facilitate producing disease-free seed.

Reportedly, about 20 percent of U.S. domestic garlic production is grown for the fresh market, 65 percent for dehydration ("dehy" garlic), and 15 percent for seed. Garlic can be switched among the different uses, and some switching occurs depending on the profitability associated with each use. Occasionally, garlic is diverted to processing when it falls short of required fresh market or seed quality standards.

Most commercial garlic production is located in sunny, relatively dry climates with cold, but not severe, winter temperatures. The exception to this generalization regarding a dry climate occurs in western Oregon, where garlic is grown in a relatively humid region with a substantial amount of natural rainfall.

To promote bulb production, garlic prefers a vernalization period with cool temperatures (below 40° F) for 6 to 8 weeks during the growing season. Once vernalized, the plant initiates bulb production when the day length reaches

approximately 13 hours and soil temperatures are above 60° F. Prolonged low soil temperatures (below 32° F) may cause the plant to produce rough-shaped bulbs and numerous small axillary cloves.

Because of garlic's sparse root system, the upper layers of the soil must be kept moist to attain maximum growth rates and yields. Plenty of moisture is especially needed in the spring to promote vegetative growth. Virtually all U.S. commercial garlic is irrigated. Even in western Oregon, where rainfall is relatively dependable, growers irrigate most garlic acreage.

Although planting and harvesting dates vary somewhat among areas, garlic is generally planted in the fall and harvested the following summer. For ease of digging, and to reduce soil compaction, garlic is usually planted on beds raised 6-8 inches high and spaced 40 inches apart (center to center). Two rows are planted on each bed.

Untimely rain at planting is the primary production peril in garlic production in central California. In contrast, a combination of extreme cold and lack of snow cover was cited as the most damaging peril in the seed-growing areas of northern California, Oregon, and Nevada. Various insects and diseases attack garlic, but growers are able to control losses with available management practices.

White rot is a particularly serious peril for seed producers. If a field becomes infected, buyers do not want the garlic for seed. Farmers may be able to sell infected fields as dehydrated garlic, but at a heavily discounted price. The greatest loss from white rot infection, however, may be that the farmer's reputation as a producer of disease-free garlic becomes tainted. The white rot inoculum, once in the soil, remains for years.

Ad hoc disaster payments for garlic losses were made in 19 states over the 1988-94 period, totaling \$1.415 million. The major producing states--California, Oregon, and Nevada--collected 81 percent of the total payments. No payments were made to Arizona growers.

Seed garlic growers in eastern Oregon, Nevada, and northern California may have more interest in purchasing crop insurance than producers in central California. The reason is that these areas have colder winter temperatures than central California, increasing the risk of crop loss. In central California, growers view garlic as relatively free of production perils.

Despite the likely interest in crop insurance in seed garlic areas, there appears to be a limited potential for a garlic

policy due to the small number of growers and the small acreage. Oregon reported 3,000 acres of garlic in 1995, having a value of \$9.0 million. Nevada reported 1,650 acres of garlic in 1995, having a value of \$4.4 million dollars. Nevada's acreage has ranged from 550 to 1,650 acres in the past eleven years.

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

Introduction

Garlic, *Allium sativum*, is a bulbous plant closely related to the onion. Garlic is produced commercially for its composite bulb, which consists of several individual bulblets, known as 'cloves.' These individual bulblets are enclosed in a membranous bag that is whitish or purplish in color. In its fresh form, garlic is usually sold as a composite bulb.

Garlic is noted for its pungent odor, which is caused by organic sulphur compounds. These compounds reportedly possess antibacterial properties, which have played a role in folk medicine from time immemorial.

The major use of garlic is as a flavoring in cooking. In addition to use in its fresh form, garlic is also processed into numerous dehydrated products and may be pureed or frozen. A portion of each year's production is also used as seed garlic for planting future crops.

California produces 80-90 percent of the garlic grown in the United States and virtually all of the commercial production intended for consumption. Oregon, Nevada, and Arizona also have commercial garlic production.

This report examines those aspects of the U.S. garlic industry that relate to the demand for crop insurance and the feasibility of developing a garlic insurance policy.

Types of Garlic

One taxonomic classification divides the garlic species (*Allium sativum*) into two subspecies (*A. sativum ophioscorodon* and *A. sativum sativum*). These subspecies are commonly referred to as hardneck garlics (*A. sativum ophioscorodon*) and softneck garlics (*A. sativum sativum*).

Softneck Types

Softneck garlics, so named because they do not produce a seed stalk, are the most common in the United States. Because they rarely produce seed stalks, softneck garlics are also referred to as non-bolting varieties.

There are two sub-classes of softneck garlics--silverskin and artichoke. Silverskin garlic is so named because of the whitish (silver) color of the bulb. Artichoke garlic receives

its name from the arrangement of the cloves within the bulb, which overlap one another, similar to the scales composing an artichoke bud.

The most widely grown commercial garlic varieties in the United States, *California Early* and *California Late*, are silverskin garlics. Garlic producers and processors have developed numerous selections and strains of *California Early* and *California Late* for the fresh market or for their own use in dehydration.

Artichoke garlic is similar to silverskin garlic, except that the bulbs tend to have smaller cloves. In addition, artichoke garlic is adapted to colder climates than is silverskin garlic and is grown primarily by home gardeners.

Hardneck Types

Hardneck garlics are characterized by their tendency to produce a stiff flower (or seed) stalk. The inflorescence, however, contains sterile flowers so that the plant does not produce any true seeds. The seed stalk of some hardneck varieties may be topped with a cluster of small fleshy buds called bulbuls (also referred to as topsets). The bulbuls may be used for planting, although this is not a common practice. The plant's production of bulbuls reduces its ability to bear an abundance of large garlic cloves, thereby diminishing yields.

There are several sub-classes of hardneck garlic--Rocambole, Roja, Continental, Porcelain, and Asiatic. Hardneck garlics range in color from paper-white (characteristic of the Porcelain type) to brownish-red (common to the Rocambole and Roja types). Most types display some amount of reddish or brownish color.

Although they have a shorter storage life than the softneck garlics, hardneck garlics are noted for their full flavor. Hardneck garlics are most commonly grown in home gardens and for specialty markets.

Elephant Garlic

Elephant garlic (also called great-headed garlic) is not a true garlic, but rather, a type of leek which produces very large cloves. It produces a bulb which may consist of a cluster of several cloves, as does garlic, or a single massive bulb that is surrounded by a number of small bulblets. Elephant garlic also produces a large seed stalk.

The flavor of the elephant garlic clove is milder than the true garlics, but stronger than onion. The more tender, fleshy, lower portion of the seed stalk is prized for use in stir-fried Oriental dishes.

Although there is some commercial acreage, elephant garlic is most frequently grown in home gardens. Small quantities are sold through farmers' markets or through specialty produce stores or specialty produce sections of supermarkets.

The Garlic Industry

California accounts for the bulk of domestic garlic output. The Census of Agriculture reported 21,179 harvested acres of garlic in the United States in 1992, 18,609 of which were in California (Appendix table 1). California had 248 farms producing garlic that year, up from 171 farms in 1987.

Oregon had 135 farms with garlic in 1992 (and 1,464 harvested acres), and Nevada had 9 farms (and 592 acres). These states are noted for their production of seed garlic, most of which is grown under contract with California producers. Oregon and Nevada also produce some garlic for consumption. In contrast, garlic in Arizona (with 20 farms and 194 harvested acres in 1992) is grown for the fresh market. Arizona growers produce strains that mature early in the season, enabling packers to ship new-crop garlic to the higher-priced early-season market (Call).

USDA's National Agricultural Statistics Service (NASS) reported 512 million pounds of garlic production in California in 1995, which was produced on 31,000 harvested acres. The estimated farm value of this production was \$180 million (Table 1).¹ In addition to California's output, Oregon reported 3,010 harvested acres, with a crop value of \$9 million, and Nevada reported 1,650 harvested acres, with a crop value of \$4 million (Appendix tables 3 and 4).

USDA reports garlic acreage and production only for California. The state governments in Oregon and Nevada, however, report garlic acreage and production in those states. The Census of Agriculture reported acreage for 16 states in 1992. Only in California, Oregon, Nevada, and Arizona did the Census acreage exceed 100 acres. Appendix table 2 reports data published by California's county agricultural commissioners. Note that the agricultural commissioners' data in some years differ from the USDA estimates provided in Table 1.

California's garlic output has risen sharply in recent years, with production tripling between 1981 and 1995. Acreage and

Table 1--Garlic: California harvested acreage, yield per acre, production, and value, 1970-81 and 1992-95

Year Total	Harvested area	Yield per acre	Production	Value
				Per cwt
	Acres	Cwt	1,000 Cwt	Dollars
\$1,000				
1970	5,600	130	728	8.39
6,111				
1971	3,700	130	481	9.32
4,485				
1972	5,100	130	663	9.84
6,525				
1973	6,900	130	897	11.73
10,522				
1974	9,000	130	1,170	12.19
14,265				
1975	10,800	130	1,404	13.12
18,415				
1976	8,800	105	924	12.98
11,995				
1977	10,400	110	1,144	14.28
16,336				
1978	13,000	120	1,560	15.85
24,723				
1979	14,200	130	1,846	15.15
27,974				
1980	15,200	130	1,976	17.11
33,816				
1981	13,200	125	1,650	21.79
35,947				
1982	--	--	--	--
--				
1983	--	--	--	--
--				
1984	--	--	--	--
--				
1985	--	--	--	--
--				
1986	--	--	--	--
--				
1987	--	--	--	--
--				

1988	--	--	--	--
--				
1989	--	--	--	--
--				
1990	--	--	--	--
--				
1991	--	--	--	--
--				
1992	23,000	165	3,795	27.10
102,854				
1993	26,000	160	4,160	31.84
132,470				
1994	27,000	170	4,590	39.44
181,038				
1995	31,000	165	5,115	35.16
179,834				

--

-- = Not available as the USDA suspended reporting production statistics for garlic from 1982 through 1991.

Source: USDA, National Agricultural Statistical Service.

production have risen particularly quickly in the past four years, rising 35 percent between 1992 and 1995. The bulk of California's production is grown for consumption as fresh or dehydrated garlic. By comparison, an estimated 92 percent of Oregon's production in 1995 was grown for seed (Sears).

Although garlic is grown throughout California, the industry is concentrated in the central part of the state (Figure 1). The largest acreage is grown in the western San Joaquin Valley, between the towns of Firebaugh to the north and Bakersfield to the south. The second major production area lies west of the Diablo mountain range, extending from Santa Clara County in the north to Monterey County in the south, and centers around the towns of Gilroy and Hollister. The latter region was the original garlic-growing center in California, and most of the fresh-market shippers and dehydrators still have their facilities located in this area. Gilroy bills itself as the "Garlic Growing Capital of the World."

Lassen and Siskiyou counties in northern California produce a small amount of garlic, which is primarily used for seed. Lassen County production is centered southeast of Susanville, near the Nevada border. Siskiyou County production is located in the Kalmath Basin near the Oregon border. Northern California's climate is more similar to the climate in eastern Oregon and in Nevada than it is to the central California garlic areas. As in northern California, production in eastern Oregon and Nevada is intended mostly for seed garlic.

Reportedly, about 20 percent of U.S. domestic garlic production is grown for the fresh market, 65 percent for dehydration ("dehy" garlic), and 15 percent for seed (USITC). Garlic can be switched among the different uses, and some switching occurs depending on the profitability associated with each use. Occasionally, garlic is diverted to processing when it falls short of required fresh market or seed quality standards.

Farm Characteristics

A special tabulation of the 1987 Census of Agriculture indicated that the bulk of California's garlic was grown on relatively large farms in that year (U.S. Department of Commerce, 1987). Sixty-two of the 171 farms producing garlic

in 1987 reported \$500,000 or more in crop sales.² Forty percent of the farms with garlic, on the other hand, appeared to be part-time operations, reporting less than \$25,000 in crop sales. In addition to

garlic, farms commonly raised other vegetables, fruits and nuts, and field crops.

In the 1990's, garlic in California appears to be produced primarily on large farms in rotation with other crops. The average garlic acreage was 75 acres per farm in 1992, inching up slightly from 70 acres in 1987. According to extension contacts, most commercial production is produced by large grower-packers or is grown under contract with grower-packers or "dehy" companies.

Seed garlic also is produced on large farms and is controlled by grower-packers and dehydration companies. In Oregon, for example, the bulk of Jefferson County's garlic production is seed garlic and is grown under contract with grower-packers or dehydration companies from California. Jefferson County reportedly has only 10-15 farms producing garlic (Appendix table 1; Brown). In 1995, Jefferson County reported 1,980 acres of harvested garlic, and an estimated 130-200 acres of garlic are produced per farm.

The U.S. Garlic Market

Supply

Domestic production accounted for 512 million of the 607 million pounds of total U.S. garlic supplies in 1995 (Table 2).³ The remainder of U.S. supply in 1995, about 96 million pounds, was imported. Imports are generally heaviest in the months of March through July (Table 3). They originate mainly from Mexico and China, and are about equally divided between fresh and dried products (Table 4). China is the principal supplier of dried garlic imports, while Mexico is the major

Sales included the value of all crops, including fruits, other vegetables, nursery products, and field crops.

Total supply represents garlic for fresh-market and for processing uses. Since most seed garlic is grown in Oregon and Nevada, it is not included in USDA production estimates.

supplier of fresh garlic.⁴ U.S. garlic imports have risen sharply since 1990.

Demand

U.S. consumers used 544 million pounds (farm weight) of garlic in 1995, the equivalent of 2.1 pounds of raw garlic per person. In addition to domestic consumption, the U.S. exported 63.6 million

Imports of fresh garlic from China in 1995 declined sharply from a year earlier. In 1994, the United States imported 13 million pounds of fresh garlic and 17 million pounds (46 million pounds farm weight equivalent) of dried garlic from China.

Table 2--U.S. garlic, all uses: Supply, utilization, and price, farm weight, 1970-96

Season average		Supply		Utilization			
price							
Year	Produc-	Imports ²	Total	Exports ²	Total	Per	
Current	tion ¹					capita	
dollars	1987					use	
	dollars ³						
		----- Million pounds-----					Pounds
		----- \$/cwt-----					
1970	72.8	19.4	92.2	--	92.2	0.4	
8.39	23.90						
1975	140.4	22.1	162.5	3.7	158.8	0.7	
13.10	26.63						
1980	197.6	24.5	222.1	22.1	199.9	0.9	
17.10	23.85						
1981	165.0	20.0	185.0	30.1	154.9	0.7	
21.80	27.63						
1982	169.6	34.5	204.1	24.9	179.2	0.8	
17.90	21.36						
1983	234.4	30.3	264.7	26.3	238.4	1.0	
15.00	17.20						
1984	173.8	39.1	212.9	27.7	185.3	0.8	
18.70	20.55						
1985	242.0	36.0	278.0	20.0	258.0	1.1	
30.95	32.79						
1986	177.5	45.8	223.3	35.7	187.7	0.8	
25.65	26.47						
1987	268.5	39.2	307.7	25.0	282.7	1.2	
18.55	18.55						
1988	261.9	38.8	300.7	32.4	268.3	1.1	
15.15	14.58						
1989	262.1	44.5	306.6	50.4	256.2	1.0	
20.15	18.57						
1990	341.3	57.1	398.4	63.1	335.3	1.3	
21.25	18.76						
1991	376.6	73.3	449.9	65.4	384.5	1.5	
22.75	19.35						
1992	379.5	65.0	444.5	61.7	382.8	1.5	
27.10	22.42						

1993	416.0	118.4	534.4	71.8	462.6	1.8
31.80	25.75					
1994	459.0	97.3	556.3	73.7	482.6	1.9
39.40	31.20					
1995	511.5	95.8	607.3	63.6	543.7	2.1
35.20	27.14					
1996 f	500.0	100.0	600.0	70.0	530.0	2.0
--	--					

f = ERS forecast.

1/ Sources: U.S. Department of Agriculture, National Agricultural Statistics Service (1970-81 and 1992-present). Between 1981 and 1991, production is from the California County Agricultural Commissioners' report.

2/ Source: Bureau of the Census, U.S. Dept. of Commerce and Statistics Canada.

Dried garlic & garlic flour trade adjusted to fresh weight basis using a factor of 2.7.

Dried exports were not reported until 1978. Fresh exports only prior to 1978.

3/ Deflated by the GDP implicit price deflator, 1987=100.

Table 3--Garlic arrivals from producing areas, 1992¹

Source	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
DEC Total											
	1,000 cwt										
California	36	27	32	22	25	34	19	17	24	22	21
26 305											
Mexico	-	-	1	3	5	10	4	-	1	-	-
- 24											
Other imports	-	-	1	2	-	-	-	-	1	1	-
- 5											
Total	36	27	34	27	30	44	23	17	26	23	21
26 334											

¹ Based on arrivals in 22 U.S. cities. Arrivals statistics reportedly represent 33 to 50 percent of total product. They are intended only to indicate relative availability of the product.

Source: U.S. Department of Agriculture, Agricultural Marketing Service.

Table 4--Garlic: U.S. imports by country of origin, 1995

Country	Fresh	Dried ¹	Total
	Million pounds (farm weight)		
Argentina	6.5	*	6.5
Chile	2.3	*	2.3
China	1.1	45.4	46.5
Mexico	35.4	*	35.4
Spain	2.0	*	2.0
Other	2.9	0.2	3.1
World	50.2	45.5	95.8

¹ Dried garlic adjusted to fresh weight basis using a factor of 2.7.

Source: U.S. Department of Commerce, Bureau of the Census.

pounds of raw garlic (Table 5). Canada and the United Kingdom were the major export markets, while Australia and Mexico also purchased notable amounts of U.S. garlic. In most years, the U.S. exports 10-20 percent of its garlic.

No statistical price-quantity relationships estimating the demand for garlic were found. However, consumer demand is likely inelastic, meaning that relatively large price changes are associated with small changes in the amount consumed. The reason is that consumers use garlic primarily for flavoring foods, and its cost constitutes only a small part of the cost of a dish. Although the price of garlic has very little effect on the cost of a dish, eliminating garlic from a recipe may have a significant effect on the taste. Therefore, a large price increase is needed to cause consumers to reduce the quantity purchased.

Farm-level demand is likely to be much more elastic than consumer-level demand, meaning that farm prices change by a smaller percentage than changes in domestic production. The reason is that, because garlic can be readily bought and sold in international markets, the amount imported and/or the amount exported changes when domestic output varies. This smooths out total supply and moderates price variation.

In addition, fresh garlic can be diverted to dehydrated use or processed into diced or pureed garlic and stored for future sale. This further reduces farm-level price variability by smoothing supplies from season to season.

Prices

USDA's National Agricultural Statistics Service (NASS) reports marketing-year average prices for garlic (Table 1). These prices are based on estimates of the average returns for all sales and include garlic sold for fresh use as well as that sold for processing and for seed.

In addition, two state sources provide season-average price estimates. The county agricultural commissioners in California report the average price per unit of garlic for selected counties (Appendix table 2). As with the USDA estimates, these county-level prices reflect the season average price received by growers for all sales.

A third resource for price information is the Department of Agricultural and Resource Economics at Oregon State University, which compiles county-level season average prices for garlic (Appendix table 3). The prices that are reported

for Jefferson and Linn counties, the two largest garlic-producing counties in

Table 5--Garlic: U.S. exports by country of destination, 1995

Country	Fresh	Dried ¹	Total
	Million pounds (farm weight)		
Australia	1.0	4.0	5.0
Canada	2.7	11.5	14.1
Costa Rica	1.7	*	1.7
Germany	*	2.4	2.4
Japan	0.4	1.9	2.3
Mexico	5.2	1.4	6.6
Netherlands	*	1.7	1.7
Singapore	*	1.4	1.4
South Africa	*	1.0	1.0
Sweden	*	1.7	1.7
Taiwan	2.9	*	2.9
United Kingdom	0.6	8.0	8.6
Other	2.3	11.6	13.9
World	16.9	46.7	63.6

* = less than 50,000 pounds.

¹ Dried garlic adjusted to fresh weight basis using a factor of 2.7.

Source: U.S. Department of Commerce, Bureau of the Census.

the state, are for seed garlic. Prices for "other" counties are an average of returns for all garlic sales.

Although the USDA's Agricultural Marketing Service (AMS) does not report shipping-point prices for fresh-market garlic, the agency reports wholesale market prices for fresh garlic in several major cities. An analysis of wholesale prices in Los Angeles indicates that fresh-market garlic prices peak during March and April, months which coincide with the end of the storage season (Figure 2). Once harvest of the new crop begins (usually during May), prices decline and continue to fall throughout the harvest season. Prices tend to bottom out during September and October, and then rise as shippers sell garlic from storage.

Fresh-market garlic prices exceed the value of processing garlic by a substantial margin. The Fresno county agricultural commissioner's office, for example, estimated the farm price for fresh-market garlic at \$1,420 a ton in 1995, and the processing price at \$300.

Price comparisons between fresh-market and processing garlic are not very meaningful, however, because fresh-market prices include returns for services not included in the price for processing garlic. Fresh-market prices, for example, include the returns for grading, storage, packing, and selling services, which represent value added beyond the field. Garlic for processing, on the other hand, represents the returns for raw garlic alone.

In addition, processing garlic may not be priced at its full market value. This is because virtually all garlic for processing is grown under contract with processors who provide the seed and, at times, other inputs. In addition, the processor may harvest the crop. The returns for these inputs may not be reflected in the farm price.

The fresh market pays a premium for large-bulb garlic. A cursory assessment of wholesale prices for garlic suggests that the price per pound rises as bulb size increases.

Environmental Requirements and Cultural Practices

Climate

Garlic in home gardens is grown under a wide range of climates in the United States. Most commercial production, however, is located in sunny, relatively dry climates with cold, but not

severe, winter temperatures. The exception to this generalization regarding a dry climate occurs in western Oregon,

where garlic is grown in a relatively humid region with a substantial amount of natural rainfall.

To promote bulb production, garlic prefers a vernalization period with cool temperatures (below 40° F) for 6 to 8 weeks during the growing season.⁵ Once vernalized, the plant initiates bulb production when the day length reaches approximately 13 hours and soil temperatures are above 60° F. Prolonged low soil temperatures (below 32° F) may cause the plant to produce rough-shaped bulbs and numerous small axillary cloves.

Soil

Garlic grows in almost any well-drained, friable soil. Soils with an abundance of organic matter promote uniform bulb development and have superior water-holding capacity. Water-holding capacity is important because garlic has a sparse and shallow root system, and dry conditions early in the growing cycle reduce vegetative growth and subsequent bulb development.

The ideal soil pH for garlic production is between 6.5 and 7.0. Soils with a pH below 6.0 may be associated with poorly-formed and discolored cloves.

Water and Irrigation

Because of garlic's sparse root system, the upper layers of the soil must be kept moist to attain maximum growth rates and yields. Plenty of moisture is especially needed in the spring to promote vegetative growth. Virtually all U.S. commercial garlic is irrigated (Appendix table 1). Even in western Oregon, where rainfall is relatively dependable, growers irrigate most garlic acreage.

A critical management decision in garlic production involves deciding when to make the last application of water prior to harvesting. For fresh-market garlic, "water shut-off" occurs about 3 weeks prior to harvest, when the garlic shoots start to bend over. Late irrigation can result in rotting and discoloration of the bulb skins, thus decreasing market value. For dehydrated garlic, where bulb appearance is less important than for fresh-market garlic, water shut-off may be closer to harvest-time to promote bulb size and yields. Garlic for

Certain plants require a period of exposure to cold temperatures, called vernalization. In the case of garlic, vernalization promotes bulb formation.

dehydration may receive light irrigation until most of the shoots have collapsed.

Water quality is important in obtaining high garlic yields. High salinity in the irrigation water can reduce yields.

Seed Garlic

Seed garlic is grown principally in Nevada and eastern Oregon, where the dry, cool high-desert climates facilitate producing disease-free seed. A small quantity of seed garlic also is grown in northern California.

Producers and dehydrators in California generally control the seed-producing operation. They contract with farmers in seed-growing regions for a given acreage. Then, they supply the amount and strain of seed which they want planted. At the end of the season, seed producers sell all of their production to the California producers/dehydrators. California producers may plant the seed for commercial garlic or return part of it for further "multiplication."

White rot is a particularly serious peril for seed producers. If a field becomes infected, buyers do not want the garlic for seed. Farmers may be able to sell infected fields as dehydrated garlic, but at a heavily discounted price. The greatest loss from white rot infection, however, may be that the farmer's reputation as a producer of disease-free garlic becomes tainted. The white rot inoculum, once in the soil, remains for years. Consequently, producers/dehydrators in California may refuse to contract with the affected grower for future seed production.

Propagation and Planting

Garlic is seeded by planting individual cloves. Bulbs for planting are first "cracked" (separated into individual cloves) and graded. Small, damaged, and infected cloves are discarded. Cracking is accomplished using specially-built rubber-faced rollers that minimize damage to the cloves. After cracking, the bulbs may be treated with hot-water and a fungicide to help control white rot fungus and stem and bulb nematodes.

Although planting and harvesting dates vary somewhat among areas, garlic is generally planted in the fall and harvested the following summer. In Arizona, garlic is planted in November and harvested the following May. In central California, garlic planting extends from September through November for harvest during June-August (Rubatzky). In

northern California, Nevada, and Oregon, planting is usually complete by the end of October and harvesting takes place the following July.

For ease of digging, and to reduce soil compaction, garlic is usually planted on beds raised 6-8 inches high and spaced 40 inches apart (center to center). Two rows are planted on each bed. Plant density ranges from 12 to 18 plants per bed-foot. The lower densities are used to produce large bulbs for sale to the fresh market, while the higher densities are used to produce maximum yields for processing, where bulb size is less important.

Fertilization

Garlic has relatively high plant nutrient requirements. Fertilizers are usually applied based on soil test results. General fertilization recommendations consist of applying 50-75 pounds of nitrogen per acre in the fall and an additional 100-175 pounds in the spring. Phosphorus and potassium are usually applied just prior to planting, at a rate of 100-150 pounds of phosphorus (P_2O_5) per acre and up to 150 pounds of potassium (K_2O). Sulfur is applied in the fall, usually at a rate of 30-50 pounds per acre.

Rotations

Garlic is grown in rotation with other crops. Most farmers raising garlic also grow a number of other vegetables and field crops. Rotating land out of garlic at least every four years before planting another crop is essential for controlling white rot, as well as other diseases and nematodes.

Harvesting and Handling

Garlic is ready for harvest when the tops become partly dry and bend to the ground. Garlic that is intended for fresh-market use may be harvested at an earlier stage (with some green color still remaining in leaves) than garlic for dehydration. Earlier harvesting allows for peeling and braiding (some garlic is sold in bunches in which the tops are braided).⁶

Garlic bulbs are surrounded by a multi-layer sheath of dry leaves. The outer layers of this sheath, which may be stained by the soil or by rain during field drying, are peeled off fresh-market garlic to give it a shiny white color.

The first step in harvesting fresh-market garlic involves running a cutter bar beneath the plants to loosen the bulbs from the soil. Fresh-market garlic is then pulled from the soil by hand and placed in windrows where the tops are arranged to protect the bulbs from sunscald. The bulbs are then dried in the field for 10-20 days. At this point, the tops and roots are hand clipped, and the bulbs are placed in large bins for transport to storage.

With both garlic for processing and seed garlic, the tops are removed by flailing and burning the field with a propane flamer before digging. After the bulbs are dug from the ground, they are placed in windrows for a brief (1 to 2 day) curing period. They are then hand-placed into sacks or bins for final curing (10 to 14 days, or as needed). Excessive sunlight may cause sunscald on the bulbs during the windrowing period, especially when temperatures exceed 90° F. Excessive exposure to sunlight may also cause the garlic bulbs to develop an undesirable green coloring.

Storage and Packing

Fresh-market garlic maintains its marketable quality for up to three months in conventional cold storage. When held in controlled-atmosphere cold storage, fresh garlic maintains its marketable quality for up to 10 or 11 months. As a result, shippers can offer fresh garlic throughout the year.

Fresh garlic is commonly shipped in 30-pound cartons. Some garlic is also sold in other container sizes, such as 5-, 10-, 15-, and 22-pound cases or cartons. A 22-pound carton (10 kilograms) is the common size of container for fresh garlic from Argentina and China.

Marketing Garlic

The bulk of U.S. garlic is sold through a small number of large firms. Reportedly, there were only about 10 major firms in California which packed and shipped fresh-market garlic in 1994, and 6 firms that produced dehydrated garlic (USITC). In addition, a few firms market seed garlic.

The U.S. standard for fresh garlic includes only one grade, USDA No. 1. All other fresh garlic is designated as "unclassified," which is not a grade standard. The California Department of Food and Agriculture offers an inspection service for fresh garlic. Inspection, however, is at the option of the buyer and seller. If a sale is contingent on

the garlic meeting the USDA No. 1 grade, the buyer or seller may request a California Department of Food and Agriculture inspection to verify the grade. Costs for this service are paid by the party requesting the inspection.

The fresh-market garlic trade uses a descriptive system to designate bulb size. Although size classifications are widely recognized by individuals and firms dealing in garlic, the system is voluntary and different shippers may use somewhat different definitions. The following table describes the system used by one large garlic company, A&D Christopher Ranch:

Trade name	Diameter	Average count per pound
Small Tube	1 1/2" to 1 7/8"	19-24
Medium Tube	1 3/4" to 2"	18-19
Large Tube	1 3/4" to 2"	15-16
Giant	1 7/8" to 2"	12 1/2
Jumbo	2 1/8" to 2 1/4"	10 1/2
Extra Jumbo	2 1/4"	8 1/2
Super Jumbo	2 3/8"	7 1/2
Colossal	2 5/8"	6 1/2
Super Colossal	2 3/4" and up	5 1/2

Garlic destined for dehydration is weighed and inspected by California Department of Food and Agriculture inspectors as it enters the processing plant (Rohmer). Samples are taken from each load and graded to determine the extent of defects, trash, and dirt. A clove is declared defective if it is decayed, has "waxy breakdown" or insect or mechanical damage, is green, or has started to sprout. Waxy breakdown is identified when the flesh has a yellow or brown, waxy, transparent appearance.

The extent of dirt and cull material in the sample also is determined and deducted from the gross weight. Dirt consists of clods, loose soil, and soil adhering to the raw product. Cull material includes tops, roots, rocks, loose outer scales,

and material other than the raw product. The sample is also tested for excess moisture.

Various categories of garlic for processing do not require inspection. These categories include garlic that is produced in foreign countries, cull-outs from fresh-market packing, loads of mixed ownership, and the processors' own garlic.

Costs of Production

We located three cost of production budgets for garlic--one each for California, Arizona, and Oregon (Appendix A). Significant differences appear in a comparison of the estimated costs for the three areas. This is in part because the California budget is for garlic for processing, while the Arizona budget is for fresh-market garlic and the Oregon budget is for seed garlic. In addition, note that the California budget represents costs associated with 1983 input prices, which may differ substantially from costs in the 1990's (as represented in the other budgets). Pre-and post harvest and ownership costs are summarized in Table 6.

Additional cost data appear in a U.S. International Trade Commission study of the U.S. garlic industry, which was conducted as part of an investigation of fresh garlic imports from China. As part of that study, the USITC reported operating expenses for producing garlic in California (Appendix table 5). Their estimates show that the costs associated with producing garlic for the fresh market in the early 1990's were higher than the costs associated with producing garlic for processing.

Three factors partially explain the higher costs associated with fresh-market garlic production. First, harvesting expenses for fresh-market garlic are higher because it is hand-harvested, while dehydrated garlic is mechanically harvested. Second, grading and packing expenses for fresh-market garlic exceed the processing costs for dehydrated garlic. Third, per-acre yields for fresh-market garlic tend to be lower than per-acre processing yields, explaining part of the higher planting and growing costs for fresh-market garlic.

Production Perils

Untimely rain at planting is the primary production peril in garlic production in central California (Rubatzky, Smith). In contrast, a combination of extreme cold and lack of snow cover

was cited as the most damaging peril in the seed-growing areas of northern California, Oregon, and Nevada. Garlic for seed is typically grown in areas with lower winter temperatures than garlic produced for the fresh market and dehydrated garlic. Various insects and diseases attack garlic, but growers are able to control losses with available management practices.

Untimely or Excessive Rains

Extended wet periods during the planting season can make the soil too wet to work, delaying planting past recommended planting dates. The bulk of the garlic in central California is planted during October and November, which coincides with the start of the rainy period. In some years, rains may begin before the entire garlic crop is planted.

Table 6--Garlic: Costs of production

Item	Arizona (1993)	California (1983)	Oregon (1994)
		Pounds	
Yield	19,500	14,000	17,000
		Dollars per acre	
Cash expenses:			
Preharvest	492	844	472
Post harvest	1,329	--	484
Total	1,821	--	956
Ownership costs	566	919	236
Total costs	2,386	--	1,192

Note: Preharvest and postharvest expenses include allocated cash overhead expenses.

Sources: May and Yeary; Turner and Butler; University of Arizona.

Once planted, garlic plants growing in saturated soils for extended periods during the winter may produce numerous shoots but fail to form bulbs, or they may make poorly-formed bulbs (Voss). This condition is called "brooming."

Excessive rain is also a problem after harvest. Excessive rains that occur during the field-drying operation may discolor the bulbs, reducing their value for the fresh market. Excessive rain while the garlic is drying also promotes bulb decay.

Flooding

Flooding was cited as a cause of crop loss in the Willamette Valley in western Oregon and in parts of California (Mansour; Smith). Flooding may cause damage in several forms. It may wash the seed cloves out of the ground, deposit thick layers of silt over the seed, or kill the plants (from drowning) if they remain submerged for a long period of time.

Extreme Cold

Although garlic can withstand frosts and light freezes, garlic plants can be killed by excessively low temperatures (Butler). Losses due to freeze damage are most likely to occur when no snow cover exists to insulate the plant.

Extreme cold was cited as the major production peril in eastern Oregon. Over \$300,000 in ad hoc disaster payment were made for garlic in Jefferson County in 1991 due to losses caused by freezing temperatures (Brown). Yields in Jefferson County averaged only 0.5 tons per acre in 1991, whereas yields in most years average 7-10 tons an acre. Cold temperatures, in combination with drought and a lack of snow cover, also were cited as a cause of yield losses in Nevada in 1991.

Cold temperatures reportedly are not a serious peril in the central California growing areas. The winters are relatively mild, and garlic can withstand even the coldest temperatures likely to exist in these areas.

Drought

Even though nearly all U.S. garlic production is irrigated, drought is occasionally cited as a contributing factor to yield losses. For example, drought was a cause of ad hoc disaster payments for garlic in Fresno County in 1991 and 1992 (Jones). California experienced an extended drought in the

late 1980's and early 1990's, and growers did not receive their full water allocations.

Drought was also cited as a contributing factor for losses in Nevada in 1991. Farmers reportedly received only 35 percent of their normal water allotment in 1990 and cut back on irrigation. As a result, garlic plants entered the 1990/91 winter in weakened condition. This situation was accompanied by a lack of snow cover and extreme cold. The combination of weakened plants, extreme cold, and lack of snow cover resulted in a high incidence of winterkill (Cook).

Excessive Heat

Excessive heat can reduce garlic yields, but it is unlikely to cause losses to the extent that insurance indemnities are triggered. Excessive heat slows bulb development, potentially reducing bulb size and lowering yields (Rubatzky). High temperatures at harvest-time also can increase the incidence of sunscald among drying garlic bulbs. Although sunscald reduces the value of the crop, growers can take measures to reduce damage and losses are likely to be fairly small.

Hail

Hail storms occasionally cause isolated losses to garlic in eastern Oregon, depending on when they occur and the severity of damage. Hail is most serious when it occurs during the growing period, before the bulbs have reached their mature size. Hail is less of a peril in central California because it occurs infrequently in that region.

Insects

The following section describes a number of insects which are pests of garlic. In general, insects are not considered to be a serious peril to garlic production because growers have the means to control them with present management practices.

Onion Thrips

Onion thrips are small (about one twenty-fifth of an inch long), and pale yellow to light brown in color. The adults have fringed wings and fly great distances. The young are pale yellowish-green and wingless.

Both the adults and larvae suck juices from plant leaves. Injured areas turn white or silvery and may shine in the sun. This sheen results from the air which occupies the space in the damaged cells. Damage first appears as small spots that

eventually run together to form large damaged areas. Plants may become desiccated, and wither and collapse.

Thrips are managed using a combination of cultural practices (including crop rotation, sanitation practices, and cultivation practices), as well as biological and chemical controls intended to keep populations below economic threshold levels.

Cutworms, Armyworms, and other Moth Larvae

Several species of moth larvae (worms) may attack garlic. They cause damage by tunneling into the bulbs or by chewing off new shoots. Generally, control is easily achieved by applying bacillus thuringiensis, a biological pesticide.

Wireworms

Wireworms are the larval stage of the click beetle, a hard-shelled, yellow or brown beetle that is between one-half to one-and-one-half inches long. The larval stage feeds on garlic roots and bulbs in the field. Wireworm problems are most likely to occur in fields which were recently used to produce sod.

Wireworms are managed by avoiding planting garlic in soils known to be infested with this insect. Chemical pesticides also are available to control wireworm populations.

Garden Symphylans

Symphylans are small, white, centipede-like animals which live in the soil. They feed on plant roots, reducing vigor and yields. Infestations generally are associated with heavy silt or loam soils. Soils can be treated with chemical pesticides to control symphylans if a problem occurs.

Diseases

Root rots and viruses are the most serious disease perils. When substantial losses occur, they are frequently associated with lax management. Viruses are widespread in the major growing areas, and reduce production potential for all types of garlic. Planting virus-free garlic gets the plants off to a good start and minimizes the yield-reducing effects of viral infections (Rubatzky; Smith).

Fusarium Basal Rot

Fusarium basal rot is a fungal disease that causes preemergence decay of garlic cloves and seedlings. It may also cause in-season decay of the stem plate and storage leaves, and post-harvest decay of the cloves in stored bulbs. Post-harvest decay may involve single, several, or all cloves in the bulb.

Fusarium basal rot was first found in California in 1976 and since has been found in Oregon and Nevada. Losses have ranged from negligible to 40 percent of the bulbs in a field. Additional losses have also occurred in storage (Schwartz and Mohan). Reportedly, California growers experience Fusarium basal rot infections each year in some fields (Smith).

Initial infections can be transmitted through the soil. Thereafter, the disease can be transmitted through seeds to future generations. Bulbs and cloves from infected plants, however, may or may not develop disease symptoms. Infected seed cloves may be produced through successive generations without symptoms, only to have the disease flare up later. Environmental or handling factors may be responsible for this erratic occurrence. In addition to transmission through the seed, the pathogen may be transported from field to field with soil and infected debris and in irrigation runoff water.

The incidence of basal rot increases with the frequency of growing susceptible crops. The production of garlic in a four-year or longer rotation with non-host crops reduces the rate of infection. Avoiding seed sources known to carry the disease also lowers the infection rate. Sanitation practices that prevent transporting the disease from field to field help to minimize the chance of infection.

White Rot

White rot is one of the most widespread and destructive fungal diseases of onions and garlic. It is a constant threat in the major garlic-growing regions. Caused by a soil-borne fungus, white rot produces premature yellowing and death of older leaves and stunting of plants, rapidly followed by the death of all foliage. The roots then rot, and the plant can be easily pulled from the soil. When high levels of white rot fungus are present, plants may die suddenly in large areas of the field. In areas that are infected to a lesser extent, plants may die in isolated clusters. White rot may also cause bulbs to rot in storage. The fungal inoculum can remain viable in the soil for long periods (perhaps as long as 20 years), even in the absence of host plants.

Primary control measures include the planting of disease-free cloves in well-drained soil and the avoidance of planting in fields with a history of white rot infection. Another control measure involves treating the seeds with hot water. Hot water treatment kills inoculum on the surface of the cloves, but does not destroy the fungus within the cloves. Applying fungicides to the seed at planting-time has reportedly provided partial control (Oregon State University Extension Service; Davis, et al.).

Pink Root

Pink root, a fungal disease, occurs mostly in areas with high soil temperatures. Although it affects a wide range of vegetable and cereal crops, onions and garlic are most likely to suffer economic damage. Pink root and Fusarium basal rot often occur together, making it difficult to distinguish which of the two diseases is the main cause of damage.

Pink root attacks only the roots of the garlic plant, which turn pink, shrivel, and die. The garlic plant commonly produces new roots, but they, too, are soon infected. Although infected plants seldom die, they become stunted and yields decline. A three-to-four year rotation in which neither onions nor garlic are grown reduces the incidence of pink root infection. Some garlic varieties are resistant to pink root. Reportedly, pink root is not a serious problem in California (Smith).

Garlic Mosaic

Caused by a complex of viruses, garlic mosaic results in stunted plants and diminished yields. Mosaic has been reported throughout the United States wherever garlic is grown. It may be transmitted from generation to generation through the seed. In addition, aphids readily transmit the virus from plant to plant. Losses of up to 50 percent have been reported in field trials comparing infected garlic with virus-free garlic. Planting large cloves reduces production losses when using infected seed. However, planting virus-free cloves has proven the most effective means of reducing yield losses.

It is difficult to determine the extent to which losses are caused by garlic mosaic because all fields are affected to some extent. Using virus-free seeds delays the onset of mosaic and minimizes yield losses. Because the virus is so readily transmitted by aphids, even fields planted with virus-free seed become infected during the season and yields fall somewhat short of their virus-free potential.

Nematodes

Stem and Bulb Nematodes

Although not a widespread problem in California, the bulb and stem nematode, nevertheless, is a potential threat to garlic production. The only known hosts for this nematode are plants that belong to the onion family, principally garlic, onions, leeks, and chives.

The symptoms of infected plants include erratic stands, stunting, and premature ripening of the top growth. In severe cases, cloves become a spongy mass, leaving little evidence of the cloves or the bulbs at harvest-time. The nematode thrives under warm conditions. Affected plants may show few or no symptoms under cool growing conditions, while high temperatures bring on symptoms quickly.

Stem and bulb nematodes are primarily spread through planting infected seeds. The nematodes lodge beneath the protective leaf and abscission layer of the clove, where they attach to the main stem. The nematodes can also be spread by machinery carrying infested soil from field to field, and by the spreading of infected debris from bulb processing and storage houses. Hot water treatment of the seed is useful in preventing seedborne infections. Bulb and stem nematodes can be effectively controlled by rotating a garlic field every 2 to 4 years with non-host crops.

Weeds

Garlic plants are poor competitors for sunlight and soil moisture and need protection against weed competition. Weed control involves a combination of mechanical cultivation, field selection, rotation, and, when needed, application of chemical herbicides.

Grower Organizations

No garlic grower organizations were identified from our contacts. The America Dried Onion and Garlic Association (ADOGA) represents the largest garlic processors in California. Because processors contract with farmers for garlic, ADOGA provides an indirect link with growers.

In addition, agricultural extension agents frequently represent a direct link with producers. In the Gilroy-Hollister area of California, the farm advisor for garlic is Richard Smith (see contact list). The agricultural extension

agent in Jefferson County, where the bulk of Oregon's garlic is grown, is Marvin Butler. He indicated that he has a close working relationship with garlic growers, and that he would serve as an initial contact person with growers in that county (see contact list).

Ad Hoc Disaster Assistance for Garlic

Ad hoc disaster payments were made available to garlic growers for losses due to natural causes in each of the years 1988 to 1994. Since garlic was not eligible for crop insurance in those years, garlic producers were required to realize a yield loss of at least 40 percent in order to be eligible for ad hoc disaster payments.

Data on ad hoc disaster payments provide an indication of potential high-loss areas. The states and counties with large ad hoc payments from 1988 to 1994 are most likely to face a relatively high risk of loss under a potential FCIC policy for garlic, and would likely have a relatively high demand for crop insurance.

Disaster assistance payments for garlic (except elephant garlic) losses totaled \$1.415 million over the 1988-94 period (Table 7). The largest payments were made in 1991 (at more than \$854,000). Payments were large again in 1992 (at more than \$266,00). These payments were due primarily to a combination of drought and extreme cold, which resulted in excessive winterkill in Nevada and eastern Oregon. Payments to California growers were reportedly the result of insufficient water allotments, which precluded irrigation of all garlic acreage.

Total disaster payments for garlic were made in 19 states over the 1988-94 period (Figure 3). The major producing states--California, Oregon, and Nevada--collected 81 percent of the total payments. No payments were made to Arizona growers. Counties collecting large payments include Fresno County, California (\$398,500 over the seven-year period); Jefferson County, Oregon (\$323,200); Colusa County, California (\$129,000); and Washoe County, Nevada (\$129,300).

Ad hoc disaster payments made for elephant garlic losses totalled \$96,645 over the 1988-94 period. Payments were made to growers in five states, with Oregon growers collecting 58 percent of the total.

Insurance Implementation Issues

Demand for Insurance

There is likely to be relatively little potential for garlic crop insurance beyond the catastrophic coverage levels because of a lack of serious perils and limited acreage. In California, where most of the acreage is located, growers view

garlic as relatively free of production perils. Most growers have large operations

and follow production practices that avoid serious insect and disease-related losses. In addition, the weather is favorable for growing garlic and weather-related yield losses rarely occur. There were only \$528,000 in disaster payments made to California farmers for garlic losses between 1988 and 1994. This amounted to less than one-tenth of one percent of the value of garlic production during this period.

Seed garlic growers in eastern Oregon, Nevada, and northern California may have more interest in purchasing crop insurance than producers in central California. The reason is that these areas have colder winter temperatures than central California, increasing the risk of crop loss due to extreme low temperatures. Producers in eastern Oregon (primarily in Jefferson County) lost approximately 95 percent of the crop in 1991 due to extreme cold and a lack of snow cover. Yields also were down in Nevada that year, due to a combination of drought and winterkill (Cook).

Despite the likely interest in crop insurance in seed garlic areas, there appears to be a limited potential for a garlic policy due to the small number of growers and the small acreage. Oregon reported 3,000 acres of garlic in 1995, having a value of \$9.0 million. Nevada reported 1,650 acres of garlic in 1995, having a value of \$4.4 million dollars. Nevada's acreage has ranged from 550 to 1,650 acres in the past eleven years.

In addition, garlic growers tend to produce a number of crops in addition to garlic, including other vegetables and field crops. This diversification provides a measure of risk protection against production losses.

Despite these factors, growers may be interested in catastrophic insurance coverage. Large firms account for the bulk of garlic acreage and may not be eligible to receive benefits under the Non-Insured Assistance Program (NAP) because their annual gross income exceeds \$2 million. These growers may want to see garlic become an insurable crop so that they may participate in catastrophic insurance coverage, which they could do at a negligible cost if garlic were an insurable crop.

Moral Hazard

Moral hazard is not likely to be a problem in insuring garlic. Although prices for fresh-market garlic typically decline during the main harvest period in late summer, garlic is storable and can be held until prices rise. In addition, the bulk of production is grown under contract with processors or

fresh-market packers, which assures the grower of a market for his or her production. This further reduces the incentive for moral hazard.

Adverse Selection

Adverse selection is most likely to occur in cases where garlic is planted in poorly-drained fields or near rivers where losses may occur because of excessively wet soils or flooding. Another potential for adverse selection occurs when garlic is planted in fields which have recently grown other allium crops, including onions. Such fields run an increased risk of harboring high levels of root rot organisms, which may cause measurable yield losses. FCIC may wish to require field inspections prior to the offering of insurance.

Reference Prices

USDA publishes season average garlic prices for California, which would serve adequately for setting reference prices for California. In Oregon the Department of Agriculture and Resource Economics at Oregon State University compiles season average prices for seed garlic. These estimates could serve as a guide for setting the price election in Oregon. The Nevada Agricultural Statistics Service reports a season average price for garlic, which could be used to set price elections in that state.

Yield Data

The best source of yield data is likely to be the garlic companies or the processors who contract with farmers for growing garlic. The companies contract for a specific acreage and pay on the basis of the amount of production. Farmers, themselves, also are likely to have good acreage and production records. Most garlic farmers have large operations and likely keep extensive records on acreage and production.

In addition, the county agriculture commissioner offices in California record data on each grower's acreage for which pesticides are applied. This information could provide further acreage documentation.

References

- A&D Christopher Ranch. Personal communication. April 1996.
- Brewster, James L. and H. D. Rabinowitch. *Onions and Allied Crops. Vol. II. Agronomy, Biotic Interactions, Pathology, and Crop Protection.* CRC Press. Boca Raton, Florida. 1990a.
- Brewster, James L. and H. D. Rabinowitch. *Onions and Allied Crops. Vol. II. Biochemistry, Food Science, and Minor Crops.* CRC Press. Boca Raton, Florida. 1990b.
- Brown, Sam. County Executive Director. Farm Service Agency. Jefferson County, Oregon. Personal communication. April 1996.
- Butler, Marvin. Agricultural Extension Agent. Jefferson County, Oregon. Personal communication. April 1996.
- Call, Robert. University of Arizona Extension Service. Personal communication. April 1996.
- California Agricultural Statistics Service. *California County Agricultural Commissioner Data.* Various years.
- Cook, Gary. Farm Service Agency. Lyon County, Nevada. Personal communication. April 1996.
- Davis, R. M., F. F. Laemmlen, and R. E. Voss. *Onion and Garlic Pest Management Guidelines.* University of California. UCPMG26. March 1993.
- Division of Agricultural Sciences. *Growing Garlic in California.* University of California. Leaflet 2948. 1976.
- Jones, Mildred. Farm Service Agency. Fresno County, California. Personal communication. April 1996.
- Mansour, N. S. Extension Vegetable Crops Specialist. Department of Horticulture. Oregon State University. Personal communication. April 1996.
- May, Don and E. A. Yeary. *Cost Analysis Work Sheet - Garlic - Fresno County - 1983.* University of California Cooperative Extension Service. 1983.
- Nevada Agricultural Statistics Service. *Nevada 1995 Agricultural Statistics.* 1996.

Oregon State University Extension Service. *Garlic*.
[gopher://sulaco.oes.orst.edu:70/00/ext/vegetables/garlic.asc]
. 1995.

Oregon State University. Department of Agriculture and
Resource Economics. *Garlic, Harvested Acres, Yield,
Production, Price, and Value of Production*. Statistical
tables. 1990-1995.

Rohmer, Bob. California Department of Food and Agriculture.
Personal communication. April 1996.

Schwartz, Howard F. and S. Krishna Mohan, editors. *Compendium
of Onion and Garlic Diseases*. The American Phytopathological
Society Press. St Paul Minn. 1995.

Sears, Sandy. Department of Agriculture and Resource
Economics. Oregon State University. Personal communication.
April 1996.

Smith, Richard. Farm Advisor. San Benito County, California.
Personal communication. April 1996.

Turner, Brenda and Marvin Butler. *Enterprise Budget Garlic
Seed, South Central Region*. Oregon State University Extension
Service. EM 8574. September 1994.

Rubatzky, Vincent. Extension Vegetable Crops Specialist.
University of California, Davis. Davis, California. Personal
communication. April 1996.

University of Arizona. Arizona Cooperative Extension Service.
Garlic Production Costs in Maricopa County, 1993.
<http://ag.arizona.edu:80/AREC/Maricopa-map.html>

U.S. Department of Agriculture. Agricultural Marketing
Service. *Fresh Fruit and Vegetable Arrival Totals for 22
Cities*. Calendar Year 1992. FVAS-3. 1993.

U.S. Department of Agriculture. Farm Service Agency.
Disaster Assistance Data Files, 1988-94. Compiled by the
General Accounting Office.

U.S. Department of Agriculture. National Agricultural
Statistics Service. *Vegetables Summary*. Various.

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

U.S. Department of Commerce. *Census of Agriculture, 1987*.
Special tabulation. 1987.

U.S. Department of Commerce. Bureau of the Census. U.S.
Trade Statistics. Various years.

U.S. International Trade Commission. *Fresh Garlic from the
People's Republic of China*. Investigation No. 731-TA-683
(Final). Publication 2825. November 1994.

Voss, Ron. Extension Vegetable Specialist. University of
California, Davis. Personal communication. April 1996.

Garlic Contacts

Marvin Butler
Agricultural Extension Agent
Jefferson County, Oregon
24 Southeast D Street
Madras, Oregon 97741
(541) 475-3808

Ronald Voss
Extension Vegetable Crops Specialist
University of California, Davis
Davis, California
(916) 752-1249

Richard Smith
Farm Advisor for Garlic
San Benito County, California
P.O. Box 699
Hollister, California 95023
(916) 637-5346

Ed Kurtz
American Dried Onion and Garlic Association (ADOGA)
P.O. Box 1763
Salinas, California 93902

Appendix A

Cost of Production Budgets for Garlic

South Central Oregon
Fresno County, California
Maricopa County, Arizona