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Optimal climate regions in Mexico for greenhouse crop production

Jop Kipp

Ministry of Agriculture, Nature and Food Quality

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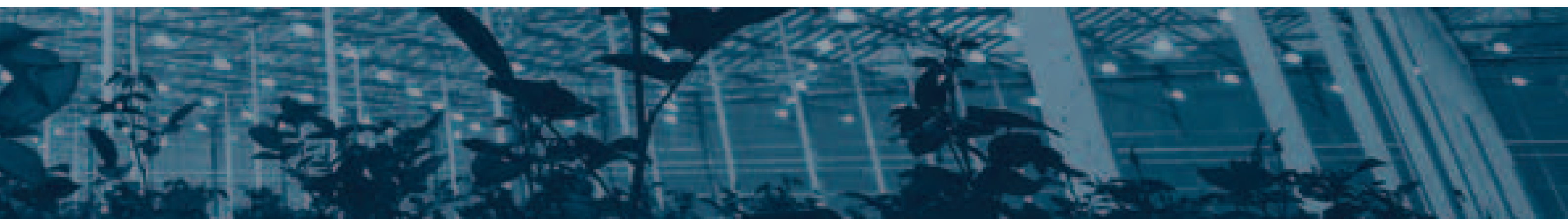

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Preface

Horticulture is an important sector in Mexico. The excellent geographical position towards the US consumer market and the growing domestic market of almost 112 million inhabitants make that Mexico has a fast increasing acreage of horticulture, from open field to low, medium and high tech protected horticulture.
This report is the result of the research done by Mr. Jop Kipp of Wageningen UR Greenhouse Horticulture and his students of Tec de Monterrey, Queretaro campus. The research was financed by the Netherlands´ Ministry of Agriculture, Nature and Food Quality from the International Cluster of the Research Program with Wageningen University and Research Center during the years 2008 and 2009. The objective of the study was to find suitable regions for high and medium tech greenhouse production of vegetables and flowers looking at the climatic conditions in Mexico.
Mexico has been in the recent years the most important export market for Dutch greenhouses. In 2009 the export value was almost 10 million Euros (source: Eurostat). This report can give guidance to potential investors in Mexican horticulture in their decision to where, from climatic perspective, new projects could be located.

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Abstract

Greenhouse horticulture has developed rapidly in Mexico since 2004. For Dutch suppliers off greenhouse equipment and installations and policy makers, it is interesting to get an overview of the regions with potential for further development. An important factor is how local climate conditions match with crop requirements, and the possibilities provided by greenhouses for improving this fit. In this study, climate conditions in Mexican regions are described, as well as crop requirements. The Mexican central plain seems most suitable for both *high tech* greenhouses and *medium tech* greenhouses, together with smaller areas elsewhere.

1 Introduction

Over the past decade Dutch supplying greenhouse industry focused more and more on the Mexican market. As a result, in 2007 the main export country for this industry was Mexico. (Table 1.)

Table 1. Export destination of Dutch greenhouses (LEI, EUROSTAT (2010))

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mexico	6.3	0.9	0.2	0.2	5.5	14.4	17.1	23.6	9.8	9.8
UK	4.4	1.9	3.9	8.3	7.4	7.9	9.9	6.3	8.8	6.8
Turkey	2.0	1.4	0.2	1.2	0.8	0.2	5.6	9.0	4.1	6.3
Poland	0.3	0.7	0.3	0.6	2.3	3.0	7.0	10.6	7.1	2.1
Russia	0.1	0.1	1.1	0.6	3.7	1.8	4.6	9.7	3.5	1.3
USA	2.9	4.5	4.4	3.5	5.9	6.8	13.2	6.8	4.9	1.3
Canada	1.3	0.4	0.8	2.2	9.8	5.9	2.1	5.0	4.5	1.5
Germany	4.8	4.5	6.1	7.0	6.1	7.2	6.1	5.3	6.8	3.7
other countries	8.3	9.7	13.0	15.6	25.1	22.8	38.2	49.3	48.2	25.1
total	30.3	24.1	30.0	39.2	66.6	69.9	103.8	125.6	97.7	57.9

With this rapid growth, also critical notes were made about the type of greenhouse and the infrastructure, in relation to the prevailing local climatic conditions. To prevent these discussions and to help the industry this study was carried out. Two types of greenhouses were distinguished: high-tech (HT) and medium-tech (MT), although the latter is hardly exported by Dutch greenhouse builders. However, Dutch companies supplying infrastructure for greenhouses, have joint ventures with greenhouse builders from Mexico, France and Spain. For this group, information about MT greenhouses may be valuable also.

The approach of this study was to identify different climate zones in Mexico and compare them with plant requirements for different greenhouse grown crops under Mexican conditions, taking the two greenhouse types into account.
Plant requirements were collected for comparable areas elsewhere, mainly from the southern states of the USA. Information about the Mexican climate was obtained from the Comisión Nacional del Agua (CONAGUA, Mexican Water Board) and the Servicio Meteorológico Nacional (SMN).

Climate is one of the main issues, because it determines crop production and thus the need for climate conditioning and associated costs for equipment and energy. It also determines the greenhouse construction dependent of, for example, wind forces, hail and intensity and duration of rainfall. However, also other factors are important when considering investment in greenhouses. Although this study in mainly focused on climate, also other factors are important and will be shortly discussed in chapter 7.

2 Definition of high- (HT) and medium-tech (MT) greenhouse

In this study, two types of greenhouse are distinguished:

- High-Tech greenhouses are aimed at maximal production with high quality produce in year-round production with the optimal use of technology in an environment-friendly way.
- Medium-Tech greenhouses are aimed at minimal investment costs with acceptable production and quality. Compared to HT, energy-efficiency will be lower and emission of chemicals and nutrients will be inevitable.

Item	High-Tech	Medium-Tech
Roof shape	V-shape (Venlo type) for maximal ventilation capacity	Arched
Greenhouse cover	Plastic or glass The never-ending discussion about the cover is still going on, especially in warm climates. In modern greenhouses constructions with both materials can be used in combination with double top ventilation.	Plastic
Gutter height	Minimal 5 meters	4-4.5 meters
Ventilation Due to high insect pressure in almost any region in the country, insect netting is inevitable for both types)	Double top ventilation However, this reduces the ventilation capacity dramatically. For this reason double top ventilation is necessary to maximize ventilation for stabilization of the greenhouse climate	one side top ventilation and/or side ventilation
Screens	Movable Screens Screens are used in periods of extreme high radiation. Also extra screens can be installed for energy savings during the night.	No screens
Heating	Hot water boiler with natural gas for CO_2 supply combined with a hot water storage tank Pipe rail system for optimal heating of the crop	Gas burners in the greenhouse, above the crop
Cooling	High temperatures during the day occur almost all over the country in spring and summer. To lower the temperature in the greenhouse, cooling equipment can be installed.	No cooling

Item	High-Tech	Medium-Tech
Climate control	Computerized climate control in the greenhouse is absolutely necessary when using above mentioned equipment. HT-greenhouse operation has been getting more and more complex. 'Green fingers' are not enough anymore, but still necessary	Simple time-based automated irrigation systems and temperature control by T-sensors in the greenhouse
Root environment)*	Hydroponics: substrates combined with recirculation of the nutrient solution	Soil-grown
Integrated Pest management)*	IPM works best when greenhouse climate is optimally controlled	IPM is less effective because climate control is limited
)* these items are not necessary for this study, but are, amongst others, aimed at reduction of the use and emission of chemicals and nutrients.		

3 Climate regions

Climate in any region is determined by the parallel climate zones in north-south direction, elevation and influence of oceans and seas. For Mexico, the tropic of Cancer effectively divides the country into temperate and tropical zones.

3.1 Temperature

(After Merill & Miró (1996))

Land north of the 24th parallel experiences cooler temperatures during the winter months. South of the 24th parallel temperatures are fairly constant year round and vary solely by elevation. Areas in the southern part with elevations up 1000 meters, (the southern parts of both coastal plains as well as the Yucatan Peninsula) have a yearly medium temperature between 24°C and 28°C. Temperatures here remain high throughout the year, with only 5°C difference between summer and winter medium temperatures. Although low-lying areas north of the 24th parallel are hot and humid during the summer, they generally have lower yearly temperatures averages (20°C – 24°C) because of more moderate conditions during the winter.

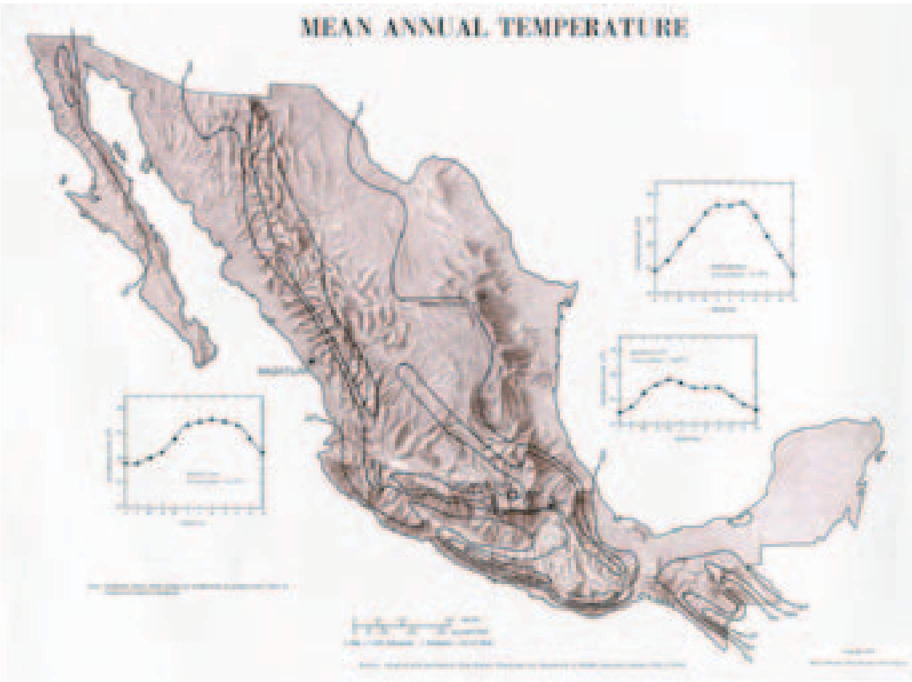
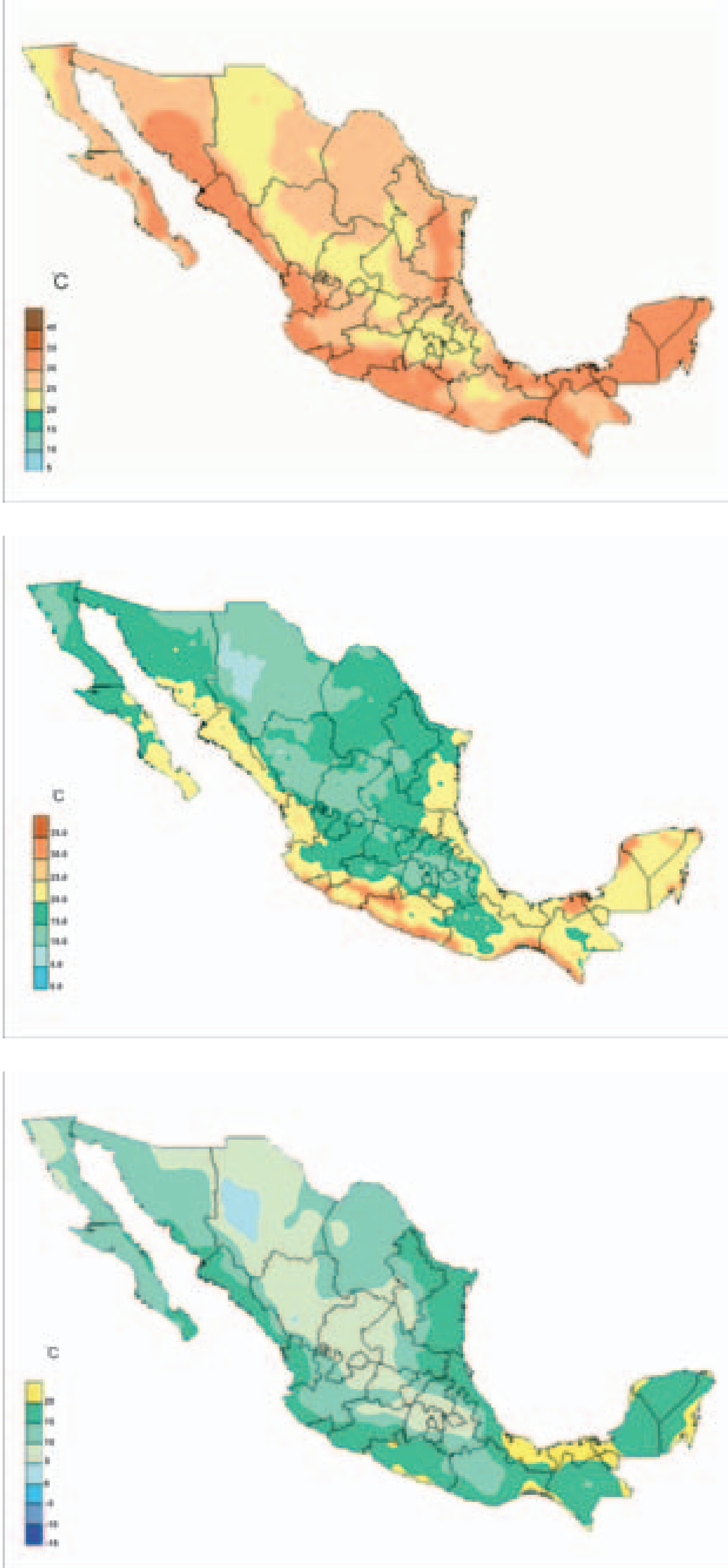


Figure 1. Mean annual temperatures by isotherms

Between 1,000 and 2,000 metres, one encounters yearly average temperatures between 16°C and 20°C. Areas at this elevations south of the 24th parallel have relatively constant temperatures, whereas more northerly locations experience sizable seasonal variations.

Above 2,000 meters, temperatures can drop as low as an average yearly range between 8°C and 12°C. Mexico City, at 2,300 meters, has a yearly medium temperature of 15°C with pleasant summers and mild winters.

In figure 2, the temperature distribution for maximum, minimum and average are shown.



Tmax

Tavg

Tmin

Figure 2. Yearly maximum, average and minimum temperatures

3.2 Radiation

Mexico has pronounced wet and dry season. Most of the country experiences a rainy season from May till mid-October. Apart from rainfall, this also has a pronounced effect on incoming radiation. The statement 'Mexico has always enough light' is therefore incorrect.

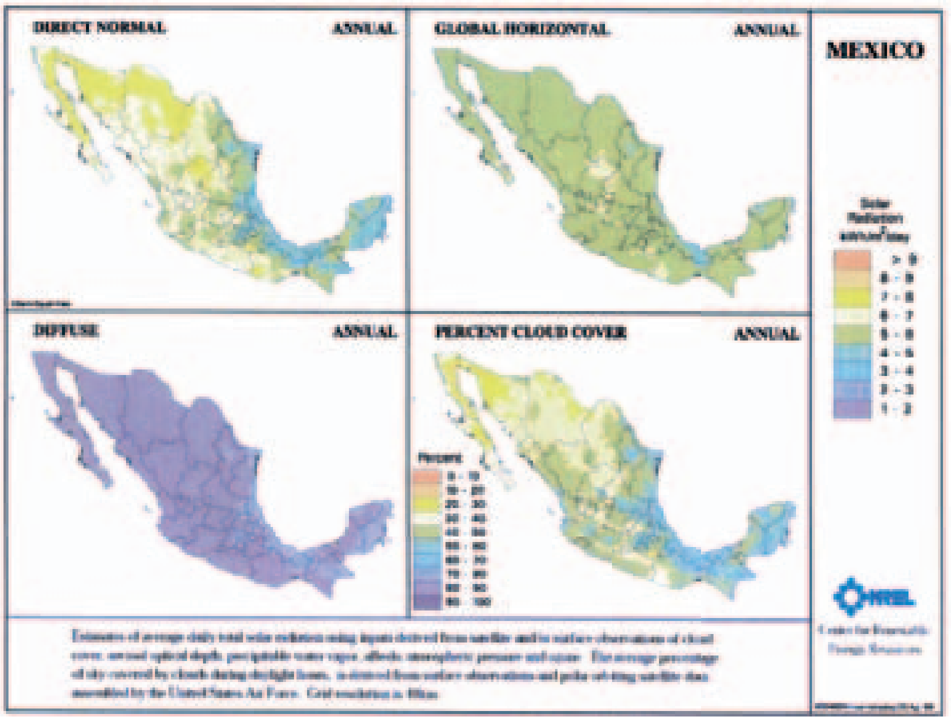


Figure 3. Radiation and cloud cover for Mexico

From the picture right under in figure 3 can be seen that the eastern coast around the Gulf of Mexico has severe cloud cover (50%-70%) on a yearly basis. Also the western part has some areas with yearly high cloud cover. The lowest cover (< 40 %) is in the north and more south follows the centre of the country.

3.3 Humidity

High humidity occurs mainly in the coastal zones and the Yucatan Peninsula. In the context of this study it is only important when cooling is applied (see 4.2). In all cases absolute humidity (water vapour) outside is always lower than inside the greenhouse, so in the situation of natural ventilation by opening the vents, water vapour always will flow from inside the greenhouse to the open air.

Figure 4. Climate types based on temperature and humidity

3.4 Rainfall

Most of the country experiences a rainy season from June mid-October and significantly less during the remainder of the year. February and July are the driest and wettest months, respectively. Coastal areas, especially those along Gulf of Mexico, experience the largest amount of rain in September.
However, rainfall (duration and intensity) is only relevant for the construction of the greenhouse (capacity of the gutters and sewerage system). These data are mostly not available and should be obtained from local sources. A rough estimation can be derived from the yearly rainfall in figure 5.

Figure 5. Yearly rainfall distribution

4 Additional techniques to influence HT greenhouse climate

4.1 Heating & CO_2-supply

At high elevations during the night, temperature can drop below 15ºC, which is too low for most greenhouse crops. So in almost all suitable regions, heating has to be applied.
Since CO_2 is essential for photosynthesis, in greenhouse types where ventilation is limited, CO_2 concentration will drop during the day, as a result of CO_2 consumption by the crop. This will influence the photosynthesis dramatically, especially when the concentration drops lower than the outside concentration (360 ppm). For this reason extra CO_2 supply is essential for high production. This can be achieved by buying liquid CO_2. However, this is very expensive. For this reason heating with natural gas with a hot water boiler is mostly applied in greenhouses. The CO_2 is extracted from the combustion gasses. This can only be done when natural gas is available, so high-tech greenhouses should be located in the vicinity of natural gas pipelines (see fig. 6.)

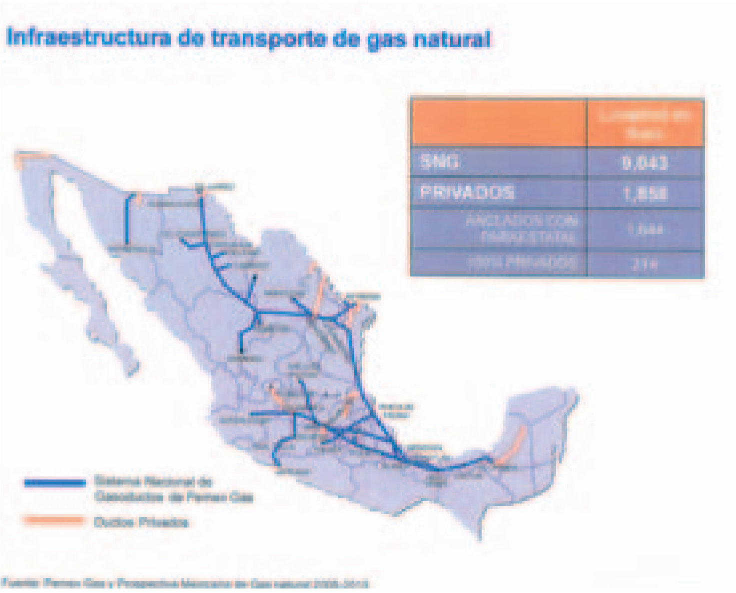


Figure 6. Main natural gas pipelines

4.2 Cooling & forced ventilation

Cooling in greenhouse can be applied in several ways. Most common are pad/fan and high-pressure misting systems. With pad/fan severe cooling can be achieved, but with high-pressure misting only a few degrees.
Pat/fan can only be used when the ambient relative humidity is lower than 56% and therefore will perform best in hot dry areas (Mandhar *et al.* 2001). Special care should be taken about the horizontal temperature gradient. In the vicinity of the wet pad where cool air comes into the greenhouse, temperature will be the lowest; near the fan where the air will leave the greenhouse temperatures will be high again.
To avoid this, special measures has to be taken, *e.g.* installing small vertical blowing fans. Greenhouse air will then be forced to go down, resulting in a better mix of air above the crop and in the rows. For the same reason also high-pressure misting will perform optimal in combination with vertical installed fans.

5 Crop requirements

When knowing the climate, these data have to be combined with crop requirements for optimal growth, to identify the optimal climate regions.

5.1 Tomato

Temperature management is very important for successful tomato crops. According to Hochmuth (2008a), poorly controlled temperature regimes can increase disease problems and lead to fruit color and quality problems. Tomatoes produce the largest yields of highest quality fruits when day temperatures are in the range of 27-29°C and when night temperatures remain above 17°C and below 22°C. Temperatures above 32°C result in all kind of physiological disorders and also in poor pollination and reduced fruit set. Low temperatures (below 15°C) may also lead to quality problems and a reduction in flower production.
Others (Hanna (2001), Johnson (1980), Jensen & Rorabough (2000) and Snyder, R.G. (1999)) come to the same disorders, but use other ranges for optimal day and night temperatures.

Tomato				
	Temperature (°C)			Reference
min	opt night	opt day	max	
15	17-22	27-29	32	Hochmuth (2008a)
15	15-17	19-27	32	Snyder (1999)
	17-20	24-27	29	Hanna (2001)
15	>16	24-27	30	Johnson (1980)
15	16-18.5	21-26	29	Jensen & Rorabough (2000)
	18	25		Seed company (pers. com.)

5.2 Sweet & Bell Pepper

According to Gonzáles & Peréz (2002) bell pepper is a temperature demanding plant. For vegetative growth they recommend 20-25°C during the day and 16-18°C during the night. For flowering and fruit set 26-28°C during the day and 18-20°C during the night. Daily maximum should not exceed 35°C and not lower than 18°C during the night.
Calpas (2007) only gives optimal temperatures during the day: 21-23°C.

Sweet and bell pepper				
	Temperatue (°C)			Reference
min	opt night	opt day	max	
18	18-20	26-28	35	Gonzales & Prez (2002)
15		21-23		Calpas (2007)
	18	25		Seed company (pers.com.)

5.3 Cucumber

Swaider et al (1996) states, that the ideal day temperature is 28°C. Temperatures above 32°C and below 16°C cause slow growth.

Hochmuth (2008b) describes cucumber as a warm season crop with required growing conditions of 27-29°C. Minimum temperatures should be no lower than 18°C for sustained production. Prolonged temperatures above 35°C should be avoided as fruit production and quality are reduced at these extremely high temperatures

According to Johnson (1985), a temperature range of 24-27°C during the day is desirable for good production. While peak daytime temperatures of 29°C to 35°C degrees are tolerable, prolonged periods of high temperatures may adversely affect fruit quality. Night temperatures no lower than 18°C will allow a rapid growth rate and earliest fruit production. At 13-15.5°C, savings in fuel costs will be significant, but growth rate will be slower and harvest will be delayed.

Cucumber				
	Temperatue (°C)			Reference
min	opt night	opt day	max	
16	17-19	28-30	32	Swaider ett al (1996)
		27-29	35	Hochmuth (2008b)
	18	24-27		Johnson (1985)
	18	25-27		Seed companies (pers.com.)

5.4 Rose & Gerbera

In more temperate climate zones, only T_{24h} are given for cut rose by seed companies and plant propagators because daily temperatures hardly ever rises above 28°C. Only a few data could be found for optimal temperature ranges for day and night under Mexican conditions.

Rose				
	Temperatue (°C)			Reference
min	opt night	opt day	max	
10	15-18	21-24	< 28	Linares Outiveros (2004)
15		18-25	< 28	Heladio Lopes Melida (1981)

For Gerbera no T_{max} was given. Personal information from other sources gave 26-27°C. Optimal night temperatures are higher than rose, while daily optimum are more or less the same.

Gerbera				
	Temperatue (°C)			Reference
min	opt night	opt day	max	
15	18	22-24		Sakata Ornamentals
12	18-21	20-24		Global Flowers
	16-18	21-24		Samurai Gerberas
	16-18	18-25		Agro 2000

5.5 Conclusion

The crops described above can be divided in 3 groups concerning temperature (see table below):
Rose and gerbera prefer lower T during the day, while cucumber prefers higher day T compared to tomato and bell pepper.

Crop	Opt. Day (°C)	Opt. Night (°C)
rose/gerbera	20-24	16-18
tomato/bell pepper	20-28	17-20
cucumber	25-30	17-19

From the optimal temperature regimes, average monthly temperatures during the warmest months were set for group 1, 2 and 3 at max 18, 20, 24°C respectively, combined with a monthly maximum temperature in the same period of < 20, <22 and <28 °C respectively. Cloud cover should be <40% on a yearly basis and for HT greenhouses relative humidity < 60%.

6 Discussion

Optimal regions for greenhouse crop production

From figure 7. can be derived that the central plain in Mexico is the most suitable area for MT greenhouse crop production, together with some smaller areas elsewhere. When HT greenhouses are considered, all marked regions are suitable when natural gas pipelines are in the vicinity.

Temperature is by far the most important climate factor for greenhouse crop production. In HT greenhouses, other climate factors can be controlled to a large extend: light and humidity by ventilation and screening; CO_2 can be applied when suitable and available. In MT greenhouses these factors can hardly be controlled and no CO_2 is available. For this reason the basis for the maps was temperature (fig. 2.) but also light (cloud cover, fig. 3.) and humidity (fig. 4.) were taken into account.

Figure 7. Optimal regions for different crops and MT and HT greenhouses

HT versus MT-greenhouses

In chapter 2 the definition of high- (HT) and medium tech (MT) greenhouse described in terms of construction and installed equipment. This of course is arbitrary but generally accepted as useful.

The main difference between the 2 types is that with a MT greenhouse you buy mainly a greenhouse with relative cheap equipment inside, whereas a HT greenhouse is not only a greenhouse but a 'system'. The greenhouse construction and the installed equipment form an integral concept. This is often not realised by people who want to invest; they only look at the price difference.

The 2 types also demand a different kind of greenhouse manager with a different level of education. Unfortunately high skilled greenhouse managers for big HT operations are hard to find. Also, the need for education of middle management is still high. Lack of education is one of the reasons why the production in HT greenhouses often stays behind the expectations. This damages the image of Dutch technology.

For a MT greenhouse the management is less complicated and stays close to open field culture. So MT greenhouses must be seen as a first step into greenhouse horticulture. When being successful, the step to HT can be taken.

Additional techniques to improve greenhouse climate

Although large areas are suitable for both HT and MT greenhouse production (see fig 7.), the lack of natural gas reduces the area for HT to those places where gas pipelines are in the vicinity.

Mexico has 9,000 km of main pipelines. This is not much compared to *e.g.* The Netherlands, where the total length is 12,000 km. However, the main lines have frequent bypasses to maintain a constant pressure within the pipe line system. So it is important to collect information from local authorities if pipelines are in the vicinity.

Because of the scale of the maps, the line thickness on the maps is 20-30 km. So the thickness of the lines itself is the limit for HT greenhouses, outside these lines the connection to the main lines are too expensive.

Cooling seems to be in favour for high production and quality, but it is not clear whether this is economic feasible. A model study about this item by Van't Ooster *et al.* (2007) showed that in Mexico cooling is only feasible in hot dry regions with cool nights, compared to temperate and humid conditions. But this has to be validated in practise.

Developments

New developments are on their way *e.g.* NIR-blocking foil, long term heat storage in the soil, geothermal heat, new ways of cooling etc. This will result in more areas with suitable climate conditions for HT greenhouse crop production.

7 Other important factors for greenhouse investment

This study focuses on climate, but there are also other matters that should be considered before investing in greenhouses. Below these issues are summed up (after Van Henten *et al.* 2006).

- **Market size** and regional physical and social infrastructure which determines the opportunity to sell products as well as the costs associated with **transportation**. For High-Tech equipment year-round production with export quality is essential because of the high level of the investment. The USA is by far the main export market, with reasonable prices, so the more south the production area is, the higher the transport costs.

- Availability, type and costs of **fuels and electric power** to be used for operating and climate conditioning of the greenhouse. The higher the technology, the more energy is needed. For this reason, renewable energy sources have to be found in the near future and should be an additional factor for HT.

- Availability and quality of **water**. Also in Mexico more and more areas obtain a water restriction, which means that water use per area is limited. Apart from that, also special attention should be paid to water quality, especially when substrates are used. In many cases water has to be purified before it can be used for irrigation. This will bring extra costs. Also the temperature of the irrigation water should not be higher than 20°C. If higher, the water should be cooled, which will lead to extra costs for equipment and energy.

- **Soil quality.** For HT in terms of drainage, the level of the water table, risk of flooding and topography. For MT the soil is also used as growing medium. For this reason, the physical structure and chemical quality of the soil has to be examined.

- Availability and cost of **land**, present and future **urbanization** of the area, the presence of (polluting) industries and **zoning restrictions**. Regulations concerning the use of the land.

- Availability of **capital**.

- The availability and cost of **labor** as well as the **level of education**.

- The availability of **materials, equipment and service level** needed for structures and instrumentation of greenhouse systems.

- **Legislation** in terms of **food safety**, **residuals of chemicals on the crop**, the use and **emission** of chemicals to soil, water and air.

8 Policy advise

The floricultural sector
This study shows that two regions offer possibilities to improve the technical level of the cut flower sector. This makes it possible for Mexico to become a key player in the region for export of flowers to the USA and can compete with South American countries, because of the relatively short nearness of the US market, which also offers opportunities for the export of Dutch technology.

The vegetable greenhouse sector
Since the main greenhouse production in Mexico still comes from MT greenhouses, a stepwise improvement in the technical level of this greenhouse type should be emphasised. This will be encouraged because exporters get a fair amount of produce from MT greenhouses, after receiving GlobalGAP. Automatically the skills of the management of MT greenhouses will improve, which brings the step to HT closer. Therefore Dutch companies should consider also offering greenhouses in the MT segment.

Sustainability
HT greenhouse production has been accepted as a sustainable way of vegetable and flower production, because it minimizes water use, through recirculation of the nutrient solution and dehumidification of the greenhouse air. Furthermore, the use of chemicals is also minimized using biological control of pests and diseases.
Last be not least, new developments in energy savings by semi closed greenhouses will increase the contribution to sustainability of flower and vegetable production worldwide. For this reason and to meet with consumers' demands ('license to produce'), renewable energy sources has to be found, together with additional CO_2 sources. Initiatives in this field should be supported.

Knowledge transfer
Knowledge on all management levels is still lacking. Over the past years many initiatives has been taken to come to one or more training centres. These initiatives mostly failed because investments as well as running costs were too high.
Experiences in many other countries made clear that training centres can become self sustainable after 3-5 years with a combined private/public financing. In Mexico financial support from the Federal government is slowly on its way, which will give the opportunity to start with a knowledge centre in due course. Private initiatives however, has been realised, but are only aimed at practical advice towards growers.

Plant requirements
Published temperature requirements are not consistent. This makes it difficult to interpret the data. It seems to be related to the prevailing conditions at the place where the data came from. Therefore we only used data from the region, but still some inconsistency remained. This problem will be hard to tackle, but a first step can be organising a seminar on this topic.

9 References

Agro 2000.
www.Agro2000.com.mx
Calpas, J. 2007.
Production of sweet and bell pepper. Government of Alberta. Department of Agriculture & Rural development. Alberta, Canada.
Global Flowers. Odense, Denmark. www.global-flowers.com
Gonzáles Morales, P. & R. Peréz Lara. 2002.
Producción de Pimiento Morrón Bajo Invernadero. ITESM, Campus Queretaro, Mexico
Hanna, Y. 2001.
Greenhouse Tomato Production Manual. Louisiana State University Agricultural Center, USA.
Heladio Linares Outiveros, M.C. 2004.
El cultivo del Rosal. Secretaría de la Reforma Agraria, SAGARPA, Mexico.
Hochmuth, R.C. 2008.
a. Production of Greenhouse Tomatoes. In: Florida Greenhouse Vegetable Production Handbook, Volume 3. University of Florida, Institute of Food and Agriculture Sciences, USA
Hochmuth, R.C. 2008.
b. Greenhouse Cucumber Production. In: Florida Greenhouse Vegetable Production Handbook, Volume 3. University of Florida, Institute of Food and Agriculture Sciences, USA
Johnson, J. 1980.
Greenhouse vegetable production. General information and bibliography. Divison of Agricultural University of California. Extension leaflet 2667. Riverside California, USA
Jensen, M. & P. Rorabough, 2000.
Growing Hydroponic Tomatoes. University of Arizona, College of Agriculture, USA.
López Melida, J. 1981.
Cultivo del Rosal en Invernadero. Ediciones Mundi-Prensa, Madrid, España. pp 173-197.
Mandhar, S.C., K.Singh & C.R. Kumari, 2001.
Environmental conditions and gerbera production under different types of greenhouses. Jour. Appl. Hort. 2001, 3(1)28-31
Merill, T.L. & R. Miró (Eds.) 1996.
Mexico: A country study. GPO for Library of Congres, Washington, USA.
Sakata Ornamantals. Morgan Hill, Canada. www.sakata.com
Samurai Gerbera, Langly, British Columbia, Canada www.samuraigerbera.com
Snyder R.G. 1999.
Greenhouse Tomato Handbook. Mississippi State University, Extension Service, USA.
Swaider, J.M., G.W. Ware & J.P. MacCollum, 1996.
Producing Vegetable Crops. Interstate Publishers Inc., Danville, Illinois, USA.
Van Henten, E.J., J.C. Bakker, L.F.M. Marcelis, A. Van't Ooster, E. Dekker, C Stangellini, B.H.E. Vanthoor, B. Randeraat & J. Westra, 2006.
The adaptive greenhouse: an integrated systems approach to developing protected cultivation systems. Acta Horticulturae 718: 399-406
Van't Ooster B., E. Heuvelink, V.M. Loaizo Mejía & E.J. Van Henten, 2007.
Technical solutions to prevent heat induced crop grow reduction for three climate regions in Mexico. Acta Horticulturae 801: 1251-1258.

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