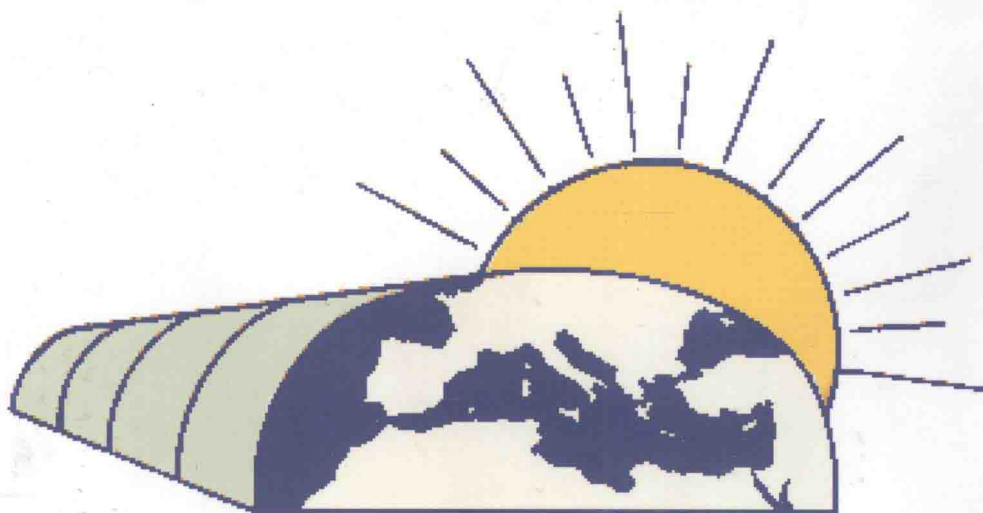


Good Agricultural Practices for greenhouse vegetable crops

Principles for Mediterranean climate areas



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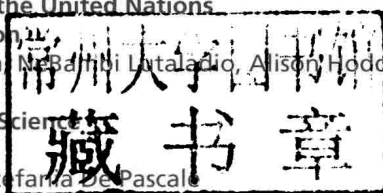
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Preface

A very significant event in the world history of Agriculture is the domestication of plants by mankind. Instead of depending on wild growth, it was realized that the planting of seeds or cuttings allowed the propagation of the type of plants desired. Another important breakthrough resulted from the need to protect the domesticated plants from abiotic and biotic stress factors. Protected cultivation emerged as a way to protect crops from adverse weather conditions allowing year-round production and the application of an integrated crop production and protection management approach for better control over pests and diseases.

Greenhouse crop production is now a growing reality throughout the world with an estimated 405 000 ha of greenhouses spread over all the continents. The degree of sophistication and technology depends on local climatic conditions and the socio-economic environment.

The experience of greenhouse production, which emerged in northern Europe, stimulated development in other areas, including the Mediterranean, North America, Oceania, Asia and Africa, with various rates and degrees of success. It has been shown that a mere transposition of north European solutions to other parts of the world is not a valid process. Each environment requires further research, development, extension, training and new norms of application to meet local requirements.

During the last 20 years countries in the Mediterranean climate area have become increasingly competitive producers of greenhouse vegetables. During this time there has been a revolution in greenhouse production technology in terms of greenhouse design, type and quality of the plastic covering material, fertigation, mulch, use of high-yielding hybrids and cultivars, plant training and pruning techniques, integrated pest management, the use of pollinator insects, climate control, soil solarization etc. Only a few years ago, a yield of 100 tonnes per hectare of tomato in a greenhouse was considered a good performance. Today, for growers in Mediterranean climate areas, a harvest of 300 tonnes per hectare is not unusual.

Besides supplying the local markets, the production of greenhouse vegetables is greatly valued for its export potential and plays an important role in the foreign trade balance of several national economies in the Mediterranean region. However, the intensification of greenhouse crop production has created favourable conditions for many devastating pests and diseases. This has significantly increased the need for pesticide applications. At the same time, legislative measures and standards requirements regarding the quality and safety of vegetables have become

increasingly demanding. Consumer awareness has risen and the demand for pesticide-free products is a reality which cannot be ignored.

Since 1993, the Regional Working Group on Greenhouse Crops in the Mediterranean Region facilitated by the FAO's Plant Production and Protection Division has supported training and research and development initiatives to strengthen national capacities in upgrading the greenhouse crop sector in Mediterranean climate areas. This publication builds on experience gained through partnerships forged by the working group and represents the interpartner effort of two decades. It aims to summarize the knowledge and practical experiences of scientists from the Near East and North Africa region, specifically from Algeria, Cyprus, Egypt, Jordan, Lebanon, Libya, Malta, Morocco, the Syrian Arab Republic, Tunisia and Turkey and in collaboration with the Commission of Protected Cultivation of the International Society for Horticulture Science (ISHS) and a worldwide panel of subject matter specialists.

This technical document intends to illustrate the benefits that can be drawn from an "integrated production and protection" (IPP) approach linking production technologies and plant protection practices to minimize the use of pesticides and adopting "sustainable intensification" of greenhouse crop production as the guiding principle. It is in line with the new FAO "Save and Grow" paradigm that helps to limit agriculture's impact on climate change and strengthens resilience of open-field and greenhouse farming systems to socio-economic and climate risks.

It is believed that greenhouse crop production is destined to play an increasingly important role in the Mediterranean climate environment as a means for sustainable crop intensification leading to optimization of water-use efficiency in an environment of water scarcity in addition to better control of product quality and safety, in line with the market demand, standards and regulations.

By sharing their knowledge and experience, the authors of this publication wish to sustain the competitiveness of the vegetable greenhouse sector in the Mediterranean climate areas and contribute to its further development to the benefit of growers, consumers and the environment.

This publication discusses the principles of Good Agricultural Practices (GAP) as they may be applied to greenhouse farming in the Mediterranean climate areas. It illustrates different aspects of greenhouse crop production and protection with special emphasis on greenhouse technologies, design and climate control, cropping systems, in particular those practices which help reduce pests and diseases incidence in crops, integrated pest management, the use of adapted cultivars, and the need for traceability and product labelling.

The guidebook is expected to serve as a training guide for trainers and a resource document for advanced growers and stakeholders of the greenhouse vegetable value chain. It is also a valuable source of information for programme managers, international and multilateral development organizations, NGOs and the private sector – as well as researchers, advisors and professionals in greenhouse agriculture. We trust that it will help to further strengthen the work of the FAO-facilitated Regional Working Group on Greenhouse crops in the Mediterranean Region.

Abdessalam Ould Ahmed

FAO Assistant Director-General and Regional Representative
Office of the Near East

List of acronyms and abbreviations

AAP	Air acidification potential
ADI	Acceptable daily intake
ADP	Abiotic depletion potential
AESA	AgroEcoSystem Analysis
AFP	Air-filled pore space
AGN	FAO Food Safety and Quality Division
AGP	FAO Plant Production and Protection Division
ALARI	Arid Land Agricultural Studies and Research Institute
AoP	Areas of protection
ARI	Agricultural Research Institute
ASABE	American Society of Agricultural and Biological Engineers
ASEAN	Association of Southeast Asian Nations
ATP	Adenosine triphosphate
BER	Blossom end rot
BSI	British Standards Institution
CA	Controlled atmosphere
CB	Certification body
CEC	Cation exchange capacity
CED	Cumulative energy demand
CEN	European Committee for Standardization
CFD	Computational fluid dynamics
CGMMV	Cucumber green mottle mosaic virus
CHP	Combined heat and power
CI	Chilling injury
CMV	Cucumber mosaic virus
CNL	Compensated no leakage
CPCC	Control Points and Compliance Criteria
CVYV	Cucumber vein yellowing virus
CWSI	Crop Water Stress Index
CYSDV	Cucurbit yellow stunting disorder virus

DE	Delivery efficiency
DFT	Deep flow technique
DIF	Day-night temperature difference
DT	Day temperature
DTPA	Diethylene triamine pentaacetic acid
DU	Distribution uniformity
DWC	Deep water culture
EAW	Easily available water
EBA	Ethylene butyl acrylate
EBI	Ergosterol biosynthesis inhibitor
EC	Electrical conductivity
EDDHA	Ethylene diamine di-o-hydroxyphenylacetic acid
EDTA	Ethylene diamine tetraacetic acid
EPC	Electronic product code identification
EPS	Effective pore space
ET	Economic threshold
ETc	Crop evapotranspiration
ETo	Reference evapotranspiration
EUP	Eutrophication potential
EVA	Ethylene vinyl acetate
EW	Equivalent weight
FDR	Frequency domain reflectometer
FE	Farm efficiency
FFS	Farmer field school
FH	Float hydroponics
FU	Functional unit
FW	Fresh weight
FYM	Farmyard manure
GAP	Good agricultural practice
GFT	Gravel film technique
GGN	GLOBALG.A.P number
Gm	Granular matrix
GMO	Genetically modified organism
GMP	Good manufacturing practice

GRIS	Greenhouse Information System
GWP	Global warming potential
HACCP	Hazard analysis and critical control point
HAF	Horizontal airflow
HEDTA	Hydroxyethyl ethylene diamine triacetic acid
IAA	Indoleacetic acid
ICS	Inductively coupled plasma
IE	Irrigation efficiency
IFA	Integrated farm assurance
IGR	Insect growth regulator
IOBC	International Organization for Biological Control of Noxious Animals and Plants
IPM	Integrated pest management
IPPM	Integrated production and pest management
IR	Infrared
IRTA	Institute for Food and Agricultural Research and Technology
IS	Irrigation scheduling
ISHS	International Society for Horticultural Science
Kc	Crop coefficient
Kp	Pan coefficient
LAI	Leaf area index
LCA	Life cycle assessment
LCI	Life cycle inventory
LDPE	Low density polyethylene
LER	Land equivalency ratio
LLDP	Linear low density polyethylene
LP	Local practice
MA	Modified atmosphere
MBr	Methylbromide
MOA	Ministry of Agriculture (Jordan)
MRL	Maximum residue level
NCARE	National Center for Agricultural Research and Extension
NFT	Nutrient film technique
NIR	Near infrared

NPV	Nuclear polyhedrosis virus
NT	Night temperature
NUE	Nitrogen-use efficiency
PAR	Photosynthetically active radiation
PDCA	Plan-Do-Check-Act
PDSA	Plan-Do-Study-Act
PE	Polyethylene
PepMV	Pepino mosaic virus
PGR	Plant growth regulator
PHU	Produce handling unit
PMMA	Polymethyl methacrylate
PMU	Production management units
PVY	Potato virus Y
QMS	Quality management system
QR	Quick response
RDWC	Recirculating deep water culture (system)
REI	Re-entry interval
RFID	Radio frequency identification
RH	Relative humidity
RIS	Relative irrigation supply
RNA	Ribonucleic acid
SAR	Sodium adsorption ratio
SAS	Safety access system
SCIS	Soilless Culture Information System
SNFT	Super nutrient film technique
SOM	Soil organic matter
SOP	Standard operation practice
STV	Salinity threshold value
SYD	Salinity yield decrease
TCP	Technical Cooperation Programme
TDR	Time domain reflectometer
TDR	Time domain refractometry
TDS	Total dissolved solids
TDT	Time domain transmissiometry

TI	Temperature integration
TMV	Tobacco mosaic virus
TPS	Total pore space
TSWV	Tomato spotted wilt virus
TYLCV	Tomato yellow leaf curl virus
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UV	Ultraviolet
VPD	Vapour pressure deficit
YSD	Yellow shoulder disorder
WBC	Water buffer capacity
WE	Watering efficiency
WFT	Western flower thrip
WFS	Wood fibre substrate
WP	Water productivity
WPRS	West Palearctic Regional Section (IOBC)
WUE	Water-use efficiency
ZYMV	Zucchini yellow mosaic virus

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1. Regional Working Group on Greenhouse Crop Production in the Mediterranean Region: History and development

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FAO'S PLANT PRODUCTION AND PROTECTION DIVISION (AGP): APPROACH AND ROLE IN PROMOTING REGIONAL COOPERATION IN SUPPORT OF GREENHOUSE CROP PROTECTION

In line with the “Save and Grow” concept, AGP works to strengthen global food security by promoting sustainable crop production intensification, which aims at producing more from the same area of land while conserving resources, reducing negative impacts on the environment and enhancing natural capital and the flow of ecosystem services.

AGP's mandate is to enhance and strengthen:

- effective and strategic decisions that increase crop production using an ecosystem approach and nutrition-sensitive crop diversification;
- national capacities to monitor and respond effectively to transboundary and other important outbreaks of pests;
- policies and technologies appropriate to needs of member countries to reduce the negative impact of pesticides; and
- conservation and sustainable use of plant genetic resources with strong linkages between conservation, plant breeding and seed sector development.

As part of its programme areas, AGP supports the development of greenhouse technology for horticulture and high-value crops as a means for sustainable crop intensification. To this effect, a Regional Working Group was created 20 years ago, in 1993, to enhance south-south cooperation among the national institutions