Diversification of Diseases Affecting Herb Crops in Israel Accompanies the Increase in Herb Crop Production

Abraham Gamliel[1] and Oded Yarden[2]

During the last 15 years there has been a significant increase in both field and greenhouse herb crop production in Israel. Many new species and cultivars are being grown. The increase in herb production has been accompanied by an increase in the occurrence of known soilborne and foliar pathogens along with some new diseases and new forms of existing diseases. Apart from the expansion of herb crop production, the changes in cultural and harvesting practices are likely contributors to the increase in disease incidence.
KEY WORDS: Basil; sage; pest management.

INTRODUCTION

In the past, only a narrow spectrum of herb crops was grown in Israel. Production of parsley, dill, celery, etc., was confined mainly to fields for dry spice production, or on small farms, providing fresh herbs for the local market. However, during the last 15 years a significant shift and increase in herb crop production has occurred. From a traditional handful of common herbs (*e.g.* dill, parsley, fennel) grown in the past, the variety of herbs currently grown in Israel has increased to over 30 different species (3). In 1983, production of fresh herbs for export was started and resulted in new product specifications, followed by a shift in the production practices of these crops. Two major forces characterize the new production systems: A demand for a high quality of fresh produce supplied all year round, and the need to maintain a wide variety of herbs to supply the diverse products demanded by the market. In order to maintain a continuous supply of herbs, production has been expanded to new areas where climatic conditions are better suited for year-round production. Most of the export-oriented production is in closed greenhouses. Various soils and artificial substrates are currently used for growing herbs, combined with advanced technologies for fertilization, drip irrigation and climate control. The increase in herb production has been accompanied by the inevitable introduction of new pests and diseases (8) and by an increase in the occurrence of existing pathogens on these crops (18), some of which already have devastating effects on herb production.

Chemical pest management in herb crops is problematic. Avoiding or minimizing the use of pesticides is especially required with these crops due to the restriction on pesticide residues on the marketable produce (12). Therefore it is essential to prevent the occurrence of the primary inoculum. This can be achieved by regulation of production and transfer of propagation material, seed disinfestation, suppressive growing media, and soil and substrate disinfestation.

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[1] Inst. of Agricultural Engineering, ARO, The Volcani Center, Bet Dagan 50250, Israel [Fax: +972-3-9604704; e-mail: agamliel@agri.huji.ac.il].
[2] Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel.

TABLE 1: List of existing and potential pathogens of herb crops in Israel

Family/ Common name/ Latin name	Disease name	Identified causal agent	Potential pathogens[z]
Lamiaceae			
Sweet basil	Basal rot	*Sclerotinia sclerotiorum*[y]	*Colletotrichum* spp.
Ocimum basilicum	Gray mold	*Botrytis cinerea*[y]	
	Basal rot	*Rhizoctonia solani*[y]	
	Wilt and crown rot	*Fusarium oxysporum* f.sp. *basilici*[y]	
		Orobanche aegyptiaca[y]	
Sage	Powdery mildew	*Erysiphe cichoracearum*	*Phytophthora* spp.
Salvia officinalis	Downy mildew	*Peronospora lamii*[y]	
	Gray mold	*Botrytis cinerea*[y]	
		Ampelomyces quisqualis[y,x]	
	Collapse	Not identified	
Rosemary	Powdery mildew	*Sphaerotheca fuliginea*	
Rosmarinus officinalis	Root knot nematode	*Meloidogyne javanica*[y]	
	Stem canker	*Alternaria alternata*[y]	
Melissa	Basal rot	*Sclerotinia sclerotiorum*	
Melissa officinalis	Leaf spot	*Alternaria* sp.	
	Powdery mildew	Not identified	
	Gray mold	*Botrytis cinerea*[y]	
Spearmint/	Rust	*Puccinia menthae*	
Peppermint	Rust	*P. angustata*	
Mentha apicata			
Mentha piperata			
Savory	Gray mold	*Botrytis cinerea*	
Satureja thymbra	Root rot	*Sclerotium rolfsii*[y]	
	Rust	*Puccinia menthae*[y]	
	Downy mildew	*Peronospora lamii*[y]	
Marjoram	Gray mold	*Botrytis cinerea*	
Majorana syriaca	Rust[y]	Not identified	
Oregano	Powdery mildew	Not identified	
Origanum vulgare			
Apiaceae			
Parsley/Coriander	Powdery mildew	*Oidium* sp.	
Petroselinum crispum	Basal rot	*Sclerotinia sclerotiorum*	
Coriandrum sativum	Basal rot	*Rhizoctonia solani*[y]	
	Septoria	*Septoria petroselini*[y]	
Dill	Leaf spot	*Ramularia* spp.	
Anethum graveolens	Powdery mildew	*Oidium* spp.	
	Basal rot	*Sclerotinia sclerotiorum*	
	Basal rot	*Rhizoctonia solani*	
Compositae			
Tarragon	Rust	*Puccinia* spp.	
Artemisia dracunculus	Basal rot	*Sclerotinia sclerotiorum*[y]	
	Wilt	Not identified	

Liliaceae			
Chive	Stemphylium	*Stemphylium botryosum*	*Peronospora*
Allium tuberosum	Basal rot	*Rhizoctonia solani*	*destructor*
	Basal rot	*Pythium* spp.	
	Pink root	*Pyrenochaeta terrestris*[y]	
	Free living nematode	*Ditylenchus* spp.[y]	
	Root knot nematode	*Meloidogyne javanica*[y]	
	Bacterial wilt	*Erwinia carotovora*[y]	

[z] Pathogens known in the world but not yet identified in Israel on the specific crop.

[y] Causal agents not mentioned as infecting herb crops in previous publications on diseases of herb crops in Israel.

[x] Mycoparasite infecting *Erysiphe cichoracearum.*

In this paper we have compiled the current accumulated observations concerning the occurrence of various diseases in herb crops in Israel, in view of the increasing number of field reports concerning diseases of these crops.

Trends in herb production

Herb production for the fresh market (mainly export) has expanded during the last 15 years and includes 150 ha of protected crops and an additional 300 ha of field-grown crops. Several factors have contributed to the number and intensity of diseases of herb crops in Israel during the last decade. In many cases infested propagation material is the source of new diseases, which must be identified. Herb crops are propagated in Israel in special nurseries. Transplants are prepared from seeds or plant cuttings. Seeds are brought from local fields or imported stocks. Cuttings are collected from selected farmer fields. The local propagation of plant material as well as the import of known or new cultivars has been shown to contribute to the establishment of disease (5,8).

An example of the potential contribution of propagation material to the increase of disease is Fusarium wilt and crown rot of basil caused by *Fusarium oxysporum* f.sp. *basilici*, which has been proven to be disseminated by infected seeds (5,8,16). Contamination of commercial seed lots by *F.o. basilici* has been demonstrated (5,16), and Elmer *et al.* (5) suggested that seeds are the logical means for rapid dissemination of this pathogen to many countries within a relatively short period. Moreover, infested seeds may serve as a means of pathogen survival. Fusarium wilt of sweet basil is an example of a new disease in Israel (8). There are other examples of known diseases which were also imported with seeds. New isolates of the bacterium *Xanthomonas campestris* were introduced with imported seed of new cruciferous herb species (A. Gamliel, unpublished).

Regardless of the source of propagation material, diseases brought about by existing pathogens, especially those with a wide host range, *e.g.* root knot nematodes, *Sclerotinia sclerotiorum*, *Botrytis cinerea* and *Rhizoctonia solani*, occur frequently. Also, more specific pathogens are present on existing herb crops such as umbelliferous plants, and can contribute to the establishment and spread of disease (Table 1). Changes in agrotechnical practices, which accompany many cases of the expansion in herb crop growth in Israel, have resulted in epidemics of pathogens. *S. sclerotiorum* is an example of a pathogen

which affects many herb crops in greenhouses, and where infested soil and favorable environmental conditions resulted in increased disease incidence (15). It is likely that, since the local soil has been used for growing susceptible vegetables or ornamental crops, it has already been infested with propagules of *S. sclerotiorum*.

Optimal conditions for disease outbreak occur during winter, especially in the northern part of Israel, and result in severe damage to tarragon, basil, sage and other crops inside greenhouses. The situation described for greenhouses is also true in the open field, where traditionally vegetable crops were grown, inoculum density of soilborne pathogens is high, and eruption of diseases is inevitable as a new susceptible crop is introduced. Pink root disease caused by the fungus *Pyrenochaeta terrestris* is one example. It attacks chives (*Allium tuberosum*) and other *Allium* species. The disease is not greatly influenced by climatic conditions and damage to the crops has been recorded year-round. Disease control is difficult since soil type (in particular heavier soils) makes soil disinfestation difficult. Cultivation on artificial substrates is an alternative, but in many cases is not economically feasible. Free-living and root knot nematodes also inhabit agricultural soils nationwide and attack many herb crop species in greenhouses and the open field throughout the year.

In addition to the increase in soilborne diseases, devastating effects of foliar disease outbreaks have increased in parallel to the changes in production. An example can be found in the significant number of gray mold outbreaks in the major Israeli herb crop, basil, which have occurred during the past few years (3,18). Observations of disease development in commercial greenhouses revealed that Botrytis infection occurs on stem cuttings, soon after harvest (18). The disease then progresses along the stems, killing all leaves and secondary buds. When the pathogen infects the main stem at the bottom of the plant, the entire plant dies. It was noticed that outbreak of the disease occurs when harvesting is carried out on rainy days, but not when it is done a few days before or after precipitation. Stem cuttings are highly susceptible to infection soon after harvest but susceptibility is diminished 48 h post-harvest. A proposed explanation for this is the *de novo* development of a protective opaque layer on the cutting after harvest, which prevents penetration and subsequent infection of germinating *B. cinerea* spores. Other examples of disease development in greenhouses are downy mildew of sage, and rust of tarragon (2,6). These pathogens have occurred on sage and tarragon since the introduction of commercial cultivation of these crops in greenhouses. Eruption of rust and downy mildew usually occurs when crop foliage is dense and humidity is high (1,7). The shift in plant cultivation practices requires the re-identification and elucidation of the factors involved in disease establishment and development.

New and unfamiliar diseases

Another problem affecting new crops or accompanying changes in agricultural practices is the occurrence of new, unfamiliar diseases or unfamiliar forms of known pathogens. Perhaps the most striking example of a new disease in Israel which has significantly affected all growers of sweet basil is Fusarium wilt of this herb (8,9). It appeared within a short period of time at most locations where basil is grown. Symptoms include vascular wilt, and crown and root rot. Pathogenicity and vegetative compatibility tests have provided evidence that Italian and American and Israeli isolates of *F.o. basilici* from roots, stems, and seeds belong to a single vegetative compatibility group (5,14). Disease is usually associated with massive production of conidia (consisting almost

exclusively of macroconidia) produced on the diseased stems. Conidia production on stems is considered rare in Fusarium wilt diseases incited by pathogenic *F. oxysporum* (4,8,13). *F.o. basilici* displays both soilborne and airborne behavior, a phenomenon that reflects its epidemiological pattern. These outbreaks are the result of the combined effects of climatic conditions and harvesting practices. Most of the greenhouse structures can become contaminated with the pathogen by the end of the season from airborne, soilborne and plant debris sources. The large number of conidia produced and the abundant air circulation due to fan operation in the greenhouse disperse airborne propagules during the growing season. Soilborne pathogens which also have the characteristics of foliar pathogens are especially difficult to control. *F.o. basilici* was detected in a new tuff (volcanic ash) substrate in which basil was grown as a first crop (8). Such situations call for the development of a holistic, integrated approach to deal with the different inoculum sources at various sites, before, during and after planting. Primary inoculum, *e.g.* on seeds, greenhouse structures and potting mix in the nursery, must be prevented or eradicated. On the other hand, eradication of soilborne inoculum may not be practical in all cases, due to economic and technological considerations; hence, efforts should be aimed at suppressing or reducing it to tolerable levels (9).

Future perspectives

Potential means of pathogen control and disease management are: regulation of production and transfer of propagation material, seed disinfestation, suppressive growing media, sanitation of the greenhouse by heating or chemicals (9,19), crop rotation (7,20), soil and substrate disinfestation using methyl bromide or solarization (9), biocontrol agents (17), and fungicides (10). Avoiding or minimizing the use of pesticides is particularly important with herb crops, due to the restriction on pesticide residues on marketable produce (3). A combination of appropriate means of control, with emphasis on eradicating or avoiding the primary inoculum and breeding resistant cultivars, will enable the achievement of this goal.

The trend described in this report is likely to continue. Thus, records of new or recurring diseases of herbs, *e.g.* black spot of basil caused by *Colletotrichum gloeosporioides* (11), Fusarium wilt and *Phytophthora* foot rot of sage (6), none of which has been positively identified in Israel, will continue to surface as long as additional herb crop species are introduced and crop management favors disease development. Furthermore, such trends are likely to be observed in other crops. In addition to the identification of diseases of herbs as specified in Table 1, reports on wilt symptoms and collapse of plants brought about by yet unidentified causal agents are accumulating continuously (A. Gamliel and O. Yarden, unpublished). Therefore, it is likely that more pests and conceivably abiotic causes as well, will expand the current list.

Viruses are an important group of plant disease agents. Data about viral diseases in herb plants are very limited, and there are no records of such diseases in Israel. It is most likely, however, that such diseases may occur. Production of virus-free seeds and transplants, combined with effective management of the possible vectors, can minimize the occurrence and outbreak of such diseases.

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