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Distribution of fig mosaic in Jordan

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Summary. Fig mosaic (FM) is one of the most important diseases of figs in Jordan. A nationwide survey was conducted to determine the incidence and severity of this disease in trees and in seedlings propagated by cuttings in orchards and nurseries in 13 provinces and cities all over the country. Cultivars surveyed included Khdari, Mwazi, Zraki, Khartamani, Dafoori, Turki, Hamari, Esaili, Ajlouni, in addition to an Italian and a French cultivar. Disease severity varied from moderately severe to extremely severe with leaf malformation and fruit drop FM was found in all provinces. Incidence of FM, averaged over trees of all cultivars and all age categories, was 95.3%. Fig trees 3 years and older had the highest disease incidence, ranging from 93.3% to 100% in the different orchards. The Esaili cultivar had the lowest incidence ranging between 50% and100%, with an average of 76.5%. The highest FM incidence was on Dafoori. Of the most common cultivars, Khdari was the most susceptible. Jerash province had the highest percentage (12.5%) of fig seedlings and trees in the most severe disease category. The highest percentage (27.8%) of healthy fig seedlings and trees was in Irbid province. This paper reports the incidence of FM in various local and imported fig cultivars of different ages, and relates the spread of the disease to the method of fig propagation practiced in Jordan. Suggested solutions for the problem, which include the introduction of disease and pest free fig seedlings derived from tissue culture and the establishment of new rules and regulations to prevent the spread of the disease are discussed.

Key words: Fig mosaic disease, Jordan, cultivars.

Introduction

The edible fig *(Ficus carica* L.*)* is a deciduous tree or bush. Fig production in the world is mainly from the Mediterranean countries. Spain is the leading fig producing country followed by Italy, Turkey, Greece, Portugal and the United States (Sulaiman, 1985; Anonymous, 1988; Shdaifat, 1997).

Mature fig trees grow best and produce the best quality fruit in dry warm-temperate climates. In winter, trees withstand temperatures of 12 to 9.5°C depending on the cultivar (Condit, 1947; Katana, 1978; Al-Khateeb, 1996). Fig trees grow well in a wide range of soils but do best in deep, non-alkaline clay loams (Hilgard, 1912; Shdaifat, 1997).

In Jordan, figs are usually consumed fresh. However, dried fruits are also imported from Syria, Turkey and Lebanon. According to the 1998 Statistical Yearbook of the Ministry of Agriculture, the estimated area planted with fig was 14,400 ha. Jordan produced around 7,200 tons of figs during the same year, of which 425 tons were exported (Anonymous, 1998).

Fig plantation in Jordan is concentrated in the following areas: in southern Jordan, they are grown in the Karak, Tafila, and Ma'an provinces. In the

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central region, they grow mainly in Madaba, Wadi Al-Sir, and in Baqa'. In the north, most fig plantations are found in Jerash and Irbid. More than 10 fig cultivars are grown in Jordan, most of them local cultivars with local names: Khdari, Zraki, Mwazi, Khartamani, Dafoori, Esaili, Hamari, etc. (Al-Khateeb, 1996; Mahmour, 1996 ; Anonymous, 1998).

Figs are reproduced mainly by stem cuttings (Eisen, 1997). This method of propagation has several advantages over other methods but is also responsible for the spread of many diseases that limit fig production. Almost all nurseries in Jordan use stem cuttings to propagate fig trees. The main source of these cuttings is usually one or more old mother trees with good agronomical characteristics located in the nursery. Cuttings are usually taken in winter from 1-or 2-year-old dormant wood and placed in black plastic bags containing a mixture of soil and sand (or peat moss and perlite) to promote callus formation and rooting. Farmers using old mother fig trees as a source of planting material do not usually fertilize such trees or inspect them for pests and diseases. Furthermore, many farmers are not educated and do not have any information about the diseases and pests that might infect fig trees, or the cultural practices by which they are transmitted.

Fig mosaic (FM) is an important disease that causes premature defoliation and fruit drop. The causal agent of the disease has not yet been identified but the involvement of the virus is strongly suspected (Martelli, 1993).

On the leaves, mosaic spots are distinctly yellow, contrasting with the normal green foliage. The margins of these yellow spots blend gradually from light yellow into the dark green of healthy tissue.

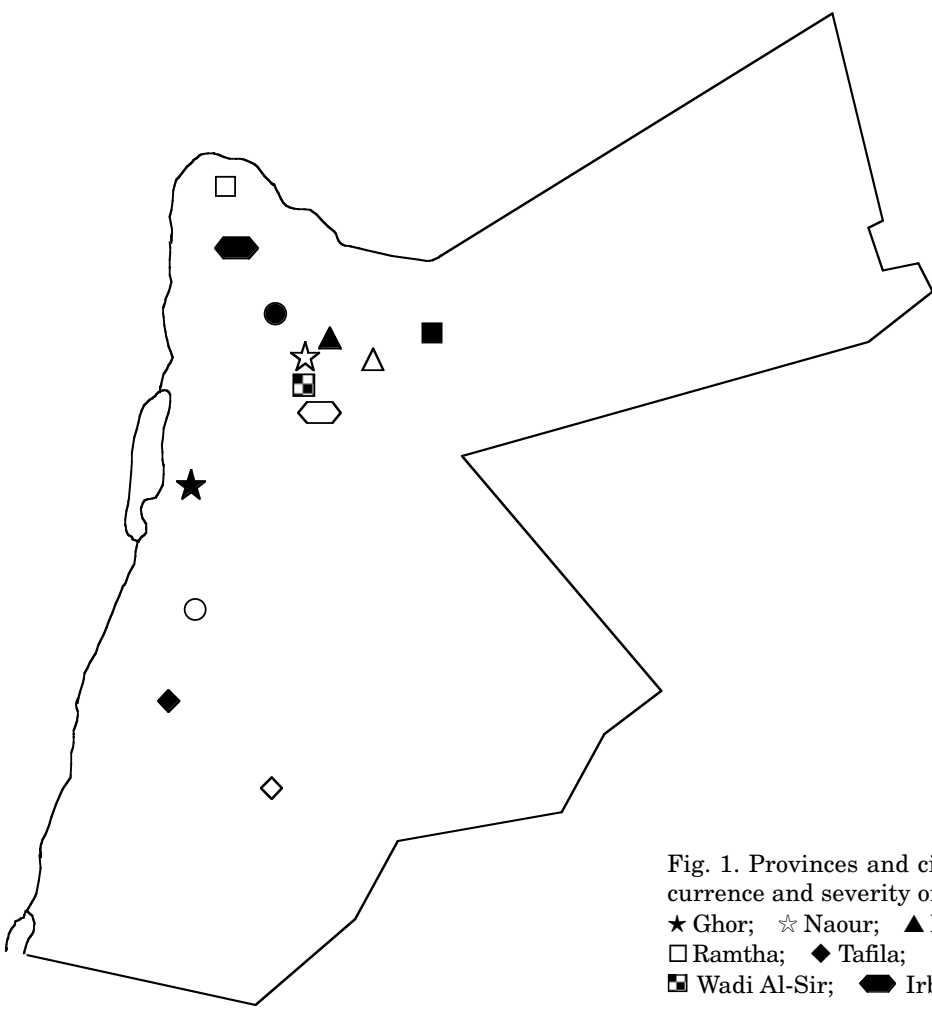

Fig. 1. Provinces and cities of Jordan surveyed for occurrence and severity of fig mosaic disease in 1999.
★ Ghor; ☆ Naour; ▲ Madaba; △ Zarka; ■ Mafraq; □ Ramtha; ◆ Tafila; ◇ Ma'an; ○ Karak; ● Jerash; ◪ Wadi Al-Sir; ⬬ Irbid; ⬭ Baqa'.

Fig. 2. Symptoms caused by fig mosaic on a 2-year old fig seedling.

Sometimes mosaic spots appear as irregular patches of light green diffused throughout the leaf blade. Later in the season, a rust-colored band develops along the border of these spots. Deformed leaves may occur on the same twig along with normal leaves. Mosaic spots on fruits are very similar to those on the leaves, but less conspicuous. Premature fruit drop may also occur and infected trees seem to produce smaller and fewer fruits (Mamluk *et al*., 1984). The causal agent of FM is transmitted by stem cuttings (Mamluk *et al*., 1984) and vectored in nature by the eriophyid mite *Aceria ficus* (Ueckermann, 1991). In past years, it was noted that a high percentage of fig trees planted in different Jordanian locations showed mosaic symptoms and premature fruit drop (Al-Mughrabi and Anfoka, 1997, unpublished). Since most farmers in Jordan purchase their trees from local Jordanian nurseries that use stem cuttings to propagate fig trees, the present study was conducted in order to investigate the incidence and severity of FM in local nurseries. The results of this study will also shed some light on practices that may help the farmer to limit further spread of the disease and offer practical solutions to the existing problem.

Materials and methods

Between 5 April and 16 May 1999, 99 nurseries and fig orchards were surveyed for the incidence and severity of FM in 13 provinces and cities of Jordan (Fig. 1). A total of 1844 randomly selected-seedlings and trees, 1 to 20 years old, were inspected. Symptoms observed were documented and photographed. Surveyors walked a transect through each nursery or orchard, stopped at five sites, and scored plants within a one-square-meter area. Overall scoring for disease severity was done on a 5-point scale as follows: 0 = no symptoms; 2 = mild mosaic and mottling; 4 = severe mosaic and mottling; 8 = severe mosaic and leaf malformation; and 10 = severe leaf malformation. Disease incidence was calculated as the percentage of seedlings or trees infected out of those surveyed.

Table 1. Incidence and severity of fig mosaic (FM) disease in Jordan on seedlings and trees of various ages.

Seedling/ tree age	No. of nurseries/ orchards surveyed	Total no. of seedlings/ trees surveyed	Average disease incidence[a] (%)	No. of plants in each disease category[b]				
				0	2	4	8	10
1 year	31	488	94.0 (53.3–100)[c]	31 (6.4)[d]	270 (55.3)	90 (18.4)	73 (15)	24 (4.9)
2 years	42	780	95.8 (76.5-100)	33 (4.2)	320 (41)	230 (29.5)	146 (18.7)	51 (6.5)
3 years	15	290	94.0 (76-100)	18 (6.2)	65 (22.4)	101 (34.8)	82 (28.3)	24 (8.3)
> 3 years	11	286	97.7 (93.3-100)	1 (0.4)	25 (8.7)	141 (49.3)	115 (40.2)	4 (1.4)
Total	99	1844	95.3[e]	83 (4.5)	680 (36.9)	562 (30.5)	416 (22.6)	103 (5.6)

[a] Disease incidence, at age indicated, as percentage of affected plants surveyed in each nursery or orchard.
[b] Disease severity was scored as follows: 0 = no disease symptoms; 2 = mild mosaic and mottling; 4 = severe mosaic and mottling; 8 = severe mosaic and leaf malformation; and 10 = severe leaf malformation.
[c] Range of disease incidence.
[d] In brackets, percentage of plants infected with FM disease in the disease category indicated.
[e] Overall average disease incidence on seedlings/trees of all age categories in all provinces and cities in Jordan.

Table 2. Incidence and severity of fig mosaic (FM) disease in Jordan on various fig cultivars.

Seedling/ tree age	No. of nurseries/ orchards surveyed	Total no. of seedlings/ trees surveyed	Average disease incidence[a] (%)	No. of plants in each disease category[b]				
				0	2	4	8	10
Khdari	41	763	96.7 (85–100)[c]	25 (3.3)[d]	252 (33)	313 (41)	63 (21.4)	10 (1.3)
Mwazi	13	222	96.4 (85-100)	8 (3.6)	80 (36)	64 (28.8)	56 (25.2)	14 (6.3)
Zraki	16	195	98.0 (90-100)	4 (2.1)	101 (51.8)	54 (27.7)	27 (13.9)	9 (4.6)
Khartamani	8	102	95.1 (80-100)	5 (4.9)	65 (63.7)	19 (18.6)	12 (11.8)	1 (1)
Mwazi Aswad	3	50	98.0 (76-100)	1 (2)	13 (26)	8 (16)	19 (38)	9 (18)
Dafoori	3	47	100.0 (100)	0 (0)	10 (21.3)	15 (31.9)	19 (40.4)	3 (6.4)
Turki	3	41	82.9 (80–100)	7 (17.1)	28 (68.3)	5 (12.2)	0 (0)	1 (2.4)
Hamari	2	33	100.0 (100)	0 (0)	30 (91)	2 (6.1)	1 (3)	0 (0)
Italian	2	21	100.0 (100)	0 (0)	10 (47.6)	9 (42.9)	2 (9.5)	0 (0)
Esaili	1	17	76.5 (50-100)	4 (23.5)	11 (64.7)	2 (11.8)	0 (0)	0 (0)
French	2	15	100.0 (100)	0 (0)	4 (26.7)	8 (53.3)	3 (20)	0 (0)
Ajlouni	1	5	100.0 (100)	0 (0)	1 (20)	2 (40)	1 (20)	1 (20)
Others	4	333	95.3 (85-100)	29 (8.7)	75 (22.5)	61 (18.3)	113 (33.9)	55 (16.5)
Total	99	1844	95.3[e]	83 (4.5)	680 (36.9)	562 (30.5)	416 (22.6)	103 (5.6)

Footnotes see Table 1.

Results

Symptoms accompanying mosaic infection of leaves included blistering, mottling, mosaic, malformation, crinkling, leathery appearance, rosetting, shoe stringing, witch's broom, and crowded growth. Other symptoms were ring spots on the fruits and fruit drop. Several trees and seedlings of various ages exhibited intermingling of green and white coloration on one half of the blade of some leaves, which is a genetic disorder called chimaera. Figure 2 shows some of the symptoms described.

Average incidence and severity of FM in seedlings and trees of various ages, and the overall average disease incidence in all provinces and cities of Jordan were calculated for all cultivars combined (Table 1) and for each cultivar separately (Table 2). The percentage of FM-infected plants in each disease category was also calculated for all cultivars combined and for each cultivar separately (Tables 1 and 2).

Table 1 shows the average incidence of FM in all trees subdivided by age, and the minimum and maximum incidence for each age group.

For 1-year-old seedlings, the incidence ranged from 53.3% to 100% with an average of 94%. On 2-year-old seedlings it ranged from 76.5% to 100%, with a somewhat higher average: 95.8%. For 3-year-old fig seedlings, the incidence was from 76% to 100%, average 94%. Fig trees 3 years and older had the highest average incidence, 97.7%, with a range between 93.3% and 100%. The average of FM in all fig trees irrespective of age was 95.3%.

When the figures for all age-groups were averaged, most fig seedlings and trees were in disease-rating category 2 (36.9%) followed in order by 4 (30.5%), 8 (22.6%), 10 (5.6%) and 0 (4.5%). This was true for seedlings in the 1 and 2-years-old age groups. For seedlings and trees 3 years and older, the majority were in disease category 4, followed in order by categories 8, 2, 10 and 0.

Among all the fig cultivars surveyed (Table 2), Esaili exhibited the lowest average disease incidence (76.5%, range 50-100%). The highest incidence (100%) was in Dafoori, Ajlouni, Hamari, and on the French and Italian cultivars. Khdari is the most commonly grown fig cultivar in Jordan, followed by Mwazi, Zraki, and Khartamani. Among these common cultivar, Khdari was the most susceptible to infection with FM: 41% of all seedlings/trees belonging to this cultivar were in disease category 4. For the Mwazi, Zraki and Khartamani cultivars, the largest number of diseased seedlings and trees was in disease category 2.

The incidence of FM irrespective of cultivar was high in all provinces and cities surveyed. Jerash had the highest percentage (12.5%) of fig seedlings and trees in disease category 10. This was followed by Karak (9%), Wadi Al-Sir (7.7%), Ghor (5.1%), and Mafraq (4.5%). Naour, Tafila and Irbid did not record any seedling or tree in this disease category (Fig. 3e).

Ma'an scored the highest percentage of seedlings/trees infected with FM in disease category 8, (40.4%) followed by Ramtha (32.7%), Karak (32.6%), Mafraq (29.8%), Jerash (29.3%), and Tafila (27.5%). Irbid did not record any seedling or tree is this category (Fig. 3d).

Tafila province had the highest percentage of trees/seedlings with FM in disease category 4 (60.4%), followed by Ma'an (47.6%), Karak (36.2%), and Mafraq (35.8%). The lowest percentage for this category was recorded in Irbid (Fig. 3c). In Irbid province, by contrast, 65.3% of fig seedlings and trees scored for FM were in category 2. This was followed by Madaba (56%), Naour (53.1%), Ghor (52.8%), Baqa' (52.4%) and Zarka (49.5%). The lowest percentage of seedlings or trees in this relatively mild category was in Ma'an (8.4%) (Fig. 3b).

The highest percentage of healthy (category 0) fig seedlings and trees was found in Irbid (27.8%) followed by Baqa' (8.9%), Jerash (7.7%) and Wadi Al-Sir (7.2%). By contrast, in Naour, Ramtha, Ma'an and Karak all fig seedlings and trees surveyed had at least some FM (Fig. 3a).

Discussion

The high overall incidence of FM disease in Jordan (95.3%) is presumably due to the fig propagation methods practiced at all nurseries, in which stem cuttings are taken from all infected mother trees and transplanted to pots or plastic bags filled with soil, peat moss, perlite, or a mixture of the three. Seedlings derived from such cuttings exhibit symptoms of slight to severe FM, mottling and leaf malformation. Nursery supervisors claim that such symptoms are caused by the cold weather and fade, or in some cases disappear, when temperatures rise in summer. This claim is however false,

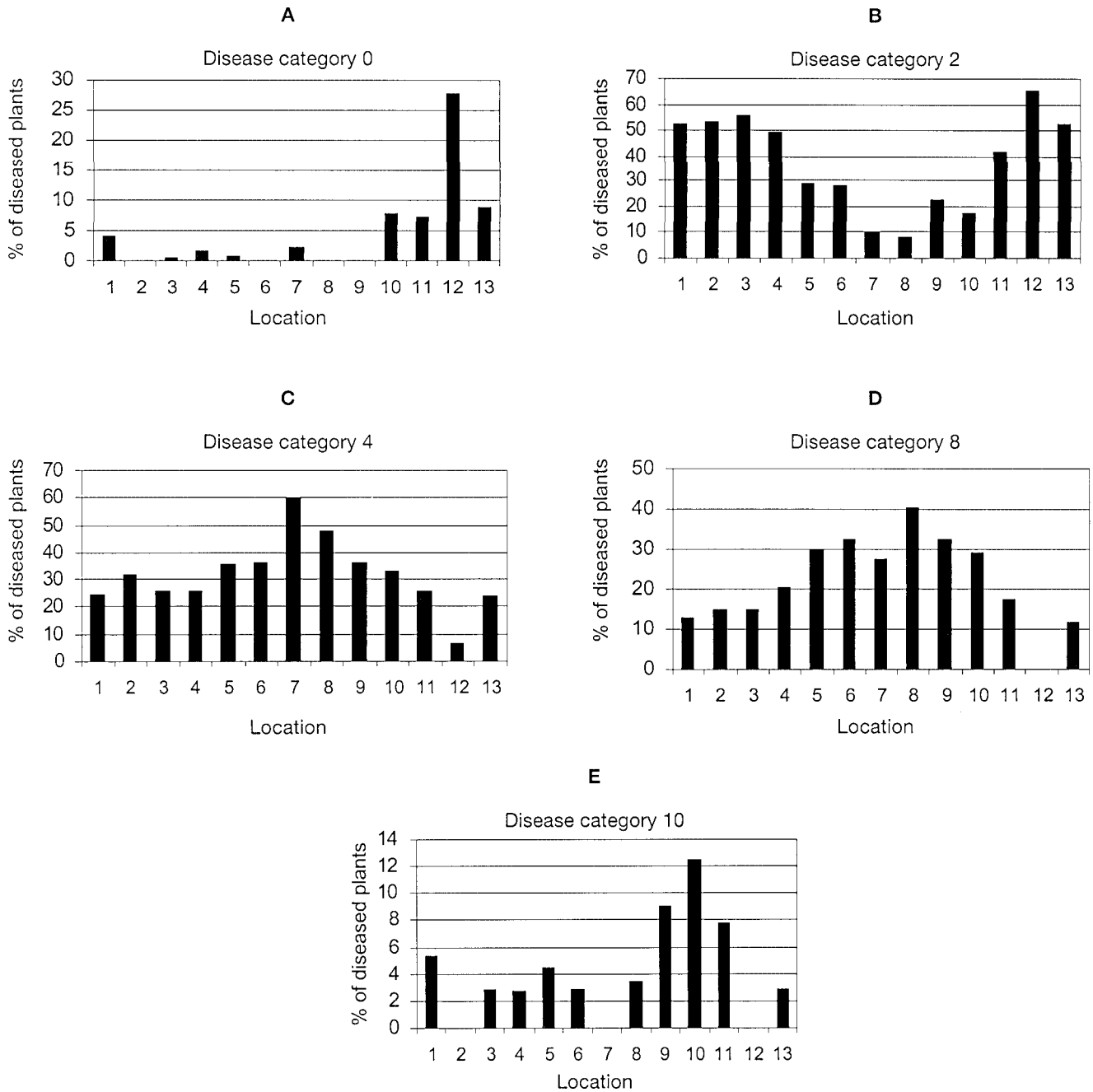

Fig. 3. Percentage of fig seedlings/trees infected with fig mosaic virus (FMV) at various disease severity rating categories (where 0= no disease symptoms; 2= mild mosaic and mottling; 4= severe mosaic and mottling; 8= severe mosaic and leaf malformation; and 10= severe malformation) in various regions of Jordan: 1= Ghor; 2= Naour; 3= Madaba; 4= Zarka; 5= Mafraq; 6= Ramtha; 7= Tafila; 8= Ma'an; 9= Karak; 10= Jerash; 11= Wadi Al-Sir; 12= Irbid; and 13= Baqa'.

as the FM symptoms are only masked when temperatures increase (Foster and Webb, 1965; Matthew, 1981). In the present study, all mother fig trees inspected were found to be infected. Symptoms appeared not only on leaves, but also on fruits. Ring spots and premature fruit drop were observed on infected mother trees.

Although the disorder can be transmitted by the eriophyid mite *A. ficus*, the presence of this mite on the seedlings and trees was not examined in this study. It is however unlikely that the eriophyid mite could cause the spread of FM in Jordan on account of its slow moving ability and the use of many broad-spectrum pesticides in nurseries and orchards that keeps its number down.

To halt the spread of FM through cuttings, it is suggested that the Ministry of Agriculture should supervise nurseries and forbid fig propagation through cuttings, replacing it with disease and pest-free fig seedlings derived from tissue culture. A nation-wide campaign is needed in order to achieve this ambitious goal.

The results showed that fig trees more than 3 years old had a higher percentage of FM infection in disease categories 4 and 8 than seedlings/trees of other ages (Table 1). This suggests that the disease progresses with time, probably because farmers or home owners do not provide fig trees with the appropriate care, fertilizers and sufficient amounts of water, nor do they apply chemicals specific against FM. Pruning without disinfecting cutting tools may be a perfect method to transmit pathogens, including viruses, and may therefore also spread FM from infected to healthy branches of the same tree or between trees. It is recommended that the authorities should educate farmers, nursery supervisors and the general public about the proper way to prune fig trees in order to prevent the spread of FM and other diseases.

The cultivar Esaili did not exhibit the most severe symptoms of FM, as no seedling/tree of this cultivar was found in disease categories 8 or 10. The highest percentage of healthy seedlings/trees (23.5%) was also reported for this cultivar. By contrast, only 3.3% of inspected seedlings/trees belonging to the most commonly cultivated Khdari cultivar were healthy. The high disease incidence (96.7%) of FM in this cultivar in all provinces was most likely due to the widespread use for this cultivar of cuttings, derived from infected mother trees. The same applies to Mwazi, Zraki and Khartamani cultivars, which are the most commonly grown after Khdari.

The Italian and French cultivars (Table 2) appeared to be moderate in their sensitivity to FM, with most seedlings surveyed in disease categories 2 and 4. This may be because these cultivars are not native to Jordan. The majority (91%) of seedlings/trees of the Hamari cultivar were in disease category 2. This may reflect varietal tolerance to FM.

Jerash province scored the highest percentage of fig seedlings/trees in the disease category 10 (Fig. 3e). This may be because most fig nurseries are located in this province and most twigs and cuttings produced by them come from heavily infected mother trees. Also, pruning tools are used without disinfection between cutting and may even be shared by different nurseries. The weather conditions prevailing in Jerash, with moderate humidity and temperatures, are very favorable for plant propagation, but also favor the spread of diseases, including viral diseases (Matthew, 1981).

The fact that FM was recorded in all provinces and cities in Jordan indicates its seriousness. A nationwide problem requires a nationwide campaign to stop further progress of the disease. The responsible agricultural regulatory authorities should set up rules and regulations to stop the spread of FM through cuttings from nurseries. Inspection should be done regularly and those nurseries that do not comply should be fined and their business licenses revoked. Existing seedlings at the nurseries should be confiscated and disposed of in the proper manner. At present, pending identification, isolation and purification of the FM causal agent which will make possible a rapid diagnosis of the disease serologically or with molecular-based techniques on representative samples of seedlings from individual nurseries, the production of disease-free fig seedlings seems to be the most promising solution to the problem posed by FM.

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Literature cited

Al-Khateeb A.I., F. Hamed and Y. Sulaiman, 1996. A preliminary study on some morphological and physiological characteristics of the most important fig cultivars spread in Lathiqia province. M.Sc. Thesis, Tashreen University, Syria.

Anonymous, 1998. 1998 Statistical Yearbook of the Ministry of Agriculture. Department of Information and Computing, Ministry of Agriculture, Amman, Jordan, 108 pp.

Anonymous, 1988. Fruit tree and vegetable horticulture. Second edition, Ministry of Education, Central Press, Amman, Jordan, 201 pp.

Condit J.I., 1947. The Fig. Chronica Botanica Co., Waltham, MA, USA.

Eisen G., 1997. The Fig – Its History, Culture and Curing. U.S. Department of Agriculture, Bulletin 9. Washington, WA, USA.

Foster R.E., and R.E. Webb, 1965. Temperature effects on symptom expression and concentration of six muskmelon viruses. *Phytopathology*, 55, 981-985.

Hilgard E.W., 1912. Soils. The Macmillan Co., New York, NY, USA.

Katana H., 1978. Fruits – Production, Use, and Storage. Damascus University, Faculty of Agriculture, Syria, 830 pp.

Mahmour M.S., 1996. Local Fig Cultivars in Jordan. Mazarena Magazine, Ministry of Agriculture, Amman, Jordan, 8 pp.

Mamluk O.F., W.I. Abu-Gharbieh, C.G. Shaw, A. Al-Musa, and L.S. A-Bana, 1984. A Checklist of Plant Diseases in Jordan. Faculty of Agriculture, University of Jordan, Amman, Jordan, 33.

Martelli G.P., M.A. Castellano and R. Lufortezza, 1993. An ultrastructural study of fig mosaic. *Phytopathologia Mediterranea*, 32, 33-43.

Matthew R.E.F., 1981. Plant Virology. Second edition, Academic Press, USA,. 445 pp.

Schurrie H.,1990. The Fig. Timber Press Horticultural Reviews, 12, 409.

Shdaifat S., 1997. Fig Growing in Jordan. Technical Leaflet, National Center for Agricultural Research and Technology Transfer (NCART), Al-Baqa, Jordan, 6 pp.

Sulaiman Y., 1985. Fruit Trees. Tashreen University, Faculty of Agriculture, Directorate of Books and Press, Syria.

Ueckermann E.A., 1991. African Aceria (Acari: Eriophyidae): species associated with plants of the family Moraceae. *Phytophylactica*, 23, 1-4.

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