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Occurrence of plant bacterial diseases in Jordan

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Different studies were done in order to investigate the occurrence of bacterial diseases on different crops grown in Jordan during different growing seasons. Surveys were made and different bacterial diseases have been recorded based on symptoms and pathogenic nature. Morphological characters, biochemical tests and PCR detections were employed in order to detect and identify the causal agents of different inspected plant bacterial diseases. In addition, the distribution of the identified bacterial diseases, throughout the country was recorded. The results of our study revealed the occurrence of different bacterial diseases attacking different crops; grown in many growing regions throughout the country. Some of them were found to have a wide host range such as crown gall and soft rot, while others had a restricted host range as in the case of bacterial speck of tomato which was found to be restricted to tomato and black leg of potato. As a result of this study, the following diseases; angular leaf spot of cucumber, tomato speck, common blight, crown gall, soft rot, black rot, black leg and bacterial cankers resulted in high economic losses in yield. The spread of these diseases in the different areas in Jordan with different environmental conditions may result in the development of new races of the causal agents without developing typical symptoms making their diagnoses under field conditions difficult. Whereas the bacterial diseases needs deep and ideal studies in order to diagnose diseases, the diagnoses of these diseases act as the base for researchers to challenge and withdraw researches into the improvement of novel, more effective and sustainable bacterial disease control strategies.

Key words: Bacterial diseases, survey, Jordan.

INTRODUCTION

The world's population is increasing every year and in order to meet their demands, global crop production needs to be increased. Plant diseases attack all agricultural crops which are considered as the main source for human food and clothing all over the world and considered among the main factors that drastically affect its production, resulting in economic losses either in the field or in storage by decreasing crop production in quality and quantity. Thus, one of the methods to increase food production is to control plant diseases. Plant disease causal agents could be; fungi, bacteria, viruses and nematodes. Different bacterial diseases have been reported to attack many agricultural crops around the world, leading to high economic losses in yield under

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favorable environmental conditions and could eliminate plantation of certain crops in certain areas as in the case of fire blight (*Erwinia amylovora*) attacking pome fruits in northern states of United States of America (Kennedy and Alcorn, 1980; Agrios, 2005).

Moreover, plant bacterial disease diagnoses are very difficult under unfavorable conditions were typical symptoms do not develop and could be masked with other disease symptoms as in the case of black rot of crucifers caused by *Xanthomonas campestris* pv. *campestris*; a humid, warm season pathogen while crucifers hosts are winter season crops, typical symptoms will not develop under cold conditions (Mahiar and Khlaif, 2000).

Plant bacterial diseases spread in tropical and subtropical regions, and host range of bacterial diseases varies according to the disease, however some of them are with a wide host rang such as soft rot *Pectobacterium carotovorum* subsp. *carotovorum* (Omar and Khlaif, 2000 and Abu-Obeid et al., 2017), and crown gall; *Agrobacterium tumefaciens* (Al-Karablieh and Khlaif, 2002; Al-Karablieh et al., 2006). On the other hand, some bacterial diseases had a narrow and restricted host ranges as in the case of black leg of potato *P. carotovorum* subsp. *atroseptica* (Al Masa'adeh and Khlaif, 2003; Masa'adeh and Khlaif, 2004; Abu-Obeid et al., 2017) and bacterial speck of tomato *Pseudomonas syringae* pv. *tomato* (Abu-El Samen and Khlaif, 1999).

Recently the interests in bacterial diseases have been increased due to its importance and its serious damage on different crops resulting in great losses in quality and quantity.

Economic importance

Losses due to bacterial diseases are difficult to estimate, especially in fruit trees where losses are not confined to the year of disease development.

The prevalence of favorable environmental conditions leads to high economic losses to the crop as in the case of angular leaf spot of cucumber under plastic houses (Khlaif, 1991a and b).

Ralstonia solanacearum (*Pseudomonas solanacearum*); the causal agent of vascular wilt disease of solanaceae, ranked the second most important bacterial pathogen (Mansfield et al. 2012). The pathogen is distributed worldwide and induces a destructive economic impact. Direct yield losses by *R. solanacearum* vary widely according to the host, cultivar, climate, soil type, cropping pattern, and pathogen strain. Due to *R. solanacearum,* yield losses were estimated from 0 to 91% in tomato, 33 to 90% in potato, 10 to 30% in tobacco, and up to 80 to 100% in banana in Africa, India and Indonesia (Kelman, 1998).

Xanthomonas oryzae pv. *oryzae* causing leaf blight of rice is a major disease of rice and is a serious threat to rice production in both temperate and tropical rice-growing regions, due to its high epidemic potential causing up to 60% loss in India and Indonesia (Ou, 1985; Raina et al., 1982).

Canker and gummosis of stone fruit trees caused by *Pseudomonas syringae* pv. *syringae*, are of major concern in fruit producing areas worldwide, and are exceedingly and difficult to control, and resulted in significant economic losses. In 1967 about 750000 peach trees were killed in France and resulted in 10-75% losses of trees and reduction in yield reached 10-20 % (Luisetti et al., 1976).

In Florida citrus canker, caused by *Xanthomonas citri* subsp. *citri*, led to the destruction of half million citrus seedlings and bearing trees and to millions of dollar losses (Kennedy and Alcorn, 1980 and Kelman, 1998).

Bacterial blight of beans causes reduction in yield and decreases the marketable value of the crop, including seed size, quality and may range from a trace to 100%, especially when favorable environmental conditions persist during the early growth and flowering stages. Kennedy and Alcorn (1980), estimated losses in dry edible beans due to bacterial blights which ranged from 75 to 90% in North Dakota, while in Jordan Valley losses of bean yield due to common blight estimated ranged from 73 to 85% of the total production (Khlaif and Qadous, 1995).

Production of tomato seedlings free from bacterial speck is impossible, especially under plastic houses conditions in the Jordan Valley; 75% of tomato fruits showed specks which resulted in a 22% yield reduction (Abu-El Samen and Khlaif, 1999).

Angular leaf spot disease of cucumber, caused by *Pseudomonas syringae* pv. *lachrymans* was found to reduce the yield of cucumber at a rate of 30.6 to 64.4% in the Jordan valley and about 50-93% in the Uplands of Jordan (Khlaif, 1991a,b,c; Khlaif and Abu-Blan, 1994).

Due to lack of information about the situation of bacterial diseases in Jordan, this study was undertaken in order to inspect, diagnose, isolate, and identify the causal agents of bacterial plant diseases and their occurrence in Jordan over a period of more than 15 years.

MATERIALS AND METHODS

Extensive field surveys were undertaken to inspect, detect the occurrence, prevalence and the incidence of different bacterial diseases affecting economic crops, including; vegetables, fruit trees and ornamentals planted in different agricultural areas in Jordan. Through field trips to different agricultural areas during the different growing seasons in Jordan, samples of different crops suspected to be infected with different bacterial diseases throughout different growing seasons in Jordan, were collected, and placed in ice box and brought to the laboratory for further identification.

Isolation and identification of the pathogenic bacteria

Initial identification was performed according to Schaad et al. (2005), through isolation by using differential, common and semi

selective media as recommended for the suspected bacterial pathogen. A small amount of suspected tissue was removed from plant parts suspected to be infected with a certain bacterial disease, with sterile scalpel, washed and rinsed with sterile distilled water (SDW) and disinfected with diluted bleach solution (0.5% sodium hypochlorite), after rinsing in sterile water, tissue was chopped up with a sterile scalpel in a droplet of SDW and left to stand for 15 min. The bits of surface sterilized tissues were transferred onto the surface of loop and the resulted suspension was streaked on the surface of dried media plates. The media used for isolation were selective media according to the suspected pathogen as for example; D1 media was used in the case of crown gall (Fakhouri and Khlaif, 1996; Al-Karablieh and Khlaif, 2002; Al-karabliah et al., 2006), BCBRVB in the case of fluorescent *Pseudomonas* (Abu-El Samen and Khlaif, 1999; Hijazin and Khlaif, 2005), Logan media in the case of *Pectobacterium* (Masa'adeh and Khlaif, 2004; Abu-Obeid et al., 2017), TZC in the case of *Ralstonia solanacearum*, NA and SX Agar in the case of the *Xanthomonas campestris pv. campestris* (Mahiar and Khlaif, 2000), on the other hand, Nutrient Agar and KB media were used as common media for other pathogens. Inoculated media plats were incubated at 25 ± 1°C, checked periodically for development of suspected phytopathogenic bacterial colonies, and then subculturing was made by transferring a suspected colony to a new media plate through streaking for purification. Then, the obtained purified suspected colonies were transferred into agar slants and allowed to grow, kept in refrigerator for further identification.

Then the colonies of the suspected bacterial pathogen causal agents were subjected to identification procedures through biochemical and physiological tests as recommended by Schaad et al. (2005). The same tests were run against a reference culture of the most different identified pathogens.

Beside these biochemical and physiological tests, detection and identification of some bacterial pathogens was done using biotechnological molecular techniques such as polymerase chain reaction, (PCR), cloning and sequencing were employed in the identification of different bacterial pathogens of these; *Agrobacterium tumifaciens* (Al-karabliah et al., 2006), *P. carotovorum* subsp. *carotovorum* (Abu-Obeid et al., 2017) *P. carotovorum* sub sp. *atroseptica* (Al-zomor et al., 2013), *P. savastaoni* pv. s*avastaoni* (Hijazin, and Khlaif, 2005), *Pseudomonas syringae* pv. *tomato* (Werikat et al., 2005), etc.

RESULTS AND DISCUSSION

Approximately, all growing regions planted with different crops have been inspected and different bacterial diseases have been recorded in cultivated and non-cultivated crop plants of Jordan. The results of this study indicated the occurrence of different bacterial diseases in the different inspected agricultural areas throughout the country. The different diagnosed and identified bacterial diseases and their causal agents are listed in Table 1.

However, the symptoms of the diagnosed and identified bacterial diseases vary from leaf spots, tumors, rots, wilts, scab, cankers, and gummosis etc., indicated by different causal agents.

The occurrence of these diseases depends on the geographical areas since Jordan is divided into different geographical areas of Jordan Valley, Jordan Valley rift, mountains or uplands and deserts (Figure 1) where the environmental conditions of these areas varies according to the season and location. In summer, it is very hot and dry in the desert, hot and dry in Jordan Valley, while it is warm and relatively humid in the uplands and mountains. In winter, it is warm and humid in Jordan Valley, cold and dry in the desert, at the same time cool and humid in the uplands. These wide climatic variations in Jordan could illustrate the importance of different plant bacterial diseases in relation to occurrence, development and spreading, as well as, under certain conditions could lead to an epidemic bacterial disease.

However, eight phytopathogenic bacterial genera were identified; *Agrobacterium* with two species were recorded. However, *A. tumefaciens* was found to be the most common, causing crown gall attacking 21 different hosts, including; stone fruits followed by grapes, roses, olives, quince, pomegranate and nemaguard. The disease was found to spread throughout the country in different climatic regions. Also, *A. rhizogenes* was with two hosts causing hairy root disease on apples and roses.

Erwinia with seven species, causing rots and blights were identified and recorded, from which the species *Carotovorum* with had two subspecies; *Carotovorum* and *Atroseptica*; *Erwinia carotovra* subsp. *cartovra* was found with a wide host range of about 30 different host plant including; vegetables and ornamentals and was found to spread all over agricultural regions either in field and storage (Khlaif, 1993). On the other hand, the subspecies *Atroseptica* has been found to be restricted to potato, causing black leg disease in winter in the Jordan Valley region and early spring in the uplands.

Erwinia amylovora the causal agent of fire blight disease on pome fruits attack four hosts; apple, pear, quince and firethorn in spring where it was severe on the flowering stage and was more serious on pears and apple (Al-Dahmashi and Khlaif, 2004). Other species of *Erwinia* such as *E. chrysanthmi* (*Dickey dadantii*), *E. trachephila* and *E. stewartii* were identified causing wilt, rot and leaf blight diseases on different hosts in many agricultural regions of Jordan (Table 1).

Seventeen species of *Xanthomonas* (Table 1) were identified and detected on different types of hosts, where *X. campestris* pv. *campestris* was the most common and reported on 10 different hosts causing symptoms ranging from black rot on crucifers to leaf spots and blights on legumes. Also, it was isolated from a wide range of weeds spreading in the same regions or fields of infected crop.

However, different phytopathogenic bacteria genera such as *X. campestris* pv. *phaseoli* and *Xanthomonas campestris* pv. *campestris* were isolated from different weeds and volunteer plants grown in the host fields (Table 1). These finding could bring a new dimensions in the epidemiology of these diseases and play an important role as a source of inoculums for these diseases.

X. arboricola pv. *pruni* attacked 6 different hosts of stone fruits causing leaf spots where it infects more seriously peaches, apricots and plums, especially in the

Table 1. List of diagnosed and identified plant bacterial diseases and their causal agents in Jordan.

S/ No	Bacterial Genus	Pathogen	Host Common name	Host Scientific name	Disease	Region
1	*Agrobacterium*	(a) *Agrobacterium tumefaciens* (Smith and Townsend) conn.	1. Almond	1. *Prunus dulcis* (Miller)	Crown Gall	Wide spread Jordan Valley and Uplands
			2. Apple	2. *Malus domestica* Brokh		
			3. Apricot	3. *Prunus armeniaca* L.		
			4. Bitter Almond	*4. Prunus amygdalus* var. *amara*		
			5. Carob tree	*5. Ceratonia siliqua*		
			6. Cherry	6. *Prunus avium* L.		
			7. Fig	7. *Ficus carcia* L.		
			8. Grape	8. *Vitis vinifera* L.		
			9. Mahaleb	*9. Prunus mahaleb*		
			10. Mulberry	10. *Morus nigra* L.		
			11. Myrobalan	11. *Terminalia chebula*		
			12. Nectarine	12. *Prunu spersica* var *nectarine* (Aitf) Maxim		
			13. Olive	13. *Olea europea* L.		
			14. Peach	14. *Prunus persica* L.		
			15. Pear	15. *Pyrus communis* L.		
			16. Plum	16. *Prunus domestica* L.		
			17. Pomegranate	17. *Punica granatum*		
			18. Quince	18. *Cydonia oblonga*		
			19. Rose	19. *Rosa* sp.		
			20. Walnut	20. *Juglan sregia* L.		
			21. Nemaguard (Peach root stock)	21. *Prunus persica*		
		(b) *A. rhizogenes* (Riker et al.1939) Conn	1. Apple	*1. Malus domestica Brokh*	Hairy root	Widespread
			2. Rose	*2. Rosa sp.*	Hairy root	

Table 1. Contd.

2	*Erwinia*	a- *Pectobacterium carotovorum* pv. *carotovorum* (Jones) Bergey	1. Artichoke	*1. Helianthus tuberosus L.*		Wide spread In Jordan Valley and uplands In storage, field and glass houses
			2. Banana	*2. Musa acuminata*		
			3. Bean	*3. Phaseolus vulgaris L.*		
			4. Beet	*4. Beta vulgaris L.*		
			5. Cabbage	*5. Brassica olearaceae var. capitata L.*	Soft rot	
			6. Cauliflower	*6. Brassica olearaceae var. botrytis L.*		
			7. Carrot	*7. Dacus carota L.*		
			8. Celery	*8. Apium graveolens L.*		
			9. Chard	*9. Beta vulgaris var. cicla*		
			10. Chinese cabbage	*10. Brassica chinensis L.*		
			11. Dieffenbachia	*11. Dieffenbachia maculate*		
			12. Eggplant	*12. Solanum melongena L.*		
			13. Garlic	*13. Allium sativum L.*		
			14. Lettuce	*14. Lactuca sativa L.*		
			15. Marrow	*15. Cucurbita pepo L.S. fal*		
			16. Onion	*16. Allium cepa*		
			17. Parsley	*17. Petroselnium crispum (Mill)*	Stem rot	
			18. Pea	*18. Pisum sativum L.*		
			19. Pepper	*19. Capsicum frutescens L.*		
			20. Pomegranate	*20. Punica granatum L.*		
			21. Potato	*21. Solanum tuberosum L.*		
			22. Pumpkin	*22. Cucurbita maxima L.*		
			23. Radish	*23. Raphanus sativus L.*		
			24. Spinach	*24. Spinacia olearaceae L.*		
			25. Sweet melon	*25. Cucumis melo L.*	Stem rot	
			26. Tomato	*26. Lycopersicon esculentum Miller*	Soft rot	
			27. Watermelon	*27. Citrullus fanatus var. caffr*	Soft rot	
			28. Gladiolus	*28. Gladiolus communis*	Soft rot	Widespread
			29. Cucumber	*29. Cucumis sativus L.*		
			30. Common mallow	*30. Malva sylvestris*		

Table 1. Contd.

		b. *Pectobacterium carotovorum* pv. *atroseptica* (Vanitall) Dye	potato	*Solanum tuberosum L.*	Black leg	Upland in spring JV in winter
		c. *Erwinia amylovora* (Burill) Winslow *et al*.	1. Apple 2. Pear 3. Quince 4. Firethorn	*1. Malus domestica* *2. Pyrus communis* *3. Cydonia oblonga Mill* *4. Pyracantha anyastifolia*	Fire blight	Widespread in the Up lands in Al Mafraq / Al Halabat
		d. *Erwinia chrysanthemi* Burkholder *et al*. *(Dickey dadantii*)	1- Banana 2- Begonia 3- Chrysanthemum 4- Potato 5- Onion	*1. Musa acuminate* *2. Begonia sp.* *3. Chrysanthemum sp.* *4. Solanum tuberosum* *5. Allium cepa*	RRhizome rot Wilt Associated with soft rot	JV in glass houses Widespread
		e. *Erwinia tracheiphila* (Smith) Bergley *et al*.	Cucumber	*Cucumis sativus L.*	Wilt	JV in winter under plastic house Up lands in Fall
		f- *Pantoea* (*Erwinia*) *stewartii*	Corn	*Zea mays*	Seedling leaf blight	JV and Uplands
		g- *Erwinia anunas*	Cucurbits	*Cucurbits*	Brown spots	JV in storage
3-	*Xanthomonas*	*a. Xanthomonas campestris* pv. *campestris*	1. Avocado	*1. Persea ammericana*	Leaf spot	
			2. Broccoli	*2. Brassica oleraceae* var. *italica* Plenk		JV in spring Uplands in fall
			3. Cabbage	*3. Brassica oleraceae* var. *capitata*	Black rot	
			4. Carrot	*4. Daucus carota* var. *sativus*		JV in Spring Uplands in Fall
			5. Cauliflower	5. *Brassica oleraceae* var. *botrytis*	Black rot	

Table 1. Contd.

	6. Chinese cabbage	6. *Brassica chinensis* L.	Leaf blight	
	7. Kohlrabi	7. *Brassica oleraceae* var. *gongylodes*	Black rot	
	8. Radish	8. *Raphanus sativus* L.	Black rot	
	9. Turnip	9. *Brassica rapa* L.	Black rot	
	10. Walnut	*10. Juglans regia*	Black rot	
	11. Pigweed	11. *Amaranthus blitoides* S. Watson	Leaf blight	JV in Spring Uplands in Fall
	12. Red-root Pig weed	12. *Amaranthus retroflexus*L		
	13. Goosefoot	*13. Chenopodium album* L.	Leaf spot	
	14. Dyer's croton	14. *Chrozophora oblique* (Vahi) sprenge		Widespread in crucifers fields in the uplands
	15. White rocket	15. *Diplotaxis ericoides* L.		
	16. European heliotrope	16. *Heliotropium europaeum*L.		
	17. Red cabbage	17. Brassica oleracea		Widespread in crucifers fields in the uplands
	18. Hairy nightshade	18. *Solanum luteum* Miller		
	19. Sow thistle	19. *Sonchus oleanaceus* L.		
b. Xanthomonas campestris pv. *phaseoli* (Smith) Dye	1. Pea	1. *Pisum sativm* L.	Blight	Wide
	2. Bean	2. *Phaseolus vulgaris* L.	Common blight	spread

Table 1. Contd.

	3. Morning glory	*3. Ipomaea purpurea* L.		JV in Fall and spring
	4. Malva	*4. Malva syriaca L.*	Leaf spot	
	5. Hairy cowpea	*5. Vigna luteola*(Jaca) Benth	Leaf spot	In fields of JV and uplandsi n fall
	6. Cowpea	6. *Vigna unguiculata L. Walp*	Leaf spot	
c. Xanthomonas campestris pv. *vesicatoria* (Poidge)1978	1. Pepper	1. *Capsicum annum* L.		
	2. Tomato	*2. Lycopersicon esculentum* Miller	Bacterial spot	Winter in the J.V
d.Xanthomonas campestris pv. *cucurbitae*	Cucumber	*Cucumis sativus* L.	Leaf spots	Plastic houses
e. Xanthomonas campestris	1. Barley	*1. Hordeum vulgaris*	Black chaff	Winter J.V
pv. *translucens* (Jones) Dye 1978	2. Oat	*2. Avena sativum*	(streaks/strips)	Spring uplands
	3. Wheat	*3. Triticum aestivum* L.		
f. Xanthomonas ampelina	Grape vine	*Vitis vinifera*	Leaf spots	Upland J.V winter
g. Xanthomonas fragariae	Strawberry	*Fragaria chiloensis* var. *ananassa*	ALS	Up lands in spring
	1. Almond	1. *Prunus dulcis* L. (Miller)		
	2. Apricot	2. *Prunus armenica* L.		
h.Xanthomonas arboricola pv. *pruni*	3. Nectarine	3. *Prunus persica* var. *nectarine*	Leaf Spot	Fall , uplands Spring, J.V
	4. Peach	4. *Prunus persica* L.		
	5. Plum	5. *Prunus domestica* L.		
	6. Sweet cherry	6. *Prunus avium* L.		
i. Xanthomonas arboricola (campestris) pv. *juglands* Dye 1978	Walnut	*Juglans regia* L.	Blight	Widespread Fall uplands

Table 1. Contd.

		j. Xanthomonas campestris pv. *pelargoni* Dye 1978	Geranium	*Pelargonium* sp.	Leaf spot stem rot	Winter uplands
		k. Xanthomonas campestris pv. dieffenbachiae (Mcculloch) Dye 1978	1. Dieffenbachiae	*1. Dieffenbachiae maculate*.	Leaf spots	Glass houses
			2. Flaming lily	2.*Anthurium andraenum*		
			3. Philodendron	*3. Philodendron* sp		
		l. Xanthomonas campestris pv. *begonia*	Begonia	*Syngonium podophyllum*	Leaf marginal lesions and wilt	Under glass houses
		m. Xanthomonas campestris pv. *schefflera*	Schefflera	*Schefflera* sp.	Leaf spots	Indoor glass houses
		n. Xanthomonas campestris pv. *raphani*	Crucifers	Crucifers	Leaf spots	JV
		o. Xanthomonas campestris pv. *musaceavum*	Banana	*Musa acuminata*	Wilt	JV
		p. Xanthomonas campestris pv. *citrumelo*	Citrus	Citrus	Bacterial spots	JV
		q. Xanthomonas axonopodis pv. *citri*	Citrus	Citrus	Bacterial canker	Imported Seedlings
4	*Pseudomonas*	*a. Pseudomonas syringae* pv. *lachrymans* (smith and Bryan) Young 1978	Cucumber	*Cucumis sativus* L.	ALS	Wide spread JV and Uplands

Table 1. Contd.

b. Pseudomonas syringae pv. *phaseoli* (Barkholder) Young	Bean	*Phaseolus vulgaris* L.	Halo blight	Wide spread
c. Pseudomonas syringae pv. *pisi*	Peas	*Pisum sativum*	Blight	Wide spread
d.Pseudomonas syringae pv. *syringae* Vanhall	1. Bean 2. Pea 3. Cherry 4. Citrus 5. Lemon 6. Pear 7. Plum 8. Sunflower 9. Tomato 10. Valencia 11. Vetch 12. Wheat 13. Barley 14. Oat	1. *Phaseolus vulgaris* L. *2. Pisum sativum* 3. *Prunus avium* L. 4. Citrus lemon 5. *Pisum sativum* L. 6. *Pyrus communis* L. 7. *Prunus domestica* L. 8. *Hellathus annus* L. *9. Lycopersicon esculentum* *10. Citrus sinensis* var. *valencia* 11. *Vicia sativa* L. 12. *Triticum astivum* L *13. Horeum vulgare* *14. Avena sativa*	Brown spot Bud blast	Wide spread

Table 1. Contd.

e. Pseudomonas syringae pv. *tomato*	Tomato	*Lycopersicon esculentum* Miller	Bacterial speck	Under plastic house in nurseries and open field
f. Pseudomonas syringae pv. *morsprunorum*	1. Cherry 2. Plum 3. Apricot 4. Peach	1. *Prunus alium* L. 2. *Prunus domestica* L. *3. Prunus armeniaca* *4. Prunus persica*	Gummosis	Wide spread
g.Pseudomonas savastanoi pv. *savastanoi*	1. Oleander 2. Olive 3. Jasmine 4. Ziziphus	*1. Nerium oleander* *2. Oleae uropea* *3. Jasminum graniflorum* *4. Ziziphus spina-christi*	Olive knots	Wide spread
h. Pseudomonas syringae pv. *tabaci*	Tobacco	*Nicotiana tabacum* L.	Bacterial leaf blight	Widespread in JV in spring In Uplands in fall
i. Pseudomonas virdiflava (Barkholder) Dowson	1. Bean 2. Cucumber 3. Tomato	*1. Phaseolus vulgaris* *2. Cucumis sativus* *3. Lycopersicon esculentum*	Stem galling Watery rot Leaf spot	Under plastic houses in JV
j. Pseudomonas corrugata	Tomato	*Lycopersicon esculentum*	Pith necrosis Leaf spot	After cold, frost damage Under plastic house in JV
k. Pseudomonas cichorii (swingle) stape	Lettuce	*Lactuca sativa*	Leaf spot	JV and uplands
l. Pseudomonas gladiola pv. *gladiola*	Gladiolus	*Gladiolus* sp.	Soft rot	Glass houses
m. Ralstonia(Pseudomonas) solanacearum	1. Banana 2. Tomato	*1. Musa acuminata* *2. Lycopersicon esculentum*	Moko disease Wilt	JV in spring and winter

Table 1. Contd.

		n.Pseudomonas syringae pv. *maculicola*	Crucifers	Crucifers	Bacterial leaf spot	Plastic houses
		o.Pseudomonas marginalis pv. *marginalis*	1. Crucifers 2. Gladiolus	1. Crucifers 2. *Gladiolus* sp.	Soft rot scab	JV Plastic houses
		p. Pseudomonas flourescense	Potato	*Solanum tuberosum* L.	Pink eye	JV
		q.Pseudomonas syringae pv. *dapulans*	Apple	*Malus domestica*	blister spot	Uplands
5	*Streptomyces*	*Streptomyces scabies*	1. Carrot 2. Potato 3. Raddish	1. *Daucus carota* subsp. *sativus* 2. *Solanum tuberosum* L 3. *Raphanus sativus*	Common scab	Widespread in southern parts of Jordan
6	*Burkholdoria*	*a .Burkholdoria gladioli* pv. *allicola* (*Pseudomoma sgladioli* pv. *allicola*)	Onion	*Allium cepa*	Slippery skin	Common in storage JV in winter
		b. Burkholdoria cepacia	Onion	*Allium cepa*	Sour skin	Common in storage JV in winter
7	Clavibacter (*Corynebacterium*)	*a. Clavibacter michiganensis subsp. michiganensis*	Tomato	*Lycopersicon esculentum*	Bird's eye spot	JV winter and spring

fall season in the uplands, followed by *X. campestris* pv. *phaseoli* causing common blights and leaf spots of bean and peas. On the other hand, *X. campestris* pv. *translucence* was isolated and identified from 3 field crops showing strips or streaks symptoms; the disease was found to be common during winter and spring in the Jordan Valley and in the uplands, where barley was found to be the most susceptible crop. Other 13 *Xanthomonas* species with narrow host range, attacking different plant types ranging from ornamentals, fruit trees and vegetables were diagnosed and recorded (Table 1).

Different species of *Pseudomonas* were isolated and identified, of these *P. syringae* pv. *syringae* was the most common species causing many diseases on 14 different hosts; brown spot, scab, wilt, cankers, citrus blast and bud blast. Other

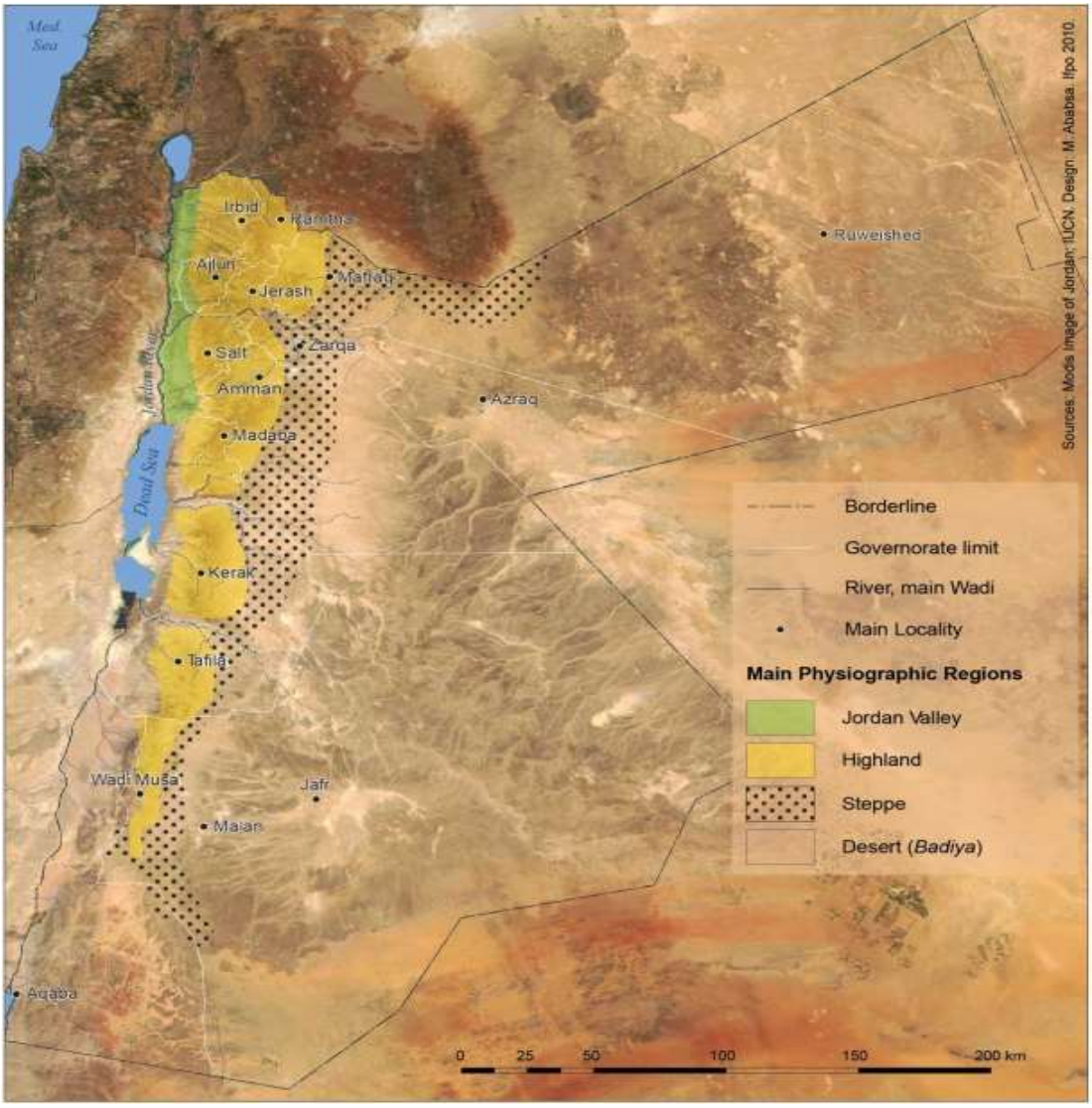

Figure 1. Map of Jordan showing the main physiographic regions.
Source: Atlas of Jordan, 2014.

Pseudomonas species attacked 24 different hosts causing different disease symptoms ranging from angular leaf spot such as ALS (*P. syringae* pv. *lachrymans*) on cucurbits especially under plastic houses, gummosis (*P. syringae* pv. *morsprunorum*) on stone fruits, knots (*P. savastanoi* pv. *savastanoi*) on olives, oleanders, jasmine and *Ziziphus* sp. and spread all over the country, causing a serious damage to all olive cultivars; Nabali baladi was found to be the less olive cultivar susceptible to olive knot disease (Khlaif, 2006).

Streptomyces scabies was found to cause common scab disease on potatoes, carrot and radish and was most common on potatoes in the southern parts of Jordan where the soil is sandy.

Burkholdoria gladioli pv. *allicola* (*Pseudomonas gladioli* pv. *allicola*) was found to cause slippery skin disease on onion.

Ralstonia solanacearum was isolated and identified from wilted plants of tomato under plastic houses and banana in the Jordan Valley during spring.

One species of *Clavibacter* (*Corynebacterium*) was detected and identified, *Clavibacter michiganensis* pv. *michiganensis* causing Bird's eye spot disease on tomato was recorded during winter in the Jordan Valley.

Conclusion

Many plant bacterial diseases were detected, identified and recorded that cause diseases of many crops grown in Jordan which resulted in high economic loss. Accordingly, the identification of these diseases using

efficient methods is essential in order to investigate the ecology of these diseases and therefore help in employing the efficient control method. The occurrence of these bacterial diseases in the different growing areas in Jordan with different environmental conditions could develop new phytopathogenic bacterial strains, where atypical symptoms could be very difficult to diagnose and control.

This work acts as the base for researchers in this field to take advantage and implement further studies in controlling these diseases and decrease losses.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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