Integrated disease management in protected vegetable crops in Morocco: problems and management strategies

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INTEGRATED DISEASE MANAGEMENT IN PROTECTED VEGETABLES CROPS IN MOROCCO: PROBLEMS AND MANAGEMENT STRATEGIES

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Summary: In general, in Morocco, the commercial production of vegetable crops in greenhouses is following traditional and empirical methods. Only few years ago, a yield of 60 T/ha of tomato was considered a fair production. Now, yields of 200 T/ha can be attained. There has been a revolution in the greenhouse production technology: Greenhouse type, quality of the plastic cover, fertirrigation, plastic mulch, new high yielding hybrids, specific pesticides, post-harvest technology. However, the intensification of vegetable production has created new optimal conditions for the development of many diseases. Pest problems were relatively simple in the early years, but they increased in importance as intensive cultivation continued. The prevailing greenhouse types in Morocco have limited ventilation. Therefore, prevention of airborne diseases is not always very successful because of the lack of ventilation. In the green houses, the development of *Pseudoperonospora cubensis, Sclerotinia spp., Botrytis cinerea, Phytophthora infestans, Altenaria solani* is very important. Furrow irrigation, which continues to be used by many growers, may cause oxygen deficiencies in the root system, increasing thereby the risks of disease and nematode attack. It increases humidity and the water is not used with efficiency. In many vegetables growing areas, the water salt content is very high. This salinity increases the susceptibility of vegetable crops to many diseases and particularly to *Fusarium* and *Verticillium* wilts. Resistant varieties become susceptible when the irrigation water has a high salt content. The attitude that pesticides are the universal panaceas is still prevailing among many vegetable growers. Because the same pesticides are being used over long periods, resistance against pesticides has developed in many diseases. Crop rotation and greenhouse rotations are not effective, because the alternative crops are often susceptible to the same diseases. In addition, many weeds act as alternative hosts to diseases and should, therefore, be controlled. Weeds are infected for instance by *Leveillula taurica* and *Verticillium dahliae*. The other cultural practices such as nursery management, elimination of crop residues, sowing and planting time, choice of the resistant varieties and of the plant spacing, are not always properly adopted. All vegetable seeds are imported and are certified seeds. However, many tests have shown that tomato or melon seeds could be infected respectively by *Clavibacter michiganense* and *Fusarium oxysporum f.sp.melonis.*

To avoid these problems, an integrated disease management program (IDM) based on local research results was implemented by some growers. The IDM program integrates all the suitable technics and methods in a compatible ways to maintain the pest populations at levels below the economic injury level

INTRODUCTION

In the last thirty years, the cultivation of vegetable crops under plastic tunnels has known an important development in Morocco. The intensification of vegetable cultivation has created new optimal conditions for the development of many diseases. Pest problems were relatively simple in the early years, but they increased in importance as intensive cultivation continued.

To avoid these problems, an integrated disease management program (IDM) based on local research results, was implemented by some growers. The IDM program integrates all the suitable techniques and methods in a compatible ways to maintain the pest populations at levels below the economic injury level.

We will develop in this paper the main problems in current protected vegetable crop protection, the IDM strategies that could help solving diseases problems and finally propose an IDM program.

MAIN PROBLEMS IN CURRENT VEGETABLES CROP PROTECTION

Greenhouse construction

The prevailing greenhouse type in Morocco is the single plastic tunnel (9 * 56 m) or the canarian type greenhouse (wood frame, 0.5 to 1 ha). The major problem of these greenhouses is their limited ventilation area. Therefore, prevention of airborne diseases is not always very successful because of the lack of ventilation.

Greenhouse climate

Several fungal diseases result from high humidity rates and condensation, which is a result of insufficient ventilation in the greenhouse (*Pseudoperonospora cubensis,Sclerotinia spp., Botrytis cinerea Phytophthora infestans, Altenaria solani*,). Ventilation is important in order to control air humidity.

Irrigation

Optimal irrigation is necessary to improve plant vigor and to reduce excessive air humidity. Current techniques involve furrow and drip irrigation. Furrow irrigation may cause oxygen deficiencies in the root system increasing thereby the risks of disease and nematode attack. It increases humidity and the water is not used with efficiency.

Drip irrigation is becoming more and more widespread, because of the economy and of the water efficiency. In combination with plastic mulching, drip irrigation reduces air humidity. Drip irrigation is also used for fertilizer and in some farms, for pesticides application.

Soil and water salinity

Soil and water salinity increase the susceptibility of vegetable crops to many diseases and particularly to *Fusarium* and *Verticillium* wilts. Resistant varieties become susceptible when the irrigation water has a high salt content.

Pesticide use

A very intensive chemical protection is applied in the protected vegetable crops, mainly as preventive sprays (up to 30 applications per season in Tomato). Because the same pesticides are being used over long periods, resistance against pesticides has developed in many diseases (table 1). Inappropriate applications of soil fumigants cause pesticide poisoning. In reaction to increased pesticide tolerance, growers use higher doses.

Agricultural practices

The small spectrum of the main vegetables (tomato, cucumber, melon, pepper, eggplant), all belonging to only two plant families (Solanaceae and Cucurbitaceae) favor the spread of diseases from one crop to another. Crop rotation and greenhouse rotations are not effective, because the alternative crops are often susceptible to the same diseases. In addition, many weeds act as alternative hosts to diseases and should, therefore, be controlled. Leveillula taurica and Verticillium dahliae infect weeds for instance.

The other cultural practices such as nursery management, elimination of crop residues, sowing and planting time, choice of the resistant varieties and of the plant spacing, are not always properly adopted.

Seed quality

All vegetable seeds are imported and are certified seeds. However, many tests have shown that tomato or melon seeds could be infected respectively by *Clavibacter michiganense* and *Fusarium oxysporum f.sp. melonis*. This seed infection decreases the efficiency of soil fumigation and could introduce new races of some pathogens such as *Fusarium* in the soil. In general, when infected seeds are used, the disease incidence is higher in fumigated soils than in non-fumigated ones.

Availability of resistant varieties

Resistant varieties are used whenever available. However, many varieties, which are available on the market, have no resistance to some important plant pathogens. Most of the tomato varieties and all the melon varieties used at the moment are susceptible to nematodes. All the tomato varieties chosen by the farmers are susceptible to *Verticillium* race 2.

Table 1: Fungicide resistance in vegetable crops

Pathogen	Fungicide used
Botrytis cinerea	Benzimidazoles Dithiocarbamates Thiophanate methyl
Leveillula taurica	Pyrimidin Benomyl
Phytophthora infestans	Anilides
Rhizoctonia solani	Benzimidazoles Dithiocarbamates
Sclerotinia sclerotiorum	Benzimidazoles Dithiocarbamates
Powdry mildews	Benzimidazoles

INTEGRATED DISEASE MANAGEMENT STRATEGIES

Seed borne diseases

The use of certified seeds is recommended, although this is no absolute guarantee that such seeds are disease free. The use of certified seeds is very common. The main seed borne diseases of vegetables are reported in table 2

Soil borne pathogens

Soil fumigation with Methyl bromide to control soil fungi and rootknot nematodes is considered as one of the main factors for the success of vegetable production in greenhouses. Specialized companies apply it. Many other chemicals are used for soil treatment (table 3).

Soil solarization is a promising technique, which may have an important future in Morocco, particularly when the methyl bromide use will be stopped in 2010, according to the Montreal protocol. The

advantages of soil solarization are that this technique is relatively cheap, effective, poses little health risks, and changes the soil microorganism composition in such a way that production is improved for more than 3 years. However, the efficacy under local conditions needs further investigations. It has been shown that uses of old plastic tunnel covers for soil solarization is effective and control many pathogens such as *Fusarium, Verticillium* and *Meloidogyne*.

Table 2. Main seed borne diseases of vegetables

Crop	Pathogen	Disease
Tomato	*Alternaria solani*	Early blight
	Didymella lycopersici	Stem canker
	Fusarium Oxysporum f.sp. *lycopersici*	Fusarium wilt
	Clavibacter michiganense	Bacterial canker
	Pseudomonas syringae p.v. *tomato*	Bacterial speck
Melon and Cucumber	*Fusarium oxysporum* f. sp. *Melonis*	Fusarium wilt of melon
	Fusarium oxysporum f. sp. *Cucumis*	Fusarium wilt of cucumber
	Cucumber Mosaïc Virus	CMV
	Pseudomonas syringae pv.*lacrymans*	Angular leaf spot
	Alternaria cucumerina	Alternaria blight
Pepper	*Alternaria solani*	Alternaria blight
	Fusarium oxysporum	Fusarium wilt
	Xanthomonas campestris pv *vesicatoria*	Bacterial spot.

Table 3. Pesticides used as soil treatment in protected vegetable crops

Pesticide	Pathogens
Aldicarb	*Alternaria*
Dazomet	*Fusarium, Phytophthora*
Dichloropropène	*Pythium, Rhizoctonia*
Dichloropropane-Dichloropropène	*Sclerotinia, Stemphyllium*
Ethoprop	*Verticillium*
Methyl bromide	Nematodes
Metam sodium	Bacteria
Promocarbe Hcl	

Airborne diseases

Prevention of airborne diseases is not very successful because greenhouses in the Moroccan conditions have to be thoroughly ventilated. Sanitation and hygiene may help to limit disease development in greenhouse.

Solarization of tomato supports is a successful control method for some diseases such as *Didymella* canker. Solarization of tomato stakes could be achieved by storing them in empty greenhouses during the hot months. This technique is applied with great success by many farmers.

Pesticide application currently is the dominant control method applied. The intensive and continuous use of pesticides created new problems: pesticides resistance (table 1) harvested product, soil and water contamination etc. Information on the safe and proper use of pesticides by growers is very much needed. The main fungicides used on protected vegetable crops are reported in table 4.

Table 4. Fungicides used on protected vegetable crops as foliar treatments

Disease	Fungicide (*)
Late blight	Captafol, Chlorothalonil, Cymoxanil, Dichlofluanide, Manèbe, Mancozèbe, Metalaxyl, Oxadixyl, Propinèbe.
Early blights	Iprodione, chlorothalonil.
Gray mold	Procymidone, Vinchlozoline, Iprodione.
Powdery Mildews	Bupirimate, Chinomethionate, Dinocap, Fenarimol,Pyrazophos, Myclobutanil, Triadimefon,Triforine.
Rhizoctonia	Mepronil, Pencycuron
Sclerotinia	Vinchlozoline, Iprodione, Procymidone.
Phytophthora	Metalaxyl, Phosetyl al.
Root rot	Thirame.

(*) Alone or in mixture.

Major diseases of tomato, cucurbits and pepper

In general, the same diseases are found on all protected vegetables. These diseases are due to the same or different pathogens. The major diseases in tomato, cucurbits, and pepper are reported in tables 5,6 and 7.

Table 5. Major diseases of tomato

Pathogen	Disease
Alternaria solani	Early blight
Botrytis cinerea	Gray mold
Didymella lycopersici	Stem canker
Fusarium oxysporum f.sp. *radicis*	Fusarium root and collar rot
Fusarium oxysporum f. sp. *Lycopersici*	Fusarium wilt
Leveillula taurica	Powdery mildew
Phytophthora infestans	Late blight
Phytophthora parasitica	Phytophthora root rot
Pythium spp, *Fusarium* spp, *Rhizoctonia* spp.	Damping off
Sclerotinia sclerotiorum	Sclerotinia stem rot
Verticillium dahliae	Verticillium wilt
Corynebacterium michiganense	Bacterial canker
Pseudomonas syringae pv. *Tomato*	Bacterial speck
TYLC	Tomato yellow leaf curl
TMV	Tomato mosaïc virus
Meloidogyne spp	Root knot

Table 6. Major diseases of pepper

Pathogen	Disease
Botrytis cinerea	Gray mold
Phytophthora capsici	Late blight
Pythium spp, *Phytophthora spp Fusarium* spp	Damping off
Sclerotinia sclerotiorum	Sclerotinia stem rot
Verticillium dahliae	Verticillium wilt
Leveillula taurica	Powdery mildew
Fusarium	Wilt
Pseudomonas syringae pv. *Tomato*	Bacterial speck
Xanthomonas campestris vesicatoria	Bacterial spot
CMVC	Cucumber Mosaic Virus
PVY	Potato Virus Y
Meloidogyne spp	Root knot

Table 7. Major diseases of cucumber and melon

Pathogen	Disease
Alternaria cucumerina	Alternaria leaf spot
Botrytis cinerea	Grey mold
Fusarium oxysporum f. sp. *Melonis*	Fusarium wilts
Fusarium oxysporum f. sp.*cucumis*	Fusarium wilts
Fusarium solani	Collar and root rot
Pythium spp, *Fusarium* spp., *Rhizoctonia solani*	Damping off
Slerotinia sclerotiorum	White rot
Verticillium dahliae	Verticillium wilt
Erysiphe cichoracearum	Powdry mildew
Sphaerotheca fuliginea	Powdry mildew
Pseudoperonospera cubensis	Downy mildew
Pseudomonas syringae pv. *Lacrymans*	Angular leaf spot
CMV	Cucumber mosaïc virus
CVYV	Vein yellowing of cucumber
WMV	Watermelon Mosaïc Virus
ZYMV	Zuchini Yellow Mosaïc Virus
CYMY	Cucumber Mosaïc Virus
Meloidogyne spp	Root knot nematodes.

CONCLUSION

Most production decisions made by protected vegetables growers influence disease development or disease management. IDM should be implemented at the various steps of the crop production:

- Disease management of the land: choice of the field and measures to be taken to reduce the pathogen

populations (rotations, pesticides, and solarization...)

- Disease management in the seed beds: cultivars to be grown; quality of the seeds, and plants; sowing date, seeding density, fumigation, fungicide spraying....

- Disease management in the field: soil preparation, cultural practices, pesticide applications, and biological control...

- Disease management of the harvested products: dates and harvesting techniques, availability of transportation and storage facilities, pesticide applications before storage, control of the storage environment.

A general integrated disease management program for vegetables grown under greenhouse is proposed (table 8).

Table 8. General Integrated disease management program for protected vegetable crops

Disease	Control applied
Fusarium wilt	Resistant varieties, certified seeds, soil solarization, rotations, use of non saline water, weed control, destruction of crop residues, soil treatment, suppressive soils.
Verticillium wilt	As for Fusarium wilt.
Late blight	Good ventilation, deleafing, chemicals, crop rotation.
Early blight	Chemicals certified seeds.
Stemphyllium blight	As for early blight.
Powdery mildew	Chemicals, weed control, resistant varieties, sanitation.
Didymella stem canker	Certified seeds, tomato support, solarization, chemical control, wound protection, deleafing technique.
Gray mold	Good ventilation, deleafing technique, lower plant densities, choice of the green house architecture.
White rot	Crop rotation, use of non contaminated seeds, resistant varieties, drainage
Downy mildew	Plant spacing, drainage, air movement, exposure to sunlight, resistant varieties, and chemical control.
Bacterial canker	Roguing, certified seeds.
Angular leaf spot	Disease free seeds crop rotation.
Viruses	Resistant varieties, control of the vectors (aphids, white fly), certified seeds, eradication of alternative hosts, sowing date.

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