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PROTECTED AGRICULTURE AS A METHYL BROMIDE ALTERNATIVE? CURRENT REALITY AND FUTURE PROMISE

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Abstract. **Despite extensive and expensive research into methyl bromide alternatives over the past decade, there is no one product that is an acceptable alternative. Methyl bromide was applied to 99% of the pepper acreage, 100% of the strawberry acreage, and 77% of the tomato acreage in Florida in 2002. Cucurbits, either cucumber or squash, are planted directly after these crops and so are indirectly dependant upon methyl bromide. Over the same time period, the areas of inexpensive, low-energy, passive-ventilated, plastic-covered greenhouses have expanded dramatically worldwide. For example, the Mediterranean Basin is estimated to have 100,000 ha, and the area in Mexico is increasing by 30% annually. The greenhouse production area in the U.S. is also expanding rapidly and is estimated at 1,000 ha (~2,500 acres). Greenhouse production offers several advantages including up to 10-fold increased yields, improved crop quality, recycling of water and nutrients, and the potential to grow pesticide-free produce. Soilless media eliminates the need for methyl bromide as it avoids weeds, soil-borne pathogens or plant parasitic nematodes. Imported, quality greenhouse produce from several countries including Mexico, Canada, and Spain is sold at a premium over U.S. field-grown produce. The Protected Agriculture Project (www.hos.ufl.edu/ProtectedAg) at the University of Florida adapts available greenhouse technology for Florida conditions and has developed extensive information for the production of most of the major greenhouse vegetable crops.**

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Greenhouse production is an effective, integrated approach that offers an alternative to methyl bromide use for production of Florida vegetables. Greenhouse production using soilless media eliminates the need for methyl bromide or other chemical fumigants. The greenhouse environment with soilless production systems avoids weeds, soil-borne pathogens or plant parasitic nematodes. Screened structures drastically reduce the presence of insects, and those that are present can be controlled using biological control. There is increased efficiency in use of fertilizer and water, which can be recycled within the system. The techniques used in greenhouse production are part of an overall integrated pest management system.

Methyl Bromide Alternatives

Research into methyl bromide alternatives to date has focused primarily on chemical alternatives to methyl bromide and this research effort has been costly. For example, between 1993 and 2002 the USDA spent $135.5 million to fund research into alternatives (Anonymous, 2003). In Florida between 1996 and 2001, there were extensive field trials with 54 projects conducted by 21 researchers from the University of Florida and USDA. The results from this research program have not provided an alternative that is considered as good as methyl bromide in terms of efficacy and ease of use. Instead, a combination of chemicals is required and these are more sensitive to environmental conditions and variations in application methods than methyl bromide (Anonymous, 2003; Mirusso, 2002; Paul, 2004).

California is the largest user of methyl bromide, although it applies methyl bromide to a lower percentage of its production area than Florida (USDA-NASS, 2003). Growers in California have made more of a transition to alternatives compared to the growers in Florida (USDA-NASS, 2003).

Alternative, non-chemical production systems have been investigated. For example, organic production of strawberry (*Fragaria* × *ananassa* Duch.) in California is considered to be a valid alternative (EPA, 1995). Soil solarization can be effective under suitable climatic conditions, but frequently does not perform well under the wet, cloudy conditions that occur during the summer in Florida. The potential of greenhouse production systems using soilless culture have not been considered as a serious methyl bromide alternative for vegetable production in the U.S. However, tobacco producers are an example of a group that has successfully made the transition from field production of seedlings with methyl bromide fumigation, to greenhouse production in a direct-seeded float system (EPA, 1996). Moreover, some growers of peppers (*Capsicum annuum* L.), strawberries, and cucumbers (*Cucumis sativus* L.) in Florida are already using greenhouse production. Other growers are considering the option, as it solves other production problems beyond replacement of methyl bromide.

Vegetable Production in Florida

Vegetable production is extremely important to the state of Florida, with a contribution in excess of $1.6 billion in 2002-2003. The largest component is fresh market tomatoes (*Lycopersicon esculentum* Mill.), which contributed $546.7 million dollars and were grown on 17,400 ha (43,000 acres) (FASS, 2003) (Table 1). Field-grown bell peppers were grown on a total of 7,200 ha (17,700 acres) (FASS, 2003) and, with a fall crop on 2,000 ha (4,900 acres) valued at $44.4 million and a spring crop on 5,200 ha (12,800 acres) valued at $131.2 million, peppers are important to the economy of the state of Florida.

Cucurbit crops are also economically important to the state of Florida. During the 2002-2003 seasons, fall and spring crops of cucumbers were valued at $60.5 million, with a total area planted to cucumbers in Florida of 4,600 ha (11,300 acres). The squash (*Cucurbita pepo* L.) crop had an economic value of $44.5 million and was grown on 4,000 ha (10,000 acres). Watermelons [*Citrullus lanatus* (Thunb.) Matsum. & Nak.] were grown on 10,000 ha (24,000) acres throughout the state and had a total value of over $61 million (FASS, 2003).

Table 1. Area, value and methyl bromide use for crops in Florida.

Crop	Area (ha)[x]	Value ($million)[z]	Methyl bromide (% area)[y]
Tomato	17,400	546.7	77
Bell pepper	7,200	170	99
Strawberry	2,800	153	100
Cucurbits			
Cucumber	4,600	56	x
Squash	5,000	44.5	x
Watermelon	10,000	62	x

[z]Fla. Dept. Agr., FASS (2004).
[y]USDA-NASS Chemical Usage Data (2003).
[x]Methyl bromide is indirectly important to 80% of cucurbits grown in a double cropping system with tomato or strawberry in Hillsborough, Palm Beach, Miami-Dade and Collier Counties.

Strawberry is also an economically important crop in Florida, especially where strawberry production is concentrated in the Dover/Plant City area in Hillsborough County. The state ranks second in harvested area, total yield, and production after California (Childers, 2003). In 2002-2003, the area devoted to strawberries in Florida was 2,900 ha (7,100 acres) with a value of $136 million and in 2001-2002 there were 2,800 ha (6,900 acres) grown with a value of $153.5 million (FASS, 2003). The decline in returns to strawberry growers in 2003 was due to a cold winter and an early inrush of strawberries from California in early March that depressed prices. Production of strawberries occurs during the winter months, from late November to February or March. Prices are highest for strawberries during December and January, and this is when field production is lowest. Currently, most of the strawberry crop is marketed in the United States, with only 1-2% exported to Europe and 5-7% to Canada.

Importance of Methyl Bromide in Production Systems

Field production in Florida is still heavily dependant upon the use of methyl bromide. Methyl bromide is considered extremely important by Florida growers due to its control of soilborne pathogens, root-knot nematodes (*Meloidogyne* spp.), and weeds, particularly nutsedge (*Cyperus* spp.). Tomato producers applied methyl bromide to 77% of the production area during 2002. For bell peppers, methyl bromide was applied to 91% and 99% of the acreage in Florida during 2001 and 2002, respectively. This compares to application to 37% of the California pepper acreage (USDA-NASS, 2003).

In the 2002 growing season, 99% of the strawberry crop acreage in Florida was fumigated with methyl bromide. This compares to application to 55% of the strawberry production area in California (USDA-NASS, 2003). The loss of methyl bromide will hurt Florida growers because although Telone II (1,3-dichloropropene, Dow Chemical, Indianapolis, Ind.) is registered as an alternative, the label specifies set-backs of 100 ft from residential areas. The Dover/Plant City area is adjacent to Tampa and very urbanized, and these set-backs will result in the loss of productive land. In addition, the soils overlie karst topography and there are concerns about groundwater contamination from Telone II. The strawberry growers applied for an exemption and have received a partial exemption for 2005.

Cucurbit production generally is not directly dependant upon methyl bromide use. During the 2000-01 growing season, methyl bromide was applied to 14% of the 4,655 ha (11,500 acres) used in squash production in Florida, and this dropped to less than 1% in 2002. The fumigant was not reported to be used in production of cucumbers, although it was applied to 12% of the U.S. production area in 2002 (USDA-NASS, 2003). However, methyl bromide is indirectly vital as 80% of cucurbits are grown in a double cropping system with tomato or strawberry in Hillsborough, Palm Beach, Miami-Dade, and Collier Counties. After application for strawberry and tomato, the benefits of methyl bromide are used for the double crop. Without the double cropping system, tomato and strawberry will become unprofitable. So methyl bromide is essential for the profitability of both crops, but is only documented for the primary crop (D. L. Hopkins, UF/IFAS CFREC, personal communication).

No exemptions have been granted for continued use of methyl bromide on cucurbits after 2005, and this will make field production increasingly difficult. Cucurbit production in greenhouses, especially of cucumbers, is standard practice in Europe, and some growers in Florida are moving to greenhouse production. The short cropping period for cucumbers and squash means that a crop can be incorporated into the yearly cropping cycle with peppers or strawberries in the greenhouse as it is in the field.

Greenhouse Vegetable Production

Greenhouse production area in the U.S. is expanding rapidly and is estimated at 1,000 ha (~2,500 acres). In Arizona, the greenhouse production area has increased by 40% since 1996. There were an estimated 40 ha (100 acres) in Florida in 2002. Major greenhouse production states are Arizona, California, Pennsylvania, and Florida. The major greenhouse crops in the U.S. are: tomatoes (500 ha), herbs (50 ha), peppers (200 ha), lettuce (*Lactuca sativa* L., 50 ha) and cucumbers (200 ha) (D. J. Cantliffe, personal communication). Compared to production acreage in the rest of the world, U.S. greenhouse production is small.

Intensive production in established greenhouses, constructed of glass and heated with fossil fuels, has been ongoing in Europe for decades, especially in the Netherlands and Canada (Cantliffe and VanSickle, 2001). More recently there has been a huge increase in greenhouse production in economical, plastic-covered greenhouses in warm climates that require little or no heat for year-round production of vegetables. Mexico is increasing its greenhouse area, and in the Mediterranean Basin, especially in Spain, greenhouse production systems have increased dramatically in recent decades (Cantliffe and VanSickle, 2001).

Greenhouse Trends in World Vegetable Production

In much of the world, greenhouse production of vegetable crops has replaced commercial field production. Greenhouse production systems in northern Europe and Canada have been established for decades; these systems are high-cost, glass greenhouses that require fossil fuels to ensure production. Unable to produce during the winter without additional lighting, Canada, with 800 ha (2,000 acres), and the Netherlands, with 3,200 ha (8,000 acres), have ceased 12-month production (Cantliffe and VanSickle, 2001)

The 1990s saw an explosion in the use of lower-cost, plastic-covered greenhouses in mild climates for producing vegetables around the world, and this trend is continuing. Major expansion in the areas of greenhouse production is occurring in countries that export into the U.S. Mexico, the largest exporter of vegetables to the U.S., currently has 2,000 ha (5,000 acres) and is expanding its greenhouse production area by 30% annually (J. Castellanos, personal communication). Spain has over 60,000 ha (140,000 acres), including 2,000 ha (50,000 acres) of tomatoes and 1,000 ha (25,000 acres) of colored peppers (Fig. 1). The Mediterranean region as a whole has the highest concentration of greenhouse production in the world with around 100,000 ha (250,000 acres) (Cantliffe and VanSickle, 2000).

The greenhouse production industry in the U.S. is expanding rapidly, although it is many times smaller than that of Europe. North America has about 75% of the population of Europe but less than 2% of the greenhouse vegetable production. This situation exists even though the U.S. has more sunlight, lower energy costs, and better availability of labor compared with Europe. In 1991, Florida had the highest acreage of greenhouse vegetable production of any state in the U.S. Now other states such as Arizona have larger greenhouse production areas (Brentlinger, 1999; Cantliffe and VanSickle, 2000; Tyson et al., 2001).

U.S. Imports of Greenhouse Produce

The U.S. was the second largest importer of vegetables ($2.1 billion annually) between 1999 and 2001 (Stout et al., 2004). Markets are increasing rapidly for greenhouse-grown produce, especially for cluster tomatoes, yellow, orange and red peppers, Beit Alpha cucumbers, and baby squash. Although these products command a relatively high price, often many times that of field-grown, consumers are willing to pay for their commensurately high quality and seasonal availability. There is a demand for high-quality, greenhouse-grown vegetables in the southeastern U.S. and growers from outside the region and country are supplying this need. For example, in 1991 just 2% of the tomatoes consumed in the U.S. were

Fig. 1. Greenhouse production in Almería, Spain, located in the coastal strip between the urban development along the shore of the Mediterranean and the mountains.

imported from Canada. By 1999, this had increased to 20% due to a large expansion in the Canadian greenhouse industry (Stout et al., 2004).

Imports of cucurbits increased substantially from 1995 to 2002: cucumbers were up by 88%, squash up 53%, and melons (*Cucumis melo* L.) increased 35%. Value of imports of squash increased from $73 million to $113 million. Value of imports of peppers rose from $242 million to $456 million over the same time period. A breakdown of the different producers of peppers with information on field- and greenhouse-grown product is shown in Table 3 (Jovicich et al., 2003; 2004). Mexico is the source of the majority of greenhouse imports (Stout et al., 2004) and the greenhouse production area in Mexico is increasing annually. Most of the imports enter the country over the period from December through April. This is the period when the competitive advantage of Florida growers would be most increased by the use of greenhouse production.

Several factors are believed to have contributed to the increase in imports, including the strong U.S. dollar during the 1990s, which lowered the costs of imports. The recent fall in the value of the dollar should help to counteract this trend. Several other factors are also still in effect, including U.S. population growth and increases in per capita GDP. Consumers are increasing their consumption of fresh fruits and vegetables. This trend looks to be set to continue as there is increased consumer awareness of the health benefits of fresh fruits and vegetables and as supermarkets continue to expand the range of fruits and vegetables that they carry (USDA-FAS, 2003).

Consequences of Increased Imports of Greenhouse Produce

Florida growers have lost market share in recent years, as a greater percentage of sales of vegetables in retail markets and supermarkets throughout the U.S. have been produced in greenhouses (Cantliffe and VanSickle, 2000; 2001). A greater percentage of tomatoes and peppers come from greenhouses, especially cluster-type tomatoes and colored peppers produced in Holland, Israel, Canada, Mexico, and Spain. The Canadians and Dutch have a long production season, and can deliver vegetables from March through November due to their high-cost production systems. Vegetables cannot be grown in northern countries during the winter months due to poor light quality. Imports of Spanish and particularly Mexican greenhouse-grown produce compete directly with Florida produce. Increases in imports of greenhouse tomatoes, peppers, and other vegetables have had significant impacts on Florida growers of winter, field-produced vegetable crops (USDA-FAS, 2003).

Challenges to Vegetable Production in Florida

Growers in Florida face several other challenges and problems in addition to loss of methyl bromide and increased competition from greenhouse-grown imports. Increased urbanization has caused losses of much of the more desirable (warmer) production land, especially in southern Florida. There is increased regulation of water, fertilizer, and pesticide inputs. Best management practices (BMPs) are being introduced with the aim of reducing environmental damage, including point-source pollution of water resources. Growers are concerned that these impose an increased regulatory burden. There are continued challenges from weather, including freezes, winds, and rain, which reduce the quality of the produce. Pests and diseases continue to cause problems and insect-vectored viruses can cause severe losses in some crops. There are also concerns that labor availability may be a problem in some areas in the future. On top of these problems, an increase in high-quality imports, including greenhouse-grown produce, since the 1990s has depressed prices and returns to growers of field produce.

Benefits of Greenhouse Production

A transition to greenhouse production provides several benefits and can alleviate or eliminate problems facing Florida growers. In the greenhouse, yields are three to ten times greater than in the field, so less land is required. Quality of greenhouse-produced fruits and vegetables are higher as the crops are protected from the weather, and this means that growers can receive premium prices. The plants are grown in soilless media, which eliminates problems of weeds, soil-borne pathogens, and plant parasitic nematodes, and eliminates the need for soil fumigants and methyl bromide. Biological control is used to manage insect pests (Osbourne et al., 1994; Rondon et al., 2003) and, in screened greenhouses, insect-vectored viruses are not a problem. Increased efficiency of harvest labor is achieved in greenhouse production compared with the field. Also, the greenhouse systems increase efficiency in use of water and fertilizer as these inputs can be recycled over and over within a closed fertigation system. Present greenhouse technology allows all water and nutrients to be recycled and sterilized, thus saving on water and fertilizer costs. More importantly from an environmental perspective, recycling reduces pollution from leached nutrients and pesticides in ground water and waterways. This lessens the potential regulatory burden compared with field vegetable growers, who must follow the BMPs to reduce fertilizer contamination of groundwater and waterways.

Competitiveness of Greenhouse and Field Production Systems

The transition to greenhouse production systems that is occurring in the rest of the world enables overseas growers to be competitive in U.S. markets. Methods of greenhouse production are well established and enable more efficient production in terms of yields per unit area, quality produce, water and nutrient use, and pest and disease management within the greenhouse environment.

Florida growers are affected by loss of market-share due to increased competition with imports of greenhouse-grown quality produce. Their use of methyl bromide has enabled them to keep their costs low and to compete with imports on the basis of cost. In the absence of methyl bromide, their costs will rise and this will have a negative impact on the economic viability of their operations (Anonymous, 2003; VanSickle, 1998). However the driving factors that have caused a transition to greenhouse production in the rest of the world are also in effect in Florida. Land is increasing in value, consumers are prepared to pay for high quality produce, and there are concerns about the intensive use of pesticides in agriculture, both from the environmental and food safety perspective.

The Protected Agriculture Project (PAP) at the University of Florida

The PAP was established in 1999 as a demonstration project for the greenhouse production of vegetables. Research is conducted inside screened, plastic-covered greenhouses with passive venting that are commercially produced and relatively economical at \$21-\$42 per m^2 (\$2-\$4 per ft^2) (Fig. 2). Greenhouse methods from other locations are adapted to function efficiently under Florida conditions. Production systems have been developed for growing peppers, tomatoes, strawberry and cucurbits, including cucumber, squash, muskmelon (*Cucumis melo* L.), and watermelon without pesticides in soilless culture (Cantliffe et al., 2003; Jovicich et al., 2003. Paranjpe et al., 2003; Shaw and Cantliffe, 2002; Shaw et al., 2000; 2004). A goal of the PAP is successful greenhouse production without the use of pesticides. This gives added value to the vegetables produced as well as providing a number of other environmental and consumer safety benefits.

Over the past 5 years, many of the requirements for successful vegetable production in a passive ventilated greenhouse have been researched, and research continues. Production success equal to or greater than Spanish and Israeli producers has been shown to be possible (Table 2). Information on the research projects, production methods, and results of trials is widely distributed and shown on the website. (www.hos.ufl.edu/ProtectedAg).

With crops such as cucumber where the cropping seasons in the greenhouse and field can be similar, there can be a direct comparison between greenhouse-grown and field-produced cucumbers with respect to marketable yield, cost returns to the grower, and also the water and fertilizer use efficiency (Table 4). Although Beit Alpha cucumbers are smaller than slicing cucumbers (115 vs 230 g), yields are over eight times greater. The returns to the grower are also greater with a cost of \$1.54 per kg for Beit Alpha cucumbers and \$0.40 per kg for field-produced cucumbers. This increase in water and nutrient efficiency in a cucumber trial at the PAP was without the benefit of a water and nutrient recycling system. With a Fertimix/Sanitation recycling system (Netafim, Israel), water and nutrient efficiency is likely to be increased several-fold.

Our preliminary economic analyses based upon the costs of greenhouse construction and of production are promising for production of cucurbits, peppers, and strawberries, and indicate that greenhouse production can be a profitable alternative to field production with methyl bromide (Jovicich et al., 2004; Paranjpe et al., 2004; Rodriguez et al., 2004). Gross returns for peppers and cucumbers are substantially higher in the greenhouse than in the field (Table 5).

Table 2. Productivity of greenhouse crops (kg m^{-2}) in Holland, Spain and Florida and Florida field production.

Crop	Almería[z], Spain	Holland[z]	Florida: Greenhouse[x]	Florida: Field[w]
Cucumber	8-9	58	7-28	3.0
Pepper	6-7	26	7-14	3.3
Strawberry	—	8-10[y]	11	3.2
Tomato	10-12	42	8-20	4.0

[z]Jovicich et al. (2004) www.hos.ufl.edu/ProtectedAg.
[y]Jose Lopez Medina, University of Huelva (pers. comm.).
[x]Values from trials at the Protected Agriculture Project. Produced without a water and nutrient recycling system.
[w]Average over 10 years (Olson and Simonne, 2003).

The Future

Increasingly, growers are interested in greenhouse production as an alternative to the use of methyl bromide. A few Florida growers of cucurbits, peppers, and strawberries are investing in greenhouse technology (Paul, 2004). However, before there is a wider transition from field-based systems dependent upon methyl bromide to greenhouse production in soilless culture, there are several issues that must be addressed. The economics of greenhouse production systems in Florida must be completely evaluated. Start-up costs for greenhouse production are significant and unless there is a reasonable return on investment, greenhouse production will not, and should not, be implemented. At the PAP, economic analyses are routinely performed on cropping systems, and the results for colored peppers, strawberries, and melons are positive with respect to the potential profitability of greenhouse production in Florida (Jovicich, 2004; Paranjpe, 2003; Rodriguez, 2003). However these need to be integrated and

Fig. 2. Greenhouse at the Protected Agriculture Project at the University of Florida. The high roofed structures are passive-ventilated and screened to exclude insect pests.

Table 3. Volumes and values of bell peppers imported to the U.S., by country, and U.S. production, exports, and domestic use, 2002 (extracted from: U.S. Dept. of Agriculture, 2003b; 2003c; 2002) (Jovicich, 2004).

Country	Volume (MT)	Volume (%)	Value (\$1,000)	Value (%)
Mexico[z]	164,724	67.8	132,727	45.7
Canada[z]	41,414	17.1	71,417	24.6
Netherlands[y]	23,852	9.8	56,844	19.6
Israel[y]	6,563	2.7	15,638	5.4
Spain[y]	3,694	1.5	10,161	3.5
Belgium[y]	267	0.1	623	0.2
Others	2,364	0.2	3,180	0.5
Total imports	242,876	100.0	290,589	100.0
U.S. prod.[x]	734,118	—	498,650	—
U.S. exports	73,247	—	73,421	—
U.S. domestic	903,747	—	715,818	—

[z]Field-grown green fruit and greenhouse-grown colored fruit.
[y]Greenhouse-grown colored fruit.
[x]Mostly field-grown green fruit and some colored.

Table 4. Comparison of greenhouse-grown Beit-Alpha cucumbers and field produced slicing cucumbers for marketable yield, water and fertilizer use efficiency.

Variable	Unit	Greenhouse[z] (Beit Alpha)	Field[y] (slicing)
Marketable yield	kg/ha	270,000	31,197
	No./ha	2,310,000	135,639
	g/fruit	115	230
Water	m^3/ha	8,190	3,215
Precipitation (Jan-Mar)	m^3/ha	—	1,808
Irrigation	m^3/ha	8,190	1,406
Water use efficiency	l/kg fruit	30	45
	g fruit/L	33	22
N applied (all drip)	kg N/ha	1260	169
N use efficiency	g N/kg fruit	4.7	5.4
	kg fruit/kg N	214	185
K applied (all drip)	kg K/ha	1620	243
K use efficiency	g K/kg fruit	6.0	7.8
	kg fruit/kg K	167	129

[z]Data from a cucumber experiment conducted at the Protected Agriculture Project in 2002 (Shaw et al.), without a nutrient and water recycling system. The leachate was collected and sprayed onto adjacent vegetable crops.
[y]Average over 10 years (Olson and Simonne, 2003).

put into a wider economic picture that considers some of the environmental costs and benefits.

The technical requirements of greenhouse production also differ from that of the field. As growers move into greenhouse production, it will be helpful for them to receive training in production practices. The greenhouse environment is different from the open field as are the cultural practices for crop production. These techniques are best taught by intensive workshops within the greenhouse. A new 0.4-ha (1-acre) greenhouse facility at the UF/IFAS Plant Science Research and Education Center at Citra is an excellent facility for conducting demonstration trials and grower education workshops, and provides a good baseline for the economic assessments that are required.

There needs to be an identification and exploitation of potential markets starting in Florida. The population of Florida is in excess of 17 million and increasing by 1,000 people each day. In addition, the tourism industry is strong and there were 74.5 million visitors to Florida in 2002 (MyFlorida.com). New marketing strategies should be devised to enable the population of Florida to purchase and consume quality produce at premium prices. Nationwide, the dramatic increase in consumption of greenhouse-produced vegetables looks to be set to continue as consumers require high quality vegetables.

Table 5. Comparison of greenhouse and field production of peppers and cucumbers for marketable yield and income.

	Greenhouse[z]	Field[y]
Peppers		
Marketable yield (kg/ha)	100,000	32,000
Fruit price ($ per kg)	5.09	1.08
Gross income	509,000	36,294
Cucumbers		
Marketable yield (kg/ha)	270,000	30,000
Fruit price ($ per kg)	1.54	0.40
Gross income	415,800	12,000

[z]Data from experiments conducted at the Protected Agriculture Project (Jovicich et al.; Shaw et al.).
[y]Average over 10 years (Olson and Simonne, 2003).

Greenhouse producers either inside the U.S. or from other countries will meet this demand for quality produce. Currently, greenhouse producers in Mexico, Canada, and Europe are exporting their produce into the U.S. Field producers in Florida are unable to compete with this produce in terms of quality, and their future is threatened, as the ability to compete in terms of a low price of production will be reduced with the withdrawal of methyl bromide. The greenhouse industry within the U.S. must recognize the potential competition from imports, but Florida growers do have several competitive advantages. Their proximity to U.S. markets means that there will be lower fuel costs for transportation and a shorter shipping period, leading to the delivery of fresher produce. The mild Florida climate means that there are reduced fuel costs for heating and an extended season for greenhouse production. Food safety issues are also of potential benefit to Florida produce with pesticide-free production and labeling and the use of Country of Origin labeling.

Greenhouse production is an alternative to field production with methyl bromide, and a transition to greenhouse production offers several advantages to the growers of Florida beyond the simple elimination of the need for methyl bromide. Greenhouse-produced vegetables are of higher quality and sell into different markets at a premium. There is increasing demand for fresh, high-quality, greenhouse-grown produce in Florida, the U.S., and overseas. Greenhouse growers in Florida are at a competitive advantage due to proximity to markets and the mild winter climate.

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