Integrated production and protection in the Mediterranean region under protected cultivation

Papasolomontos A.

in

Choukr-Allah R. (ed.).
Protected cultivation in the Mediterranean region

Paris : CIHEAM / IAV Hassan II
Cahiers Options Méditerranéennes; n. 31

1999
pages 413-424

INTEGRATED PRODUCTION AND PROTECTION IN THE MEDITERRANEAN REGION UNDER PROTECTED CULTIVATION

A. PAPASOLOMONTOS
Megalou Constantinou 14, Nicosia 2121 . CYPRUS

Abstract: The area under protected cultivation in the Mediterranean region is estimated to have reached 186 000 ha in 1994. A wide range of crops are grown, but production is facing increasing difficulties primarily due to environmental degradation, a built up of pests and diseases as well as insect resistance to pesticides. These factors have been accentuated through intensive cultivation over time, absence of adequate rotation or fallow and increased use of pesticides, often at higher than recommended rates. The prevailing situation is globally assessed and the impact on production of healthy crops through the adoption of an Integrated Production and Protection (IPP) approach is discussed. The potential use and constraints in the adoption of IPP in the Mediterranean region are evaluated and a strategy for its wider adoption outlined.

INTRODUCTION

The Mediterranean region, as envisaged in this presentation covers the area bordering the Mediterranean Sea; an area which is characterized by mild winters and long dry summers. Very often rainfall or the availability of water for irrigation are limiting factors to agricultural production. The mild winters however, provide good growing conditions for the production of out of season crops, under protected cultivation with a minimum of heating. These include vegetables, fruit and flowers, but predominantly vegetables, both for local consumption and for export. Exported crops are destined, not necessarily exclusively, for Northern European countries. The area under protected cultivation within this region has increased from about 123 000 ha in 1984/85 (FAO, 1990), to an estimated 186 000 in 1994. (Castilla and Hernandez 1996).

A wide range of structures are used for raising these out of season crops and these range from greenhouses and walk in tunnels to low tunnels (FAO 1990). For greenhouses and large walk in tunnels, which are of various types, the frames vary from wood to iron and the cover from glass to plastic. Over the years plastic has been expanding rapidly and is now becoming increasingly predominant. Low tunnels are almost exclusively covered with plastic. (Castilla and Hernandez 1996).

The increasing demand for out of season agricultural produce in the Northern European countries, the increasing cost of local production in these countries due to the high costs of heating and labor as well as low light intensities, will continue over the long term to provide an incentive for increasing production in the Mediterranean region. However to produce efficiently good quality produce to meet such demands on a sustainable basis, growers in the region have to focus in maximizing yields, at reducing environmental degradation, at optimizing quality and producing at competitive prices. It is believed that an Integrated Production and Protection approach, currently not extensively practiced as a package, although individual components may be in operation in some areas, could assist towards meeting this objective.

THE GREENHOUSE AND ITS ENVIRONMENT

For the commercial production of crops under protected cultivation, the prevailing climate, as well as soil, are of primary importance. Thus, the prevailing temperatures, relative humidity, water availability, the prevailing wind velocity and light intensity as well as suitable soils are key components. Whilst it is not the purpose of this paper to dwell in any length on these specific issues it can be said in general terms that within the Mediterranean region as a whole, the availability of suitable sites catering to the above requirements is often not a limiting factor to production. Furthermore technically, albeit at a cost, individual components that may not be up to the required standard can be artificially improved. Thus water can be transferred into the development area, wind brakes can be planted or constructed, soils improved, temperature within the greenhouses maintained through heating, ventilation, shading etc. All these improvements collectively or individually can be effected and on the assumption that they can be economically justified, commercial crops can be grown. However, the competition between countries and sites within countries is such that in the final term only optimal sites will be developed for protected cultivation on a sustainable basis. Thus it may not be possible to develop sites if suitable water for irrigation has to be pumped from great depths at a prohibiting cost, if the site is extremely exposed to winds, if the prevailing winter and spring temperatures and/or light intensities are low, or the infrastructure associated with marketing and provision of inputs is absent.

The ultimate aim for sustainable protected cultivation would therefore be the selection of sites which substantially meet production prerequisites so that a good crop can be produced and marketed economically. Furthermore, success in protected cultivation can not be viewed in isolation from the need to ensure the availability of technical knowledge, a skilled labor force, inputs, capital and funding institutions for the provision of credit as well as market outlets. Size and type of production units is also important. As a rule, holdings in the Southern Mediterranean region are characterized by their small size and single span houses whilst larger multispan units are operating in the Northern region. The latter are generally more efficient.

The environment is significant in another way. The warm weather that prevails in the Mediterranean region, even during the Autumn and Winter months, is conducive to the development of pests and diseases in outdoor crops, or weeds which can migrate into the greenhouses as soon as these are planted. The extent that these pests can be kept out of the greenhouses depends on many factors, including the implementation of general hygiene measures, both inside and outside the greenhouse, the type and efficiency of insect proofing of the greenhouses as well as the skills and technical knowledge of growers and farm laborers. (Berlinger et al., 1996. Trottin and Millot, 1994). Usually these are the factors that determine, to a large extent the success or failure of any particular crop.

Greenhouses, by their very nature, can best be described as isolated "closed" and expensive structures or units. The isolation makes pest control, through the application of general hygiene measures, easier through slowing down, reducing, or even eliminating extensive migration of pests into the greenhouses. At the same time, and because of the high capital and recurrent costs, lack of mobility, greenhouses are essentially cropped on a continuous basis or at least for five years with no possibility for fallow or suitable rotations. (FAO, 1992). This results in the rapid built up of soil pests, and over time of nutrients, pesticides as well as salts from the irrigation water to the soil. These factors often act as limiting to the production.

CROP PRODUCTION AND PROTECTION

Crop Production

The ultimate aim of the grower to produce a good crop will depend substantially on the crop production and protection technology that has been applied under any specific protected cultivation management utilized.

Apart from the selection of the cultivar itself, the growing medium, whether it is soil or an inert substrate, is of primary importance. In recent years inert substances have been increasingly used as growing media. These do not have the limitations that may be present with natural soils and assuming their availability at competitive prices, they offer distinct advantages over natural soils. These include the absence of pests and diseases and hence soil sterilization is avoided, optimum utilization of irrigation water and fertilizers, more intensive utilization of greenhouse space, more uniform maturity of the crop and often a reduced relative humidity within the greenhouse (FAO, 1990). These substrates, often used in the form of growing bags, or in pots, offer themselves easily for use in conjunction with improved irrigation systems, particularly drip or micro irrigation, often combined with fertigation. Some of the more commonly used substrates, often available at low cost in the Mediterranean region, include leaf mould, wood waste (saw dust), grape and olive marc, sand as well as vermiculite and perlite. Peat is also widely used.

Other production factors of significance include the type of greenhouse and its sitting to allow for maximum cropping as well as light absorption, the provision of heating and ventilation facilities, the adequate insect proofing of greenhouses, wind breaks as well as optimum fertilization irrigation and pollination. Mulching, usually with black plastic will keep the greenhouse free of weeds, avoid the need for cultivations, reduce irrigation needs as well as the relative humidity (FAO, 1990).

Crop Protection

Before expanding on the aspect of crop protection, it is important to highlight that the seedlings used in protected cultivation should be derived from cultivars that are not only resistant or tolerant to specific pests and diseases but that these are actually free of pests and diseases before their introduction into the greenhouse. Very often this is not the case and diseased seedlings are transferred from nurseries, (FAO, 1991) thus introducing at a very early stage a focus or foci of infection. Such seedlings will not grow into healthy plants and produce optimal yields regardless of actions that may subsequently be taken to limit or control the spread of these pests and diseases.

Diseases are generally classified into four categories. These include, seed borne diseases that are carried on or within the seed itself, usually controlled through the purchase of certified seed from reputable firms, soil borne diseases that are carried in the soil or growing media of the greenhouses and can usually be controlled through soil desinfectation either by chemicals or by soil solarization (FAO, 1991), or through the use of soil bags. The use of tolerant or resistant cultivars is also often practiced either alone or in combination with soil treatments. Microorganisms causing air borne diseases are carried by air currents and under favorable conditions, usually high relative humidity and temperature can infect susceptible hosts within the greenhouse. Control is through the use of tolerant or resistant varieties, pruning and roqueing as well as manipulation of the environment within the greenhouses (i.e., temperature and humidity) to discourage and/or delay their establishment. As a last resort pesticides could be used. Vector transmitted diseases include those that are transmitted by man, insects or mites. These constitute the fourth category and include all those diseases, including virus diseases that are transmitted by man, implements and insects or mites. Control can again be achieved through the application of general hygiene measures, the use of resistant or tolerant cultivars, the use of insect proofing of the greenhouses or again as a last resort through the use of pesticides, in the case of insects, fungi, bacteria or nematodes.

For all disease categories the adoption of good farming practices including fallow, suitable rotations, alteration in sowing dates as may be possible, the application of general hygiene measures both inside and outside greenhouses, elimination of weeds that may act as hosts to diseases, destruction of plant residues that may harbor pest and diseases, disinfestation of structures prior to cropping and implements as well as the use of spot spraying and yellow sticky insect traps as needed can, and often do, act as significant barriers to the early establishment and spread of diseases (Boukadida and Michalekis, 1994. Trottin and Millot, 1994).

Inspite of all the options that growers normally have at their disposal for preventing and controlling pests and diseases more and more reliance has however been placed on pest and disease control through the use of pesticides. The harmful side effects of such a practice are already evident. These include environmental pollution, human health hazards and a built-up of resistance of pests to currently available pesticides. As a result, growers are forced to spray more frequently and at higher concentrations with uncertain results. In certain countries of the Mediterranean region it is not unusual for 20 - 30 pesticide applications to be applied per crop/annum, without achieving satisfactory pest control due entirely to the building-up of resistance to the pesticide and the destruction of the insect's predators/parasites that are present in the greenhouse. These would have ordinarily assisted in keeping the destructive insects under adequate control (FAO, 1992. FAO, 1990).

The biological control of greenhouse insects and their potential importance in the suppression of major insect pests was noted as early as 1927, in England (van Lenteren and Woets, 1988). Commercial production and distribution of these parasites commenced immediately thereafter. Following the discovery of the chlorinated hydrocarbon insecticides (DDT, BHC) during World War II, to be followed by the organic phosphorous compounds and others later, this practice was discontinued, as these insecticides proved initially very efficient in controlling most greenhouse pests. Within a short time however, greenhouse insects built up resistance to these and other pesticides and the search for new parasites, predators or pathogens and their production for commercial use commenced. Biological control has since received increased attention worldwide, including in the Mediterranean region (Berlinger et al., 1996. Boukadida and Michelakis, 1994. Elad et al., 1994. Trottin and Millot, 1994).

Biological control programs alone, or in combination with other cultural practices or environmental manipulations, are not however likely to be readily acceptable by the growers not only because of their complexity but also because of the need to produce optimum quality crops. A pest management program based on biological control, a minimal use of selected pesticides, and the application of all other practices that lead to the suppression of pests is by far more likely to be acceptable to growers. This has resulted in the promotion of Integrated Pest Management programs.

INTEGRATED PEST MANAGEMENT (IPM)

IPM is the careful integration of a number of available pest control techniques, described earlier, that discourage pest population development and keep pesticide use to economically justified levels. It results in the growth of a healthy crop with the least detrimental impact to human health and to the environment. IPM as developed and applied by FAO and others further emphasizes the contribution of farmers themselves in diagnosing pest problems, establishing their significance and planning their control. Farmers are also involved in the research, both scientific and social, leading to the development of solutions.

IPM as applied today is exemplified, amongst others by the work of FAO and other U.N. Agencies in cooperation with various Asian governments, towards the control of rice pests which have, over the years, built up resistance to a number of insecticides. As a result of IPM implementation, Asian countries have achieved a steady increase in rice production and on rice yield per hectare accompanied by a substantial reduction in pesticide use (FAO, 1994). This has led also to an improvement in human health and the environment.

IPM revolves around the central theme of pest management on a sustainable basis, i.e., at a cost that farmers can sustain and with a minimum of environmental degradation or danger to human health. In implementing a successful IPM program, growers need to keep constant watch over their crops. In the process they develop an intimate knowledge of plant growth, pest development and the conditions that favor their development as well as those of their predators and parasites. A new approach to optimizing crop production currently been promoted, especially for crops under protected cultivation, is that of Integrated Production and Protection or IPP and is intended to cover both production and protection in an integrated and sustainable basis. The basic aim of IPP, as the name implies, is the production of a healthy crop through optimum plant management.

INTEGRATED PRODUCTION AND PROTECTION MANAGEMENT (IPP)

It will be recalled that earlier in this article, emphasis was given to the fact that the greenhouse, including the low tunnels, can be considered as isolated and closed units. This enables growers to manipulate temperature, relative humidity, light intensity and carbon dioxide content, amongst others, so as to maximize plant growth and production. These same conditions, in addition to insect proofing the greenhouse and the application of general hygiene measures within the greenhouse and its general vicinity, allow growers to manipulate conditions that are favorable to disease development and/or insect multiplication thus eliminating, delaying or reducing disease and pest built up.

Of course the application of this management technology requires on the part of the grower a close and continuous observation, or scouting, of the plants' development on a regular basis, as well as a good knowledge of their pests and diseases and of the conditions that favor their development. Similar knowledge is called for the pests' predators or parasites and continuous observation of their presence, development, density etc., need to be made to allow the grower to reach correct and timely decisions on actions that need to be taken to safeguard the health and secure the yield of the crop in question. These factors, in conjunction with the use of healthy seed, suitable cultivars, adequate fertilization and irrigation are all interconnected components in any IPP management program.

Tables 1 and 2, summarize various options that growers normally have to take in order to produce good crops and safeguard the health of the plants from the propagating material stage, to seed beds, through to the greenhouse or low tunnel itself. Each and every one of these actions can assist in the elimination, avoidance or delay in disease development of infection foci and encourage good plant growth. It will be noted that chemical control of pests and diseases is only one of these manipulations. The Tables emphasize, amongst others, again the significant part that general sanitation measures as well as adequate insect proofing play in the production of healthy plants - factors that are not always appreciated particularly in the recent past with the advent of efficient pesticides that initially easily controlled the various pests. With the passage of time, the destruction of the insects' predators and parasites, as well as the development of resistance to insecticides, environmental pollution as a result of their overuse as well as their detrimental effect on human health have forced governments as well as growers to look again into other aspects of insect control which appear in these Tables. A typical example is that of the tobacco white fly (Bemisia tabaci Genn) that infests a wide range of crops within and outside the greenhouse. The case of the whitefly infestation in Jordan is used here as a typical example of the damage that this insect can cause to crops grown under protected cultivation and the difficulties experienced in controlling it (Abdullah M. et al., 1985. Batarseh et al., 1995). The white fly, apart from the direct damage caused to host plants by sucking the plant sap, thus weakening the plant, it causes indirect damage through the exudation of honey dew, and subsequent black soot development, as well as through the transmission of tomato yellow leaf curl virus (TYLCV), cucumber vein yellow virus (CVYV) and many others. These two viruses are limiting factors in the cultivation of tomatoes and cucumbers under protected cultivation in Jordan since they can completely destroy the host plants leading to very low yields, depending on the stage of the plant's infestation. The white fly has built up resistance to a wide spectrum of insecticides even when applied at weekly intervals and at high concentrations. The control of the white fly has now come to rely substantially on the use of healthy seedlings, sound insect proofing of the greenhouse fitted with double doors so as to exclude the white fly, yellow sticker traps as well as spot spraying so as to control any initial infection foci. The introduction of the insect's predators and parasites is also being pursued but in the initial year the establishment rate has been low, primarily due to the hot weather, pesticide applications within the greenhouse, and probably transport stress of the beneficial insects from Europe (Hass V. and Schunemann P., 1995). A similar situation regarding the whitefly is present in many other countries in the Mediterranean region, including in Turkey, Syria and Egypt. (FAO, 1992).

Table 1: INTEGRATED PRODUCTION AND PROTECTION (IPP)

COUNTRY:	PRINCIPAL PESTS AND DISEASE AGENTS AFFECTING PRODUCTION UNDER PROTECTED CULTIVATION																					
CROP : Tomato	Fungi											Bacteria		Viruses			Nematodes	Insects				Mites
CONTROL METHOD	Botrytis cinerea	Sclerotinia sclerotiorum, S. minor	Fusarium oxysporum F. sp. lycopersici	Verticillium dahliae, V. albo - atrum	Leveillula taurica	Alternaria solani	Didymella lycopersici	Rhizoctonia solani	Phytophthora spp.	Pyrenochaeta lycopersici	Phytophthora infestans	Pseudomonas syringae pv. tomato	Pseudomonas viridiflava	TYLCV	TMV, ToMV	Double - Virus Streak	Meloidogyne spp.	Myzus persicae, M. Fabae	Bemisia tabaci	Lyriomisa spp.	Frankliniella occidentalis	Tetranychus urticae
PROPAGATION MATERIAL																						
Hosts Resistance/Tolerance	+	+	+	+					+	+	+		+	+	+	+	+					
Healthy Seed			+	+		+	+	+	+			+			+	+						
Grafted Resistance																						
SEED BEDS / NURSERIES.																						
Soil/Compost Sterilisation	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+						+
Seed Disinfestation			+	+		+	+	+	+			+			+	+						
General Sanitation	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Humidity Control	+				+	+	+			+	+	+	+									
Temperature control	+	+			+	+	+	+	+	+	+	+	+									
Roqueing								+	+			+	+	+	+	+	+					
Sterilised Soil Pots/Trays		+	+	+		+	+	+	+	+		+	+		+	+	+					+
Insect Proofing														+	+	+		+	+	+	+	+
Use of Stickers																+	+		+	+	+	
High Seed Benches	+	+	+	+	+	+	+	+	+	+	+	+					+					
Double Doors														+	+	+		+	+	+	+	+
Pesticide Applications	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+
GREENHOUSE																						
Soil Sterilisation		+	+	+	+	+	+	+	+	+	+	+	+		+	+	+					+
Insect Proofing														+	+	+		+	+	+		+
Plastic Mulch																				+		
Double Doors																						
Trap Crops														+					+	+		
Shading			+	+	+			+	+													
Plant Density	+	+			+	+	+						+									
Soil Drainage	+	+	+	+	+	+	+	+	+	+	+	+	+									

COUNTRY:	PRINCIPAL PESTS AND DISEASE AGENTS AFFECTING PRODUCTION UNDER PROTECTED CULTIVATION																					
CROP : Tomato	Fungi											Bacteria		Viruses			Nema-todes	Insects				Mites
CONTROL METHOD	Botrytis cinerea	Sclerotinia sclerotiorum, S. minor	Fusarium oxysporum F. sp. lycopersici	Verticillium dahliae, V. albo-atrum	Leveillula taurica	Alternaria solani	Didymella lycopersici	Rhizoctonia solani	Phytophthora spp.	Pyrenochaeta lycopersici	Phytophthora infestans	Pseudomonas syringae pv. tomato	Pseudomonas viridiflava	TYLCV	TMV, ToMV	Double - Virus Streak	Meloidogyne spp.	Myzus persicae, M. Fabae	Bemisia tabaci	Lyriomiza spp.	Frankliniella occidentalis	Tetranychus urticae
Control of N Fertilisation, N/K ratio	+	+	+	+		+	+	+	+		+		+									
Regulating Irrigation																						
-Flooding																						
-Farrow																						
-Sprinkler																						
-Drip	+	+	+	+	+	+	+	+	+	+	+	+	+									
Growing bags	+	+	+	+	+	+	+	+	+	+	+	+	+				+					
Windbreaks																						
-Artificial														+	+	+		+	+	+	+	
-Natural														+	+	+		+	+	+	+	
General Sanitation	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Crop Rotation	+	+	+	+			+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
Crop residue Elimination	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Temperature Control	+	+	+	+	+	+	+	+	+	+	+	+	+									
Humidity Control/Aeration	+				+	+	+	+	+	+	+	+	+									
Roqueing			+	+				+	+			+	+	+	+	+	+					
Eliminating excess foliage	+	+			+	+			+		+											
Pruning	+	+			+	+			+		+											
Biological Control																						
-Predators																						
-Parasites																						
CHEMICAL CONTROL																						
General Pesticide Application	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
IPM	+	+			+	+	+				+	+	+						+	+		
Spot Treatment																		+				

Table 2: INTEGRATED PRODUCTION AND PROTECTION (IPP)

COUNTRY:	PRINCIPAL PESTS AND DISEASE AGENTS AFFECTING PRODUCTION UNDER PROTECTED CULTIVATION													
CROP : Watermelon	Fungi					Bacteria	Viruses			Nematodes	Insects			Mites
CONTROL METHOD	Fusarium oxysporum, F. sp. niveum	Verticillium dahliae, V. albo - atrum	Pythium spp., Phytophthora spp.	Erysiphe cichoracearum	Colletotrichum lagenarium		Watermelon mosaic Virus 1 (WMV1)	Watermelon mosaic Virus 2 (WMV2)	Squash mosaic virus	Meloidogyne spp.	Hilemyia cilicrura	Aphis gossypi, Myzus persicae	Bemisia tabaci	Tetranychus Urticae
PROPAGATION MATERIAL														
Hosts Resistance/Tolerance				+	+		+	+						
Healthy Seed			+						+					
Grafted Resistance	+	+	+											
SEED BEDS / NURSERIES.														
Soil/Compost Sterilisation	+	+	+	+			+	+	+	+	+			+
Seed Disinfestation			+						+		+			
General Sanitation			+				+	+	+	+	+			+
Humidity Control				+	+									
Temperature control	+	+		+	+									
Roguing			+				+	+	+	+				
Sterilised Soil Pots/Trays	+	+	+		+		+	+	+	+	+			+
Insect Proofing							+	+	+			+	+	+
Use of Stickers													+	
High Seed Benches	+	+	+	+	+		+	+	+	+	+			
Double doors							+	+	+				+	+
Pesticide Applications	+	+	+	+	+		+	+	+				+	+
GREENHOUSE (Low tunnels)														
Soil Sterilisation														
Insect Proofing														
Plastic Mulch							+	+	+	+	+	+	+	+
Double Doors														
Trap Crops														
Shading														
Plant Density														
Soil Drainage	+	+		+										

COUNTRY:	PRINCIPAL PESTS AND DISEASE AGENTS AFFECTING PRODUCTION UNDER PROTECTED CULTIVATION													
CROP : Watermelon	Fungi					Bacteria	Viruses			Nema-todes	Insects			Mites
CONTROL METHOD	Fusarium oxysporum. F. sp. niveum	Verticillium dahliae. V. albo - atrum	Pythium spp.; Phytophthora spp.	Erysiphe cichoracearum	Colletotrichum lagenarium		Watermelon mosaic Virus 1 (WMV1)	Watermelon mosaic Virus 2 (WMV2)	Squash mosaic virus	Meloidogyne spp.	Hilemyia cilicrura	Aphis gossypi. Myzus persicae	Bemisia tabaci	Tetranychus Urticae
Control of N Fertilisation, N/K ratio	+	+	+	+										
Regulating irrigation														
-Flooding														
-Farrow														
-Sprinkler														
-Drip	+	+	+	+										
Growing bags														
Windbreaks														
-Artificial														
-Natural														
General Sanitation	+	+	+	+	+		+	+	+	+	+	+	+	+
Crop Rotation	+	+	+	+	+		+	+	+	+	+	+	+	+
Crop residue Elimination	+	+	+	+	+		+	+	+	+	+	+	+	+
Temperature Control	+	+		+	+									
Humidity Control/Aeration				+	+									
Roquing							+	+	+	+				
Eliminating excess foliage														
Pruning														
Biological Control														
-Predators														
-Parasites														
CHEMICAL CONTROL														
General Pesticide Application	+	+	+	+	+		+	+	+	+	+	+	+	+
IPM	+	+												
Spot Treatment														

IPP AND ITS POTENTIAL USE IN THE MEDITERRANEAN REGION

IPP in its totality is not extensively practiced in the Mediterranean region, although in the North where substantially larger units exist, often under good technical management and with skilled labor, IPP practices have been increasingly implemented in recent years. The Southern Mediterranean region, with smaller units and weaker management, operating usually with unskilled and poorly trained labor, is not extensively applying IPP practices, although individual components, such as insect proofing, the application of plastic mulch, double doors etc. may be implemented in certain cases. However, even under these conditions many of these practices are not operating efficiently due to imperfections arising from ignorance on the part of owners and/or the labor force.

The Plant Production and Protection Division of FAO has, over the last few years, been promoting the use of IPP under protected cultivation in the region through the Regional Working Group on Greenhouse Crop Production in the Mediterranean Region and there is now more awareness both on the part of Governments and growers of the benefits that may be derived through the application of a successful IPP management program under protected cultivation. The main components of such a management program for protected cultivation are outlined here and include:

- The uses of healthy, disease free and true to type seed
- Production of disease free seedlings (a basic weakness currently facing growers)
- Roquing and destroying at an early stage, and at regular intervals, all diseased or diseased looking seedlings (limiting potential disease spread)
- Adequate crop rotation practices (not usually practiced),
- The adoption of fallow where possible
- The elimination and destruction of all crop residues of previous crops, which often harbor various insects and other pathogens
- The destruction of weeds and volunteer plants from the immediate area of the crops, and a general maintenance of good sanitation measures inside and outside the greenhouses
- Proper fertilization and appropriate irrigation schedules, using microirrigation techniques if possible
- Adequate soil sterilization or desinfectation, the introduction of growing bags where indicated
- The use of high seed or seedling benches
- Use of resistant or tolerant cultivars, where available
- Grafting of a susceptible cultivar on a resistant rootstock
- The use of improved greenhouses, preferably of the multispan type, including facilities for modifying the physical environment. These include temperature, humidity and light intensity
- Insect proofing the greenhouses, and continued vigilance to maintain them insect proof throughout the growing season(s). Insect proofing will also enable the use of bumble bee for pollination
- To the extent possible, adjusting sowing dates to take advantages of decreases in inoculum or insect pest populations
- The introduction and/or encouragement of the insect's natural enemies to establish themselves and to multiply
- The introduction of insect traps as well as spot spraying to eliminate isolated pockets of pest and disease development
- The application of suitable pesticides only after the full and careful evaluation of insect densities, and not on a preventive basis at regular calendar intervals. The stage of crop growth and the presence and intensity of natural enemies should be considered before deciding on pesticide applications
- The training of management and labor in IPP technology

POTENTIAL CONSTRAINTS TO IPP ADOPTION IN THE MEDITERRANEAN REGION

The early and wide application of IPP in the region, desirable as it may be, is facing substantial constraints. These include, particularly for the Southern Mediterranean region, an inadequate knowledge of indigenous predators and parasites of insect's pests, their high cost and high mortality rate during transport following their purchase normally in Europe. In addition, there are difficulties in the adaptation of imported predators/ parasites due to the high prevailing temperatures and pesticide applications. The absence of good management and well-trained and skilled labor are also limiting factors in the early adoption of IPP technology. However, the situation is slowly changing. Thus there is now, on one hand, more awareness of the need to learn more about the local fauna, (Berlinger et al., 1996. Halima et al., 1993.), and the technology is slowly becoming available to produce at least some beneficial insects at lower costs, (Schmidt, 1994. Whipps, 1994).

The small greenhouse units, often of a rudimentary nature, that are predominantly present in the Southern Mediterranean region, often inadequate extension and research services are also major constraints to the adoption of this management package.

A STRATEGY TOWARDS THE WIDER ADOPTION OF IPP IN THE MEDITERRANEAN REGION

As indicated in the previous section, particularly the Southern Mediterranean region currently has a number of inherent weaknesses which need to be overcome before IPP can be widely adopted as the main management practice. In the first instance a clear Government commitment is prerequisite for any participating country, to be followed by the training of extension personnel in all aspects of IPP. In parallel, research needs to be focussed on components of IPP including greenhouse construction and sitting, identification of indigenous predators/parasites, introduction of resistant/tolerant cultivars and rootstocks to specific diseases etc. A vital component of such a program would however have to be the training of the growers themselves as well as their labor and the ensurance of a participatory approach to IPP implementation by the growers themselves. The Governments, if they have not already done so, should also consider banning importation, manufacture and use of highly toxic pesticides that are known to be detrimental to the environment, human health as well as to beneficial insects.

The process of adaptation of the IPP management will be neither easy nor quick. Some individual components of IPP can however be adopted earlier than others, thus facilitating the whole process and leading to better crops and certainly to less pollution through minimizing pesticide applications. These include general sanitation measures, the use of resistant/tolerant cultivars, or suitable rootstocks where possible, optimizing greenhouse design, including sitting, heating, ventilation, preferably using the multispan type of greenhouse, the use of adequate insect proofing and double doors where needed, the wide use of soil solarization at the expense of methyl bromide for soil desinfectation as well as the use of growing bags with indigenous inert material should receive priority.

Such a strategy should be spearheaded by a well-trained and motivated extension service assisted by adequate research. Initial emphasis should be placed in establishing demonstration units in farmer's greenhouses from where the technology and knowledge can spread out to other growers in the area.

REFERENCES

Abdullah, M. Al Musa, Ibrahim K. Nazer, Naim S. Sharaf, Akel N. Mansur, 1985. Muslin and plastic tunnels; effect on incidence of tomato yellow leaf curl, early blight and various growth characteristics of tomatoes. Dirasat xii (6). pp. 101 - 109.

Batarseh F. Sami, Jaddau I. Marwan, Katbeh Mohamad, Treichem S. Musa, 1995. Management of whiteflies - virus complex in vegetable and cotton products. National Center for Agricultural Research and Technology Transfer, Baqa, Jordan. Report to the United Nations Program, 37 p.

Berlinger M. J., Sarah Lebiush - Mordechi, J. Rosenfield, 1996. State of the Art and the Future of IPM in Greenhouse Vegetables in Israel. IOBC wprs Bulletin 19 (1). 3 p.

Boukadida R., Michelakis S., 1994. The use of Encarsia formosa in integrated program to control the whitefly Trialeurodes vaporariorum Westw. (Hom., Aleyrodidae) on greenhouse cucumber. Journal of Applied Entomology 118 (2). pp. 203 - 208.

Castilla N. and Hernandez J., 1996. Dept. of Horticulture, Agricultural Research and Development Center (CIDA), Spain. (Personal communication).

Elad Y., Guillino ML., Shtienberg D., Aloi C., 1995. Managing Botrytis cinerea on tomato in greenhouses in the Mediterranean. Crop protection 14 (2). pp. 105 - 109.

FAO (1994), Sustainable Agriculture through Integrated Pest Management. Twenty second Regional Conference for Asia and the Pacific, Manilla, Philippines, 3-7 Oct. 1994, 14 p.

FAO (1992), Integrated Pest Management for Protected Vegetable Cultivation in the Near East. FAO Plant Production and Protection Paper 114, 148 p.

FAO (1991), Soil Solarization. FAO Plant Production and Protection Paper 109, 396 p.

FAO (1990), Protected Cultivation in the Mediterranean Climate. FAO Plant Production and Protection Paper 90, 313 p.

Halima Kamel MBB, Hamouda MHB, Ben Halima Kamel MB, Ben Hamouda MH, 1993. Les pucerons des cultures protégées et leurs ennemis en Tunisie. Tropicultura II (2). pp. 50 - 53.

Hasse V., Schunemann P., 1995. Jordanian - German Technical Co-operation. (Personal communication).

Schmidt, J., 1994. Pirate bugs plunder greenhouse pests. Agri - food Research in Ontario, 17 (3). pp. 12 - 15.

Trottin Caudal Y., Millot P., 1994. Protection intégrée de la tomate en culture sous abri. Infos- Paris, 106. pp. 24 -28.

Van Lenteren J. C., Woets J., 1988. Biological and Integrated Pest Control in Greenhouses. Ann. Rev. Entomol. 33. pp. 239 - 269.

Whipps, J.M., 1994. Advances in biological control in protected crops. Brighton Crop Protection Conference, Pests and Diseases, 3. pp. 1 259 -1 264.