Chapter 1
Introduction

Crop production in greenhouses is an increasing industry, especially in mild climates, and is very important for the population as a source of income and clean fresh food. Greenhouses create optimal climate conditions for crop growth, and protect the crop from outside pests. At the same time, greenhouse production increases water use efficiency and provides the possibility of integrated production and protection (IPP). The environmental impact has to be considered for protected cultivation. One tool for evaluating environmental impact is, for example, the Life Cycle Assessment (LCA) (Montero et al. 2003, 2009a).

Greenhouse crop production is successful if growers produce high quality and yield.

High quality and yield depend on:

- Efficient management of production
- Knowledge and training of the growers
- Appropriate greenhouse structure
- Proper mounting, installation and maintenance of the system
- Efficient climate control during summer and winter
- Measures for integrated production and protection (IPP)

The question is:

How to produce more clean vegetables and better quality with less water, with less land and with less pesticide?

Integrated production and protection (IPP) aims at finding alternative solutions to improve yield and quality, and to reduce pesticide applications. IPP contains the following components:

- Plant materials
- Cultivation practices
- Greenhouse technology, climate control, water-use efficiency and fertigation
- Biological control and the use of bio-pesticides
- Quality norms and standards

C. von Zabeltitz, *Integrated Greenhouse Systems for Mild Climates*,
DOI 10.1007/978-3-642-14582-7_1, © Springer-Verlag Berlin Heidelberg 2011

A greenhouse with all measures of climate control is one important component for integrated greenhouse crop production and protection.

However, the growing period is very often limited to several months in the year, because of insufficient ventilation and cooling in summer as well as heating in winter. Structures and shapes of greenhouses are adapted insufficiently to climate conditions. Climate control and greenhouse structures have to be adapted and optimized with regard to outside climate, and growers must be trained in these adapted technologies (Baille 2001).

A greenhouse structure with light transmittance (through framework and cladding material), ventilation, heating, cooling, and protection from pest insects by screening, as well as all influences of management, irrigation, fertilisation, water quality, physical and biological plant protection, has to be considered as an integrated system. Greenhouse structures should be designed according to the climate conditions and to the general design criteria, as well as to the locally available and cost-effective materials. The import of greenhouses from countries with a different climate fails very often, because they are not adapted to the local conditions. Even an appropriate greenhouse structure can fail if mounting and continuous maintenance is not guaranteed.

Temperatures and global radiation allow open-air crop production throughout the year in many subtropical and tropical countries.

But the *problems for open air cultivation* are:

- High solar radiation intensities
- Low temperatures in some regions, in particular at night
- Damage of plants by heavy rainfall, flooding, and surface run-off
- Shortage of water in dry seasons
- Plant diseases due to rain, high humidity, and storm damage
- High weed infestation
- Erosion and decomposition of humus by floods and surface run-off
- Leaching of fertilizers
- Increasing use of pesticides, which are washed off by rain
- High evapotranspiration by global radiation
- Working conditions for people
- Climatic conditions in the open field which hamper a controlled cultivation for production deadlines and disease control

Advantages of protected cultivation in greenhouses are:

- Protection from heavy rainfall, too high global radiation and wind
- Physical plant protection by insect screens in front of the ventilators
- Possibility of biological plant protection
- Carefully directed fertigation (irrigation and fertilisation)
- Better efficiency of pesticides and fertiliser
- Lower transpiration and evaporation
- Water conservation by efficient irrigation and collecting of rainwater
- Possibility of soil-less culture

- Planned production for production deadlines, cultivating of seedlings
- More favourable working conditions

Crop production under adapted greenhouses results in higher yield and better quality, minor risks for quality and yield, extending of harvest time, and reduced water consumption.

Factors influencing the design technology are (Giacomelli et al. 2008):

1. Regional infrastructure (transportation) and market size (consumers)
2. Local climate conditions that influence construction and climate measures
3. Availability and quality of water
4. Availability and costs of fuel and water
5. Soil conditions
6. Availability of land
7. Availability and conditions of capital for investments
8. Availability and cost of labour
9. Availability of local materials for construction and equipment, including services for repair and maintenance
10. Legislation and government regulations of food safety, residuals of chemicals and emission of chemicals

The *general design criteria* for greenhouses are (see Chap. 4):

- The climate conditions in the region
- The general design requirements, including standards if available
- Measures for climate control and pest control
- The locally available cost-effective materials and life cycle
- Technical measures for integrated production and protection (IPP)

Different structures must be considered for different regions and various purposes.

(a) Small-scale farming. Small units of greenhouses for rural families to improve the productivity of the small area of their land. Low-cost but efficient constructions are required.
(b) Large-scale market gardening in rural areas around big towns and densely populated areas. Main source of income is horticulture. Larger investments for structure are possible.

Consumers want a year-round supply of high-quality products, but usually vegetable crops in particular cannot be grown during hot summertime in subtropical climates due to insufficient applied technologies (Castilla et al. 2008). The trend for crop growth management in subtropical, Mediterranean greenhouses was in the past to adapt the plants to a suboptimal environment, instead of optimizing and adapting the greenhouse design and climate control measures for a maximum of plant yield, quality, and health (Montero 2009; Castilla et al. 2008; Castilla 2002).

Investigations have been conducted to find out the most profitable and economically viable technologies. Greenhouses have been designed as simple locally made

plastic-film structures or screenhouses, as well as industrial-type multispan structures with all the equipment for climate control. Properly designed and adapted locally made, low-cost greenhouse structures with limited climate control can fulfil similar cost–benefit ratios to high sophisticated greenhouse and climate control systems, if some basic rules of design and climate control are taken into consideration. This is the case in "normal" years without unusual and extreme outside climate conditions and pest infestations. For more extreme conditions, more attention should be paid to adapted and improved greenhouse systems including ventilation, cooling and pest control by mechanical and optical barriers.

Two strategies can be used to achieve year round supply with horticultural products (Giacomelli et al. 2008; Castilla and Hernandez 2007; Montero 2009):

1. High technology greenhouses at one site with all necessary design components and climate control measures.
2. Adapted greenhouses at different sites with complementary climate conditions and harvesting periods, for example greenhouses in coastal areas during winter and spring and screenhouses in highlands during hot summer season.

The greenhouse area in the world increases yearly. Most of the greenhouses are built in mild climate areas, and more than 90% of the greenhouses are plastic film greenhouses. Therefore, this book focuses in particular on plastic-film greenhouses. The estimated greenhouse areas in the world are (Giacomelli et al. 2008):

	Plastic film greenhouses and large plastic film tunnels (ha)	Glasshouses (ha)
Western Europe	140,000	29,000
Eastern Europe	25,000	1,800
Africa	27,000	600
Middle East	28,000	13,000
North America	9,800	1,350
Central/South America	12,500	0
Asia/Oceania	450,000	2,500

Some existing books describe more the theoretical bases for greenhouse design and climate control (Castilla 2005; Bakker et al. 1995; von Zabeltitz 1986; Tantau 1983).

This book describes the climatic conditions in various regions in the first part, and deals then with the corresponding demands on the structures for protected cultivation and materials as well as on climate control measures. It gives instructions for technical actions, and shows by many examples of greenhouse construction, mounting, ventilation, heating, cooling, irrigation, screening, and rainwater collection "*how to do and how not to do*".