Protected Agriculture in the State of Kuwait

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Abstract

Because of the country's harsh climate, scarce water resources and poor-quality land resources, protected agriculture (PA) has a significant role in Kuwait's agricultural development. Despite difficulties, PA made spectacular progress during the 1980s (area increased from 3.5 ha in 1979/80 to 425 ha in 1989/90) and was beginning to establish an important niche in the national economy just prior to the Iraqi invasion in 1990. The 1980s boom in PA is still suffering from the extensive damage caused by the Iraqi invasion. The postwar revival of greenhouse agriculture has been relatively rapid in the Wafra area, where over 90% of the pre-invasion area under PA had been rehabilitated by 1992/93. The technology used in Kuwait's PA ranges from simple uncooled and unheated plastic tunnels to very sophisticated computer-controlled, cooled and heated, metal-frame glasshouses. Approximately 85% of the PA is carried out in uncooled (57%) and cooled (28%) plastic tunnels, with the remaining 15% in cooled greenhouses covered with fiberglass, glass or acrylic material. Cucumber and tomato are the two main crops grown in PA, accounting for approximately 90% of the total area. The relatively large area under uncooled tunnels results in overproduction during a short period (January to April) and price collapse in the local market; during the remaining period, import levels are high and prices offered are competitive. Production expansions were and still are pursued without adequate consideration of efficiency or quality, resulting in technical and economic inefficiencies. Inappropriate production technologies are adopted without considering the available soil and water resources. The lack of research and testing of technologies for adaptation in Kuwait leaves the farmers reliant on suppliers, who may be biased toward profit rather than efficiency. Productivity below international levels is attributed to gaps in technology adoption, unskilled labor force and inefficient management.

Protected agriculture is expected to become an important agribusiness industry in Kuwait with greater impact on the national economy than was traditionally perceived. For these opportunities to be realized, PA has been identified as a priority area in the 20-year agricultural Master Plan recently developed by the Kuwait Institute for Scientific Research (KISR). This Plan calls for careful evaluation and adoption of modern technologies. The Plan also calls for productivity enhancements of at least two- to four-fold by the year 2015. These targets are easily attainable if greenhouse crop production is made efficient, productive and sustainable. The main thrust of KISR's PA research in the coming years will, therefore, be to develop, test and demonstrate various water- and energy-efficient technology packages, and to demonstrate and provide training in high-quality management.

Introduction

Like other countries in the Arabian Peninsula, an important aspiration of Kuwait is to achieve at least a modest level of self-sufficiency in food production. To fulfill this aspiration, the State of Kuwait has made massive investments during the past 30–40 years to create favorable conditions for crop, poultry and dairy production. This has opened up enormous opportunities for agricultural expansion. As a result, the agricultural sector witnessed impressive growth during the 1980s. Agricultural output doubled and greenhouse production, particularly that of tomato and cucumber, increased spectacularly during the period 1983–88. Although the contribution of agriculture to the national GDP was still small, the agricultural sector was making considerable inroads in providing fresh food commodities, in fulfilling citizens' aspirations, in developing career opportunities, and in diversifying income sources. The agricultural boom of the 1980s is still suffering from the damage caused by the Iraqi invasion in 1990 and the slow rehabilitation of protected-agriculture (PA) infrastructure.

Different kinds of protected environments are created to alleviate the adverse impacts of hot desert conditions in fresh-vegetable production. Besides making cultivation less vulnerable to extreme environmental conditions, PA structures have provided opportunities for extending the growing season and have increased the availability of better-quality fresh vegetables. Although past accomplishments have been noteworthy, much remains to be done in Kuwait's PA: yields need to be improved substantially, production systems need to be made water- and cost-efficient, product quality needs to be improved and standardized further, and resource utilization needs to be controlled and made sustainable. This paper analyzes the status of PA in Kuwait, the problems faced by greenhouse growers and the measures proposed by the Kuwait Institute for Scientific Research (KISR) to overcome some of these problems.

Overview of Protected Agriculture in Kuwait

Kuwait's protected agriculture (PA) started in the late 1970s and showed spectacular growth during its initial 10 years. This was evident from the fact that the area under PA increased from 3.5 ha in 1979/80 to 424.9 ha in 1989/90 (Fig. 1). Protected agriculture accounted for approximately 8% of the total cropped area in 1988/89, and contributed over 37% to the total crop production of the country, suggesting that it was beginning to establish an important niche in the national economy just prior to the Iraqi invasion in 1990. Greenhouse crop production was concentrated almost equally in the Wafra (in the south) and

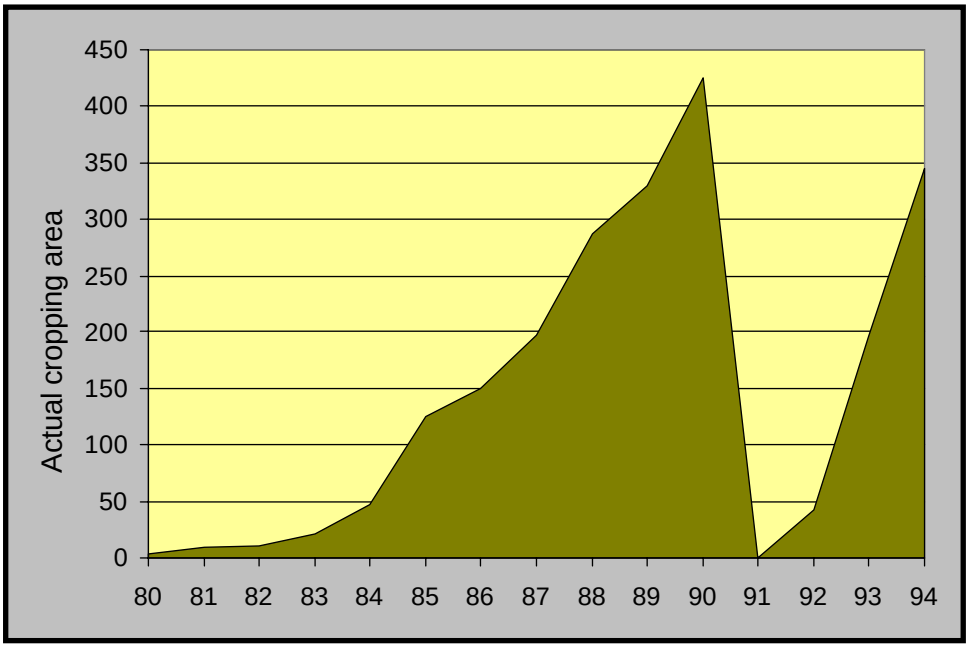

Figure 1. Area under protected agriculture in Kuwait.
Sources: KISR (1995); Attar and Shalabi (1993); PAAAFR (1995).

Abdally (in the north) areas. In Wafra, about 66% of the greenhouse area during the pre-invasion era was uncooled and about 5% was under fiberglass. Abdally had more advanced greenhouses than Wafra. The PA in both locations is still suffering from the extensive damage caused by the invasion. The postwar revival of greenhouse agriculture has been relatively quick in Wafra, where over 90% of the former area under PA was rehabilitated by 1992/93 and is expanding steadily. The restoration of damaged greenhouses in Abdally, however, has been rather slow (Table 1). The current state of PA in terms of greenhouse designs and management, adoption of efficient water-use and fertigation technology, plant protection, along with constraints is summarized below.

Table 1. Distribution of protected agriculture area in Kuwait.

Location	PA cropped area (ha)			
	1989/90	1991/92	1992/93	1993/94
Wafra	184.6	41.1	179.5	289.2
Abdally	238.7	0.8	14.6	54.7
Sulaibiya	1.6	0	0.9	1.3
Total	424.9	41.9	195.0	345.2

Source: PAAAFR (1995).

Greenhouse Design and Management

A number of reports have dealt with PA in Kuwait (Jensen 1992; Riley 1992; Mansour et al. 1992; Basham et al. 1993; Attar and Shalabi 1993; KISR 1995). In addition, KISR undertook a survey of commercial greenhouses in the Wafra area in 1993. The PA of vegetables is presently being done in cooled or uncooled plastic tunnels and environmentally controlled greenhouses (KISR 1995). An estimated 85% of the PA is carried out in uncooled (57%) and cooled (28%) plastic tunnels (Table 2). The remaining 15% of production is under cooled greenhouses covered with fiberglass, glass or acrylic material, the most advanced being a few computer-controlled, cooled and heated, metal-framed glasshouses. The average size of PA holdings in Wafra is about 2.0 ha (Mathijssen et al. 1993).

Table 2. Distribution of protected agriculture area according to the type of covering material.

	Covered area (ha)				
	Plastic tunnels	**Acrylic**	**Fiberglass**	**Glass**	**Total**
Tomato	114.0	0.9	9.5	0	124.4
Cucumber	266.1	0	34.6	2.7	303.4
Eggplant	30.5	0.4	1.8	0	32.7
Pepper	23.9	0	1.1	0.5	25.4
Total fruit-veg	475.1	2.1	47.5	3.2	527.9
Leafy veg	15.1	2.9	1.5	0	19.5
Tuber/root veg	8.1	0.5	0.8	0	9.4
Total	501.7	5.7	50.1	3.2	560.7

Source: PAAAFR (1995).

Ultra-violet-resistant polyethylene or fiberglass materials are used to cover the greenhouses, as polyvinyl chloride and polycarbonate materials are not suitable in Kuwait. Normally, greenhouse construction and sophistication depend on need and are market driven. High investment levels and long pay-back periods are limiting the expansion of cooled and heated rigid-cover greenhouses in the country.

Kuwait experiences an extended period of high temperatures from April to October when cooling is required. The relative humidity during this period is low enough to allow for adequate evaporative cooling. Therefore, it is possible to reduce greenhouse temperatures to 35°C or less during the summer. A number of evaporative cooling systems are presently used in Kuwait, but Celdeck and rope 'pads' predominate. One serious limiting factor in greenhouse cooling is the poor quality of groundwater, which requires the use of a special design to avoid salt-encrustation of the cooling pads. Cooling pads also get plugged by mobile sand particles and dust storms, and become nonfunctional after 3 to 4 months. At the same time, the use of distilled or desalinated water in greenhouse cooling is very expensive. New cooling-system designs, which allow the efficient use of brackish water, are needed to improve the profitability of protected agriculture.

Kuwait growers using ropes as an economical evaporative surface for the greenhouse cooling system

A clear understanding of relationships among temperature, relative humidity, solar radiation, ventilation and crop growth stage is important for achieving efficient cooling of the greenhouse environment. Unfortunately, most commercial greenhouses in Kuwait lack proper instruments for monitoring changes in the environment. Winter frost is fairly common, but few greenhouses have heating facilities.

The current production and productivity of important PA crops are given in Table 3. Tomato and cucumber account for nearly 90% of the total area. The relatively large area under uncooled tunnels results in overproduction during a short period (January to April) when the growing conditions are moderate. This leads to a collapse in the price offered for locally produced vegetables during peak production, whereas imports are expensive and prices are high during the rest of the year. Furthermore, because of gaps in technology adoption and inefficient management, the productivity of PA in Kuwait is far below the potential (Table 4).

Table 3. Total production and productivity of different crops under protected agriculture in Kuwait.

Crop	Production (tonnes)	Current productivity (t/ha)
Tomato	11,588	50
Cucumber	12,600	125
Eggplant	3,299	55
Pepper	211	50

Source: KISR (1995).

Table 4. Productivity (kg/m²) of tomato and cucumber in different types of greenhouses.

Crop	Uncooled plastic tunnels		Cooled plastic tunnels		Fiberglass greenhouses	
	Current	Target	Current	Target	Current	Target
Tomato	10	12	12–15	19	16	25
Cucumber	4	n.c.	6	n.c.	8	26

Source: KISR (1995).

For example, yield levels for tomato in Kuwait are about 10 kg/m² in uncooled plastic tunnels, 12 kg/m² in cooled tunnels and 16 kg/m² in cooled fiberglass greenhouses. In contrast, 25 kg/m² was achieved in some countries during the mid-1980s, indicating that there is room for improving productivity levels in Kuwait (Mathijssen et al. 1993).

Water Use Efficiency and Fertigation

The production technology in Kuwaiti PA varies tremendously, but soil-based production using the native soil with or without organic-matter addition is still common. Drip irrigation systems with desalinated water are used. Inorganic fertilizers in the form of soluble compound fertilizers are applied through drip systems at a more or less fixed rate per day.

Plant Production and Protection

The infusion of technology into the PA sector over the years has generally been inadequate. As a result, production systems have remained generally small and inefficient, with excessive demands for labor and water. The yields under PA in Kuwait have been low, diseases and pests have been uncontrolled, and agricultural products have been inferior. One of the main shortcomings in the past has been inadequate technical support for incorporation and use of modern production technologies: vendors merely promoted their products, resulting in a wide range of unsatisfactory systems and failures. Integrated production and protection programs must be introduced to overcome the problems of diseases and pests, and reduce the risk of chemical residues affecting consumer health and the environment.

Constraints

Protected agriculture in Kuwait is faced with a number of constraints relating to physical, technological, manpower and economic factors.

Physical constraints

Water: The groundwater in production areas is brackish with dissolved salt contents up to 9000 ppm. Such water is not suitable for PA and must be used cautiously in any agriculture. The use of brackish water presents problems in evaporative cooling systems due to encrustation of cooling pads. Irrigation with high-salinity water in soil-based greenhouse cropping systems, besides imposing physiological stress on plants, increases soil salinity. To overcome this problem, greenhouse growers use desalinated water for greenhouse cooling and irrigation. The use of desalinated water for cooling is not economical, requiring more water per plant than is needed for irrigation. There is a need to improve the cooling systems to allow the use of brackish water.

Soil: The native soils used in the Wafra area are generally greatly disturbed and modified during construction. The soils are predominately sandy with low cation-exchange capacity, very little organic matter, low water-holding capacity and low available phosphorus. The gatch layer when present near or at the surface obstructs natural drainage and causes waterlogging and salinity problems. Adoption of hydroponic production systems could eliminate most of the problems associated with soil-based cropping.

Harsh weather: The extended period of high summer temperatures, low rainfall, high evaporation rates, sand and dust storms presents problems in the operation of greenhouse structures and increases the cost of production.

War damage: The protected crop-production system and the water-distribution infrastructures suffered extensive damage during the invasion. The postwar rehabilitation has been mostly limited to uncooled plastic tunnels as these structures require less investment and can be brought under production fairly quickly. Most of the cooled tunnels have been developed by retrofitting these uncooled houses. Although some of the rigid-cover (fiberglass or glass) greenhouses constructed during mid-1980s have been brought back into production, there has been very little new construction since liberation. Owing to the high investment and longer pay-back period, growers are reluctant to invest in cooled and heated rigid-cover greenhouses. This is affecting progress in the PA sector.

Technological constraints

Greenhouse design and management: As stated earlier, protected crop production is carried out predominately in uncooled plastic tunnels. While these structures provide some environmental modifications—chiefly protection from wind and blowing sand, daytime warming due to the greenhouse effect and perhaps lower evapotranspiration rates than open field conditions—, they afford minimum opportunity for controlling the plant environment. The shape of these single-span houses (arc in cross-section) leads to poor utilization of covered space and results in considerable waste of ground area between houses. They also offer limited opportunity for using screening materials to restrict the entry of insects. Providing efficient drainage and adoption of high-tech production systems in such houses will be more expensive than in multi-span houses. The small size of individual units considerably reduces labor efficiency.

Crops: Profitability in PA is determined to a large extent by choice of crop (cultivars grown) and the level of technology used. As stated earlier, cucumber and tomato are the main crops grown in protected environments. As in most countries in the region, tomato under PA is less profitable than cucumber. Again no PA crops can be grown in summer months without cooling. Considering the narrow range of crops presently available to PA, the Master Plan (KISR 1995) recommends exploring new potential crops (cut flowers and potted flowering and foliage plants), besides expansion in the production of certain existing crops.

Crop production technology: While information from suppliers is useful, it is essential that producers have unrestricted access to unbiased technical information. Technical support for PA for both new technology and its adoption remains limited in Kuwait.

Marketing: Kuwaiti producers face stiff competition from imported produce from other countries in the region and market intelligence is not available to them.

Manpower constraints

The technological expertise required for high-tech PA is not available locally. Most laborers employed in PA are unskilled and not trained in commercial greenhouse operations. The majority of the management personnel also lack experience in crop planning and financial management. This results in inefficiencies in operation, besides creating problems in manpower training.

Economic constraints

The need for higher investment, high cost of production, low prices, stiff competition from imported commodities and longer pay-back periods than many investors are accustomed to, are some of the economic issues influencing the progress of PA in Kuwait.

Opportunities for Modernizing Protected Agriculture

Since the environmental disaster associated with the invasion of Kuwait, the greenhouse sector—especially in the Wafra area—has witnessed an impressive rebuilding and rehabilitation phase. Protected agriculture is expected to become an important agribusiness with greater impact on the national economy than was traditionally perceived. Therefore, the revived greenhouse sector in Kuwait, if managed properly, will have enormous opportunities for optimizing the production of selected commodities. In view of this, PA has been selected as a priority area in the 20-year (1995–2015) Agricultural Master Plan developed by KISR (1995), in collaboration with the Public Authority for Agricultural Affairs and Fish Resources (PAAAFR). This Plan calls for enhancing productivity of various crops by at least two- to four-fold by the end of the plan period. The water-use efficiency in crop production is also expected to improve considerably. To achieve this goal, the production system will have to be made both efficient and productive. This is possible only through the development and demonstration of water- and energy-efficient technology packages and the infusion of high-quality managerial skills.

The first step towards modernizing PA in Kuwait is to evaluate and incorporate all the proven technologies of greenhouse management, fertigation, water application, and pest and disease control into the existing operation. For example, providing the uncooled greenhouses with efficient cooling systems would reduce water consumption, extend the harvest period, offer opportunities for crop diversification and automation, and increase productivity, resulting in higher price realization and, ultimately, increased self-sufficiency. Applied research on multi-span greenhouses and modifications in cooling systems to allow the use of brackish water will also be required to determine their feasibility in Kuwait.

Successful PA production systems have been developed and are being used commercially in Europe, the USA and other areas. These advances have enabled growers to raise superior-quality horticultural and floricultural products in record time, throughout the year and with lower input costs. Besides being environment-friendly, these systems conserve natural resources. Production systems such as deep-flow hydroponics, nutrient film technique, aeroponics and closed insulated pallet system, require careful testing and demonstration on a pilot scale under local conditions. Other technologies that need careful evaluation include: plug transplant system, crop selection and scheduling, pest control and efficient greenhouse management. It will also be necessary to encourage the private sector to shift to technology-intensive, resource-conserving, yield-improving and quality-enhancing production systems.

Early production of young strawberry plants raised in cool multi-span houses, Mirak Agricultural Services, UAE

Considering the short- and long-term needs of PA in Kuwait, the main focus of KISR's PA programwill be to develop, test and demonstrate various water- and cost-efficient technology packages and to demonstrate and provide training in high-quality management. Therefore, the Aridland Agriculture Department at KISR is proposing to undertake a study to compare water-saving closed production concepts—such as super nutrient film technique, high-density aeroponic system and closed insulated pallet system (CIPS)—with the conventional deep-flow hydroponic system, and to explore new crops for protected agriculture. The main emphasis of this study will be to transform the existing greenhouse agriculture into a productive water- and cost-efficient high-tech enterprise.

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