British Biotechnology Journal
10(1): 1-36, 2016, Article no.BBJ.21430
ISSN: 2231–2927, NLM ID: 101616695

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Effect of Moroccan Plants against Phytopathogenic Microorganisms: A Review

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/BBJ/2016/21430
Editor(s):
(1) Marli Camassola, Institute of Biotechnology, University of Caxias do Sul, Brazil.
Reviewers:
(1) Felipe Lombo, University of Oviedo, Spain.
(2) Jeffrey Lim Seng Heng, Malaysia Agricultural Research and Development Institute, Malaysia.
Complete Peer review History: http://sciencedomain.org/review-history/11550

Review Article

Received 16th August 2015
Accepted 15th September 2015
Published 27th September 2015

ABSTRACT

Plant diseases caused by microorganisms are a major problem that touches many agricultural crops, causing damages in yield potential each year in Morocco as in other countries. To face this burden, medicinal plants are among the richest bio-resources of the drugs currently used for biological control. This review cites sixty two Moroccan plants with antimicrobial properties. The activities described here show that there are many potential plants that should undergo further application studies in the field to assess their possible use as bio-pesticide.

Keywords: Phytopathogenic microorganisms; Moroccan plants; biological control.

1. INTRODUCTION

Agriculture in Morocco is an important economic sector, with 40% of the population living on its revenues [1]. However, this African country suffers from plants diseases caused by soil-borne as well as seed borne pathogens which cause serious problems in the cultivation of economically important plants [2]. In fact, in 2006, the fire blight caused by *Erwinia amylovora* was first observed in pear in Ain Orma, region of Meknes, Morocco. Since then, the disease has progressed to the most of the rosaceous region, affecting a total area of about 4000 ha, causing serious economic losses and menacing the national production of rosaceous plants [3]. Additional bacteria have been implicated in plant pathologies such as *Erwinia carotovora*

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associated with stem rot and vascular wilt symptoms of hydroponically grown plants [4] and *Clavibacter michiganensis* subsp. *michiganensis* has been linked with the bacterial canker [5]. It is one of the most important phytosanitary tomato problems in California and Ohio [6]. In Morocco, all tomato production areas are contaminated by this pathogen, as in Souss-Massa Draa region, where it has become the main cause of the premature tomato death [5,6].

Also, phytoplasmas are plant pathogenic bacteria transmitted by insect vectors (leafhoppers, planthoppers, and psyllids). Phytoplasmal diseases of over 700 plant species have been observed globally [7] including witches' broom disease on *Paulownia tomentosa* induced by infection with Candidatus *Phytoplasma asteris*; phyllody on hydrangea attributed to Candidatus *Phytoplasma japonicum* in Japan and lethal yellowing of coconut palm trees in the Caribbean caused by Candidatus *Phytoplasma palmae* [7].

Besides bacteria, fungi have long been recognized as phytopahtogens leading to severe damage to crops. Among them, Botrytis cinerea,

Table 1. Different phytopathogens infecting plants in many countries

Phytopathogen	Type	Plant disease	Reference
Agrobacterium tumefaciens	Bacterium	Crown gall of many woody and herbaceous plants	[13]
Bacillus subtilis	Bacterium	Soft rot of Mango	[14]
Erwinia chrysanthemi	Bacterium	Tuber soft rot and blackleg	[15]
Mycobacterium sp.	Bacterium	Alfalfa bacterial wilt disease	[16]
Xanthomonas campestris	Bacterium	Bacterial blight, common blight, fuscous blight, cankers and leaf spots in French bean, cotton, paddy, tomato, etc.	[17]
Candidatus *Phytoplasma oryzae*	Phytoplasma	Rice yellow dwarf	[7]
Candidatus *Phytoplasma pruni*	Phytoplasma	Potato witches' broom	[7]
Candidatus *Phytoplasma ziziphi*	Phytoplasma	Jujube witches' broom	[7]
Alternaria alternate	Fungus	Black rot	[18]
Colletotrichum gloeosporioides	Fungus	Anthracnose of long cayenne pepper	[19]
Colletotrichum orbiculare	Fungus	Anthracnose disease in cucumber	[19]
Fusarium oxysporum f. sp. *ciceris*	Fungus	Wilt disease in chickpea	[19]
Fusarium oxysporum f. sp. *radicis-lycopersici*	Fungus	Tomato shoot and root rot	[19]
Fusarium oxysporum f. sp. *raphani*	Fungus	*Fusarium* wilt of radish	[19]
Fusarium solani	Fungus	Fruit rot	[20]
Geotrichum candidum	Fungus	Postharvest *Citrus* sour rot	[21]
Gloeosporium limetticola	Fungus	Lime anthracnose	[18]
Guignardia citricarpa	Fungus	Black spot	[18]
Lasiodiplodia theobromae / *Phomopsis citri*	Fungi	Stem-end rot	[18]
Mycosphaerella citri	Fungus	Greasy spot	[18]
Penicillium digitatum	Fungus	Green mold in *Citrus* fruits	[22, 23]
Penicillium expansum	Fungus	*Citrus* blue mold in stored apples	[24]
Penicillium italicum	Fungus	*Citrus* blue mold.	[23]
Phytophthora capsici	Fungus	Fruit rot	[20]
Phytophthora fragariae var. *rubi*	Fungus	Raspberry root rot.	[25]
Rhizoctonia solani	Fungus	Damping-off of tomato; rice sheath blight	[19, 20]
Sclerotium rolfsii	Fungus	Southern blight of tomato	[19]
Sclerotinia sclerotiorum	Fungus	Wilt and rot in *Cicer arietinum*; water soaked spot	[26, 20]
Thielaviopsis basicola	Fungus	Black root rot of tobacco	[19]
Trichoderma viride	Fungus	Trichoderma rot	[18]
Cucumber mosaic virus	Virus	Mosaic disease of cucumber	[19]
Tomato mottle virus	Virus	Tomato mottle disease	[27]
Tobacco necrosis virus	Virus	Tobacco necrosis disease	[27]

the causative agent of gray mold disease, is the most destructive tomato and table grape fungus in most countries [8,9]. *Rhizopus stolonifer* is identified as the responsible agent of some plants leak, especially strawberry, carrot, apple, plum, peach and pear [10].

Viruses are as well important factors that bring out considerable economic damages to plant products [11,5] as for example Citrus tristeza virus, Barley yellow dwarf virus, Potato leaf roll virus, Cauliflower mosaic virus, Plum pox virus and African cassava mosaic virus (Table 1) [12].

Plants diseases are often very difficult to eradicate, but to control them few effective strategies can be adopted [28]. At present, chemical control remains the main measure for the treatment of infected crops [29,2]. Although effective, the continued or repeated applications of pesticides may disrupt ecosystems equilibrium; accumulate in human adipose tissue (a health treat); widespread development of pathogens resistant to one or more chemicals and lead to environmental pollution [11,10,2,22].

These problems are the principal driving forces behind identifying alternative methods for plant protection, which are less dependent on chemicals and are more eco-friendly [10]. Some of these techniques use food additives [23] or antagonistic microorganisms, while others are based on plant extracts or essential oil compounds and their derivatives [2,19,11,10,22, 28,29,8,1,21,30,23]. Since plants have exceptional ability to produce cytotoxic agents [31] and there are good reasons to suppose that secondary plant metabolism has naturally evolved to actively protect vegetable and fruit species from microbial pathogen attacks [11], several investigations have been carried out to discover natural pesticides from Moroccan plants. Herein, this ongoing review deals with the plants valorization of the Moroccan flora by encompassing the literature from 2003 to 2015 on plants used in biological control.

2. EFFECT OF SOME MOROCCAN PLANTS AGAINST PHYTOPATHO-GENIC MICROORGANISMS

Morocco is known for its rich vegetation and plant biodiversity, due to its geographical and climatic conditions [32]. It's characterized by a varied spontaneous aromatic flora with high levels of endemism [33]. Interestingly, it has 41 ecosystems and 7000 plant species including 4500 species of vascular plants. Between this botanical diversity, 600 species are known for their aromatic and medicinal use [34]. Indeed, medicinal plants constitute a powerful source of bioactive molecules usually synthesized in response to stress conditions and produce antibacterial, antiviral and antifungal effects [33,9]. These secondary plant metabolites are often active against a small number of specific target microorganism species [11]. Furthermore, they are biodegradable to nontoxic products, not phytotoxic and are generally regarded as safe to mammals (GRAS) by the United States Food and Drug Administration [11,18]. Therefore, it becomes evident that these substances have enormous potential to improve the future agrochemical technology [11]. Consequently, many plants have been the subject of several scientific studies. For instance, in 2013, Elkhalfi et al. [28] have found that the methanolic extracts of *Nigella sativa*, *Geranuim robertianum*, *Aizoon canariense* and *Rubia peregrine* showed clear inhibitory and bactericidal activities against *Pseudomonas syringae* pv. tomato DC3000 strain. This Gram negative bacterium is the causal agent of bacterial speck which is the most persistent bacterial disease problem found in tomato-growing plants. It does not only decrease yield of plants through foliar necrosis, but it also blemishes the fruits and renders them unsuitable for the fresh market [28]. Another example comes from Askarne et al. [23], who have reported that aqueous extracts of *Anvillea radiata, Inula viscosa, Halimium umbellatum, Ceratonia siliqua* and *Asteriscus graveolens* were very effective *in vitro* and *in vivo* against *P. italicum* [23]. The antimicrobial effects of plant essential oils (EO) against fruit pathogens have been documented, too [30,24,35,36]. In fact, treatment of Clementine with the *Asteriscus imbricatus* EO, has been found to control the growth of *P. digitatum* [24]. Also of interest, Chebli et al. [36] demonstrated that EO from *Chrysanthemum viscidehirtum* at a concentration of 150 ppm strongly inhibited *in vitro* growth of four fungi e.g., *P. digitatum, Phytophthora citrophthora, Geotrichum citri-aurantii* and *Botrytis cinerea*. Additionally, the antifungal activity of this EO was compared to treatments with the synthetic fungicides procymidone, thiabendazole, guazatine and propamocarbe HCL at 1000 ppm [36]. Table 2 gives examples of the effect of Moroccan plants against phytopathogenic microorganisms.

Table 2. List of Moroccan plants with antibacterial and antifungal activities

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
1- *Nigella sativa* (Ranunculaceae)	Casablanca [28]	S + L + R	Maceration with 80% (v/v) M/DW	>40 mm against *Ps. syringae* pv. tomato DC3000	1.0 ±0.1	1.0 ±0.1	Agar well diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [28], but the antibacterial effect is most probably due to thymoquinone [37]	Significant detrimental effects of the plant extract on the bacterial growth in liquid medium [28].
	SMD Valley, Agadir [38]	Seeds	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder inhibits MG against *P. digitatum* and *G. candidum* by 81% and 74%, respectively.	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
2- *Geranuim robertianum* (Geraniaceae)	Casablanca [28]	S + L + R	Maceration with 80% (v/v) M/DW.	30 ± 2 mm against *Ps. syringae* pv. tomato DC3000	2.6 ±0.1	6.0 ±0.3	Agar well diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND	NAD
3- *Aizoon canariense* (Aizoaceae)	Casablanca [28]	S + L	Maceration with 80% (v/v) M/DW	20 ± 1 mm against *Ps. syringae* pv. tomato DC3000	4.0 ±0.2	4.0 ±0.2	Agar well diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND	NAD
4- *Rubia peregrine* (Rubiaceae)	Casablanca [28]	S + L	Maceration with 80% (v/v) M/DW	18 ± 2 mm against *Ps. syringae* pv. tomato DC3000	3.0 ±0.1	9.0 ±0.5	Agar well diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND	NAD
5- *Lavandula coronopifolia* (Lamiaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	48.8 ± 1.9 mm against *C. michiganensis* subsp. *michiganensis*	6.25	12.25	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (55.58 mg CAE/ g DW) and flavonoids (19.51 mg	Significant reduction of population size of the bacterium in the tomato seeds' surface after treatments by plant extract (72.32%). In an experimental greenhouse, contaminated tomato seeds treated with the extract had a germination rate

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
								RE/ g DW) present in the M extract of plant tested [6].	of 98%.
	SMD Valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 22.82% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 42.86% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
6- *Cistus monspeliensis* L. (Cistaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	38.6 ± 0.5 mm against *C. michiganensis* subsp. *michiganensis*	6.25	25	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (37.21 mg CAE/ g DW) and flavonoids (19.79 mg RE/ g DW) present in the M extract of plant tested [6].	Reduction of population size of the bacterium in the tomato seeds' surface after treatments by plant extract (33.92%). In an experimental greenhouse, contaminated tomato seeds treated with the extract had a germination rate of 84%.
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder had completely (100 %) inhibited the MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extracts (MIC and MFC).	ND	NAD
7- *Rubus ulmifolius* (Rosaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	40.5 ± 0.0 mm against *C. michiganensis* subsp. *michiganensis*	3.125	6.25	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. However, the antifungal activity of the crude plant extract may be due to the high content of tannins [39]. As well to the high levels of polyphenols (37.52 mg CAE/ g DW)	Extract has an improve action on the germination capacity of seeds in an experimental greenhouse (88%) and reduced significantly the viable pathogen cells from the surface of the treated seeds (50.89%) [5].

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
								and flavonoids (19.82 mg RE/ g DW) present in the M extract of plant tested [6].	
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 77.44% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder had completely (100 %) inhibited the MG of *G. candidum*	0.3125 against *G. candidum*	> 5	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extracts (MIC and MFC).	ND	*In vitro,* the plant aqueous extracts reduces 15% of spore germination of *G. candidum* at 5mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 85 % after treatment of artificially inoculated "Mandarin" fruits (*Citrus reticulata* Blanco cv. Clementine) during 7 days of storage at 26℃ and 95% relative humidity by the aqueous plant extract at 50 mg/ml. This extract reduces the disease severity to 70% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss Valley, Agadir [40]	S + L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	12.23 mm for EA plant extract at 10 mg/ml. 17.56 mm for M plant extract at 10 mg/ml. against *G. candidum*	0.625 for M plant extract.	>5 for M and EA plant extracts	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	The M plant extract showed a highest amount of phenolic compounds (115 mg GAE/g extract) which may be responsible of the antifungal effect.	*In vitro,* the plant EA and M extracts reduce 81.67% and 97% of spore germination of *G. candidum,* respectively, at 20mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 30% after treatment of artificially inoculated "Mandarin" fruits *(Citrus reticulata* Blanco cv. *Clementine)* during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 22.27% by the end

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
									of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
8- *Rosa canina* (Rosaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	40.4 ± 0.05 mm against *C. michiganensis* subsp. *michiganensis*	6.25	25.00	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (44.68 mg CAE/ g DW) and flavonoids (17.58 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
9- *Pistacia atlantica* (Anacardiaceae)	SMD Valley, Agadir [5]	L	Extracted by DW	37 ± 1.7 mm against *C. michiganensis* subsp. *michiganensis*	3.125	12.55	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (62.78 mg CAE/ g DW) and flavonoids (18.38 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [23]	L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 12.82% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 97.68% MGI of *G. candidum*	>5 against G. candi-dum	ND	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC).	ND	*In vitro,* the plant aqueous extract reduces 1.33% of spore germination of *G. candidum* at 5mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 55.56 % after treatment of artificially inoculated "Mandarin" fruits during 7 days of storage at 26℃ and 95% relative humidity by the aqueous plant extract

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
									at 50 mg/ml. This extract reduces the disease severity to 36% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss valley, Agadir [40]	L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted Chl, EA and M, sequentially	20.70 mm for EA plant extract at 10 mg/ml. 18.70 mm for M plant extract at 10 mg/ml. against *G. candidum*	5 for EA and Chl plant extracts.	>5 for EA, M and Chl plant extracts.	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vitro,* the plant Chl extract reduces completely spore germination of *G. candidum* at 10mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 55% after treatment of artificially inoculated "Mandarin" fruits (*Citrus reticulata* Blanco cv. Clementine) during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 31.82% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
10- *Anvillea radiata* (Asteraceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	35.5 ± 0.7 mm against *C. michiganensis* subsp. m*ichiganensis*	3.125	25.00	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (24.13 mg CAE/ g DW) and flavonoids (15.39 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃; extraction with	Plant powder shows complete MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, saponosids, alkaloids and tannins. These	*In vitro,* the plant aqueous extract reduces spore germination and germ tube elongation of *P. italicum* by 22.85% and 91.79%, respectively, at 10 mg/ml [23; 41]. *In vivo* test, percentage of blue mold incidence was reduced to 45% after

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			boiling DW.					molecules could be responsible for the antifungal activity [41].	treatment of artificially inoculated "Valencia-late" oranges during ten days of storage at 20 ℃ by the aqueous plant extract at 500 mg/ml. This extract reduces the disease severity to 4% and 25% by end of the 7 and 10 days storage period, respectively [23].
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	Plant powder inhibits 75.71% of MG of *G. candidum*	5 against *G. candi-dum*	ND	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC).	ND	NAD
	Souss Valley, Agadir [40]	S + L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	22.70 mm for EA plant extract at 10 mg/ml. 7.30 mm for M plant extract at 10 mg/ml. against *G. candidum*	5 for M plant extract	>5 for M and EA plant extracts	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vitro,* the plant EA extract reduces completely spore germination of *G. candidum* at 10mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 65% after treatment of artificially inoculated "Mandarin" fruits *(Citrus reticulata* Blanco cv. *Clementine)* during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 55% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet	25 ± 0.25 mm ; 28.33 ± 0.13 mm ; 16.67 ± 0.16 mm for PE, Chl and EA plant extracts, respectively. against *P. italicum*	>8 and 2 for EA, Chl and PE plant extracts respectivel y.	>8 for EA, Chl and PE plant extracts	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vivo* test, the Chl plant extract at 400 mg/ml reduces completely the blue mold incidence and severity on artificially inoculated "Valencia-late" oranges after 7 days of storage at 20 ℃ and 95% relative humidity.

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			apparatus						
11- *Lavandula stoechas* (Lamiaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	33.3±1.6 mm against *C. michiganensis* subsp. m*ichiganensis*	6.25	12.50	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (32.58 mg CAE/ g DW) and flavonoids (6.30 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 35.64% MGI of *P. italicum*	ND.	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 28.8% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
12- *Cistus crispus* (Cistaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	32 ± 0.4 mm against *C. michiganensis* subsp. m*ichiganensis*	6.25	25.25	Disc diffusion method (ABA); broth micro-dilution (MIC); culture of MIC tubes on solid medium (MBC)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (27.62 mg CAE/ g DW) and flavonoids (16.53 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 47.44% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
13- *Cistus creticus*	SMD Valley	S + L	10 g of plant	The plant	ND	ND	Incorporation in	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
(Cistaceae)	[21]		powder were added to 100 ml of melted PDA medium.	powder shows 52.46% MGI of *G. candidum*			medium agar (MGI).		
14- *Lavandula maroccana* (Lamiaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	30.4 ± 0.0 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
15- *Cotula cinerea* (Asteraceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	28.6 ± 3.2 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 43.08% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 8.44% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
16- *Ighermia pinifolia* (Asteraceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	25.9 ± 0.0 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (45.41 mg CAE/ g DW) and flavonoids (14.72 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 84.37% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, alkaloids and tannins. These molecules could be responsible for the	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
								antifungal activity [41].	
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 85.49 % MGI of *G. candidum*	2.5 against *G. candidum*	>5	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extracts (MIC and MFC).	ND	NAD
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet apparatus	15.67 ±2.08 mm ; and 10.5 ±0.87 for PE and EA plant extracts, respectively against *P. italicum*	>8 and 8 for PE and EA plant extracts, respectively	>8 for PE and EA plant extracts.	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	NAD
17- *Thymus satureioides* (Lamiaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	23.3 ± 2.4 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 11.54% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 30% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
18- *Hammada scoparia* (Chenopodiaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	22.6 ± 0.3 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium	The plant powder shows 81.79% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins,	*In vitro,* the plant aqueous extract reduces spore germination and germ tube elongation of *P. italicum* by 47.84% and 86.46%, respectively, at 10 mg/ml [23, 41].

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			at 40℃. Extraction with boiling water.					saponosids, alkaloids and tannins. These molecules could be responsible for the antifungal activity [41].	
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 80.39% MGI of *G. candidum*	>5 against *G. candi-dum*	ND	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC).	ND	*In vitro,* the plant aqueous extracts reduces 2.67% of spore germination of *G. candidum* at 5mg/ml.
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet apparatus	23 ±1 mm ; 10.83 ± 2.02 mm for Chl and EA plant extracts, respectively Against *P. italicum*	4 for EA and Chl plant extracts	8 and >8 for Chl and EA plant extracts, respectively .	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vivo* test, the Chl plant extract at 400 mg/ml reduces the blue mold incidence to 52.08% on artificially inoculated “Valencia-late” oranges after 7 days of storage at 20 ℃ and 95% relative humidity. The same extract reduces the disease severity to 19% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges.
19- *Inula viscosa* (Asteraceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	21.5 ± 2.9 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃. Extraction with boiling water.	Plant powder shows 79.74% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, saponosids and tannins. These molecules could be responsible for the antifungal activity [41].	*In vitro,* the plant aqueous extract reduces spore germination and germ tube elongation of *P. italicum* by 47.84% and 87.02%, respectively, at 10 mg/ml [23, 41]. *In vivo* test, the aqueous plant extract at 500 mg/ml reduces the blue mold incidence to 25% on artificially inoculated “Valencia-late” oranges after ten days of storage at 20 ℃. This extract reduces the disease severity to 1.81% and 18% by end of the 7 and 10 days storage period, respectively [23].

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 87.11% MGI of *G. candidum*	2.5 against *G. candidum*	>5	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extracts (MIC and MFC).	ND	*In vitro,* the plant aqueous extract reduces 52.33% of spore germination of *G. candidum* at 5mg/ml. *In vivo t*est, percentage of sour rot incidence was reduced to 58% after treatment of artificially inoculated “Mandarin” fruits during 7 days of storage at 26℃ and 95% relative humidity by the aqueous plant extract at 50mg/ml. This extract reduces the disease severity to 50% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss Valley, Agadir [40]	S + L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	7 mm for EA plant extract at 10 mg/ml. 7.16 mm for M plant extract at 10 mg/ml. against *G. candidum*	>5 for EA and M plant extracts	>5 for EA and M plant extracts	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vitro*, the plant M extract reduces 96.67% of spore germination of *G. candidum* at 20mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 55% after treatment of artificially inoculated “Mandarin” fruits *(Citrus reticulata* Blanco cv. *Clementine)* during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 52% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet	27.5 ±0.87 mm ; 21 ± 1.8 mm and 18.5 ±0.87 for PE, EA and Chl plant extracts, respectively against *P. italicum*	1 and 8 for PE, EA and Chl plant extracts, respectivel y	>8 and 8 for PE, Chl and EA plant extracts., respectively	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vivo* test, the PE plant extract at 400 mg/ml reduces the blue mold incidence to 12.5% on artificially inoculated “Valencia-late” oranges after 7 days of storage at 20 ℃ and 95% relative humidity. The same extract reduces the disease severity to 8% by the end of storage period. No

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			apparatus						visible symptoms of phytotoxicity were detected on treated oranges.
20- *Artemisia inculta* (Asteraceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	21 ± 1.3 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (21.99 mg CAE/ g DW) and flavonoids (10.31 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 44.44% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
21- *Artemisia herba-alba* (Asteraceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 68.46% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	Different regions of Morocco [36]	ND	Plant powder was subjected to steam distillation. The oil was analyzed with GC-MS. Identification of the compounds was achieved by comparing RT and MS with those of the standards	Plant EO showed 25.2% MGI of *Phyto-phthora citrophthora*at 250 ppm.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old colonies of the tested fungus.	The inhibitory effect might be due to its high levels of Camphor (46%) and α-thuyone (33.2%).	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			in the library.						
22- *Artemisia reptans* (Asteraceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 47% MGI of *P. digitatum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
23- *Ruta tuberculata* (Rutaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	20.9 ± 1 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 26.92% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 12.44% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
24- *Halimium antiatlanticum* (Cistaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	20.6 ± 0.6 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 72.82% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 95.94% MGI of *G. candidum*	0.156 against *G. candidum*	>5	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC and MFC).	ND	*In vitro,* the plant aqueous extract reduces completely spore germination of *G. candidum* at 2.5mg/ml. *In vivo* test, percentage of sour rot incidence and severity were reduced to 40 % after treatment of artificially inoculated “Mandarin” fruits during 7 days of storage at 26℃ and 95% relative humidity by the aqueous plant extract at 50 mg/ml. No visible

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
									symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss Valley, Agadir [40]	S + L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	15 mm for EA plant extract at 10 mg/ml. 16.66 mm for M plant extract at 10 mg/ml. against *G. candidum*	>5 for EA and M plant extracts	>5 for EA and M plant extracts	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	The M plant extract showed a highest amount of phenolic compounds (90 mg GAE/g extract) which may be responsible of the antifungal effect.	*In vitro,* the plant M extract reduces 96.67% of spore germination of *G. candidum* at 20 mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 30.66% after treatment of artificially inoculated "Mandarin" fruits (*Citrus reticulata* Blanco cv. Clementine) during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 23% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
25- *Halimium umbellatum* (Cistaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃. Extraction with boiling water.	The plant powder inhibits MG of *P. italicum* by 85,38%	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, alkaloids and tannins. These molecules could be responsible for the antifungal activity [41].	*In vitro,* the plant aqueous extract reduces completely the spore germination and germ tube elongation of *P. italicum* at 10 mg/ml [23, 41]. *In vivo* test, the aqueous plant extract at 500 mg/ml reduces the blue mold incidence to 5% on artificially inoculated "Valencia-late" oranges after ten days of storage at 20 ℃. This extract reduces the disease severity to 5.22% by end of the storage period. No visible symptoms of phytotoxicity were detected on treated oranges [23].
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder had completely (100 %) inhibited the MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC and MFC).	ND	*In vitro,* the plant aqueous extract reduces 30.67% of spore germination of *G. candidum* at 5mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 61.11 % after treatment of artificially inoculated "Mandarin" fruits during 7 days of

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
									storage at 26℃ and 95% relative humidity by the aqueous plant extract at 50mg/ml. This extract reduces the disease severity to 52% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss Valley, Agadir [40]	S + L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	17 mm for EA plant extract at 10 mg/ml. 22 mm for M plant extract at 10 mg/ml. against *G. candidum*	<0.156 for M plant extract	2.5 for M plant extract	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	The M plant extract showed a highest amount of phenolic compounds (139.46 mg GAE/g extract) which may be responsible of the antifungal.	*In vitro,* the plant M and EA extracts reduce completely spore germination of *G. candidum* at 2.5 and 10 mg/ml, respectively. *In vivo* test, percentage of sour rot incidence was reduced to 3.33% after treatment of artificially inoculated "Mandarin" fruits *(Citrus reticulata* Blanco cv. *Clementine)* during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 8.23% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet apparatus	12.67 ±0.29 mm for M plant extract. against *P. italicum*	2 for M plant extract.	>8 for M plant extract.	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vivo* test, the M plant extract at 400 mg/ml reduces completely the blue mold incidence and severity on artificially inoculated "Valencia-late" oranges after 7 days of storage at 20 ℃ and 95% relative humidity. No visible symptoms of phytotoxicity were detected on treated oranges.
26- *Witania adpressa* (Solanaceae)	SMD Valley, Agadir [5]	L	Extracted by DW	20.6 ± 0.8 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
27- *Thymus glandulosus*	Different regions of	Aerial parts	Plant was subjected to	Plant EO completely	ND	ND	Agar dilution method (MGI): PDA mixed	The inhibitory effect of the EO was mainly due	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
(Lamiaceae)	Morocco[30]		steam distillation. The oil was dried over anhydrous sodium sulfate, analyzed with GC-MS.	inhibits *B. cinerea* at 100 ppm. The IC_{50} was 79.2 ppm.			with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old *B. cinerea*	to the most abundant components, namely thymol (43.2%) and carvacrol (1.7%).	
28- *Thymus leptobotrys* (Lamiaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	19.6 ± 1.7 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃. Extraction with boiling water.	Plant powder shows complete MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, saponosids, alkaloids and tannins. These molecules could be responsible for the antifungal activity [41].	*In vitro,* the plant aqueous extract reduces spore germination and germ tube elongation of *P. italicum* by 73.35% and 92.77%, respectively, at 10 mg/ml [23, 41].
	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder shows complete MGI of *P. italicum, P. digitatum* and *G. candidum.*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder inhibits 27.84% of MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet	25.83 ±1.26 mm ; 12.5 ± 1.32 mm and 11.17 ±0.58 mm for PE, Chl and EA plant extracts, respectively	>8 and 2 for EA, Chl and PE plant extracts, respectively.	8 and >8 for PE, Chl and EA plant extracts, respectively.	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vivo* test, the PE plant extract at 400 mg/ml reduces completely the blue mold incidence and severity on artificially inoculated “Valencia-late” oranges after 7 days of storage at 20 ℃ and 95% relative humidity. No visible symptoms of phytotoxicity were detected on treated oranges.

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			apparatus	against *P. italicum*					
29- *Thymus pallidus* (Lamiaceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 58% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
30- *Fagonia harpago* (Zygophyllaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	18.8 ± 0.8 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder inhibits 61.03% of MG of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder inhibits 70.98% of MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
31- *Fagonia zilloïdes* (Zygophyllaceae)	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder inhibits 65.78% of MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
	SMD Valley [6]	L	Hot extraction by DW. Extraction with M.	12.7 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA	The antibacterial effect is most probably due to polyphenols (6.55 mg CAE/ g DW) and flavonoids (6.56 mg RE/ g DW) present in the M extract of plant tested.	NAD
32- *Ononis natrix* (Fabaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	18 ± 0.3 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100	Plant powder inhibits 12% of MG of *G.*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			ml of melted PDA medium.	*candidum.*					
	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 41% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
33- *Zygophyllum gaetulum* (Zygophyllaceae)	SMD Valley, Agadir [5]	S + L	Extracted by DW	17.3 ± 1.7 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 69.23% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder inhibits 68.23% of MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
34- *Cleome africana* (Capparaceae)	SMD Valley, Agadir [5]	S + L + F	Extracted by DW	16 ± 1.4 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND	NAD
35- *Ceratonia siliqua* (Fabaceae)	SMD Valley, Agadir [5]	L	Extracted by DW	15.8 ± 0.1 mm against *C. michiganensis* subsp. m*ichiganensis*	ND	ND	Disc diffusion method (ABA)	ND [5]. But the antibacterial effect is most probably due to the high levels of polyphenols (21.20 mg CAE/ g DW) and flavonoids (7.44 mg RE/ g DW) present in the M extract of plant tested [6].	NAD
	SMD Valley [23]	L	10 g of plant powder were added to 100 ml of melted PDA medium	The plant powder shows 75.64% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins,	*In vitro,* the plant aqueous extract reduces germ tube elongation of *P. italicum* by 78.40%, at 10 mg/ml [41]. In vivo test, the aqueous plant extract at 500 mg/ml reduces moderately the

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			at 40℃. Extraction with boiling water.					saponosids and tannins. These molecules could be responsible for the antifuangal activity [41].	blue mold incidence to 75% on artificially inoculated “Valencia-late” oranges after ten days of storage at 20 ℃. This extract reduces the disease severity to 17.49% and 50% by end of the 7 and 10 days storage period, respectively. No visible symptoms of phytotoxicity were detected on treated oranges [23].
	SMD Valley [21]	L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder had completely (100 %) inhibited the MG of *G. candidum*	0.3125 against *G. candidum*	> 5	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC and MFC).	ND	*In vitro,* the plant aqueous extract reduces 32.67% of spore germination of *G. candidum* at 5mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 57 % after treatment of artificially inoculated “Mandarin” fruits during 7 days of storage at 26℃ and 95% relative humidity by the aqueous plant extract at 50 mg/ml. This extract reduces the disease severity to 44% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss Valley, Agadir [40]	L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	15.70 mm for EA plant extract at 10 mg/ml. 20.67 mm for M plant extract at 10 mg/ml. against *G. candidum*	1.25 for M plant extract.	5 for M plant extract.	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	The M plant extract showed a highest amount of phenolic compounds (165.2 mg GAE/g extract) which may be responsible of the antifungal effect.	*In vitro,* the plant M extract reduces completely spore germination of *G. candidum* at 1.25mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 11.66 % after treatment of artificially inoculated “Mandarin” fruits (*Citrus reticulata* Blanco cv. Clementine) during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. This extract reduces the disease severity to 1.8% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
									concentration.
36- *Asteriscus graveolens* (Asteraceae)	SMD Valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃. Extraction with boiling water.	Plant powder inhibits 88.97% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, saponosids, alkaloids and tannins. These molecules could be responsible for the antifungal activity [41]. Another study adds that the inhibitory effect may be related to a high content of phenolic and antraquinones compounds present in plant extract [43].	*In vitro,* the plant aqueous extract reduces completely the spore germination and germ tube elongation of *P. italicum* at 10mg/ml [23, 41]. In vivo test, percentage of blue mold incidence was reduced to 60 % after treatment of artificially inoculated "Valencia-late" oranges during ten days of storage at 20 ℃ by the aqueous plant extract at 500 mg/ml. This extract reduces the disease severity to 10% and 35% by end of the 7 and 10 days storage period, respectively. No visible symptoms of phytotoxicity were detected on treated oranges [23].
	SMD Valley [21]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder inhibits 71.9% of MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
	SMD Valley [42]	S + L + F	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet apparatus	28.17 ±0..06 mm ; 24 ± 0.09 mm and 11.33 ±0.03 mm for PE, EA and Chl plant extracts, respectively against *P. italicum*	8 and 4 for Chl, PE and EA plant extracts, respectivel y.	>8 for solvent plant extracts	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	NAD
Asteriscus graveolens subsp. *odorus* (Asteraceae)	Agadir [44]	Aerial parts	The plant was subjected to hydro-distillation. The EO compounds were identified	At 500 and 125 ppm, the plant EO inhibits completely MG of *B. cinerea, P. digitatum* and *P.*	2000 ppm against *P. digitatum*	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial	The inhibitory effect of the plant EO might be due to its main constituents which are oxygenated sesquiterpenes 6-	*In vivo* trial, the plant EO tested at different concentrations on Clementine fruits (*Citrus reticulata* Blanco cv. Nules) inoculated with *P. digitatum* (10^5 conidia ml^{-1}). Spores were significantly reduced in number as

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			by, capillary GC-MS.	*expansum,* respectively, from the first day of incubation			plug from edge of 7-day-old colonies of tested fungi.	oxocyclonerolidol (30.72%) and *epi*-α-cadinol (14.50%).	compared with the control. The inhibitory effect of EO was effectively higher after 10 days of storage, at 75.83%, 77.50% and 92.50% with 500 ppm, 1000 ppm and 2000 ppm, respectively.
37- *Asteriscus imbricatus* (Asteraceae)	Agadir (Cape Ghir, Imozzer Idaoutanan, Tmanar) [8]	Aerial parts	Hot extraction with PE, EA, M and Chl using Soxhlet; aqueous extraction by maceration	The four organic and aqueous plant extracts show complete MGI of *B. cinerea* at 1000 ppm and 20000 ppm, respectively.	1000 (ppm) using organic solvents 20000 (ppm) using DW against *Botrytis cinerea*	2000 (ppm) 25000 (ppm)	Agar disc method (MGI)	ND	*In vivo* test, the aqueous and organic plant extracts (PE, Chl) have reduced the incidence of gray mold in tomato fruits by 100% at 50000 ppm and 85% at 5000 ppm, respectively.
	Cape Ghir, Agadir, [24]	Aerial parts	The plant was subjected to hydro-distillation. The EO compounds were identified by, GC-MS.	At 2000 ppm, the plant EO inhibits completely MG of *P. digitatum* and *P. expansum* and shows 97,01% of MGI against *B. cinerea.*	ND	2000 ppm against *P. digitatum* and *P. expansum*	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old *P. digitatum*, *P. expansum* and *B. cinerea*	The inhibitory effect of EO might be due to its high levels of thymol isobutyrate (18.32%), 2,5-dimethoxy-*p*-cymene (16.21%), cis-chrysanthenyl acetate (8.22%) and □-pinene (5.53%). The fungi tested are as well sensitive to the phenolic compounds, being carvacrol (0.02) and thymol (0.08%), present in minor quantities in plant EO.	*In vivo* trial, the plant EO tested at different concentrations on Clementine fruits (*Citrus reticulata* Blanco cv. Nules) inoculated with *P. digitatum* (10^5 conidia ml^{-1}). Spores were significantly reduced in number as compared with the control The inhibitory effect of EO was effectively higher after 10 days of storage, at 50%, 73,3% and 81,7% with 500 ppm, 1000 ppm and 2000 ppm, respectively.
38- *Bubonium odorum* (Asteraceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃. Extraction with	The plant powder inhibits MG of *P. italicum* by 85,64%.	ND	ND	Incorporation in medium agar (MGI)	The phytochemical screening plant tested showed that it contained flavonoids, terpenoids, coumarins, alkaloids and tannins. These molecules could	*In vitro,* the plant aqueous extract reduces completely the spore germination and germ tube elongation of *P. italicum* at 10 mg/ml [23, 41]. *In vivo* test, the aqueous plant extract at 500 mg/ml reduces moderately the blue mold incidence to 75% on

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			boiling water.					be responsible for the antifungal activity [41].	artificially inoculated “Valencia-late” oranges after ten days of storage at 20 ℃. This extract reduces the disease severity to 18% and 54.78% by end of the 7 and 10 days storage period, respectively. No visible symptoms of phytotoxicity were detected on treated oranges [23].
	SMD Valley [42]	S + L	Plant dried powder (20g) was successively extracted with PE, Chl, EA and M by using a Soxhlet apparatus	26.67 ±0.18 mm ; 23.5 ± 0.18 mm and 21.33 ±2.57 mm for PE, Chl and EA plant extracts, respectively against *P. italicum*	4 for the solvent plant extracts tested	>8 for the solvent plant extracts tested.	Disc diffusion method (MGI); agar dilution method (MIC and MFC)	ND	*In vivo* test, the PE plant extract at 400 mg/ml reduces the blue mold incidence to 19% on artificially inoculated “Valencia-late” oranges after 7 days of storage at 20 ℃ and 95% relative humidity. The same extract reduces the disease severity to 10% by the end of storage period.
39– *Pulicaria mauritanica* (Asteraceae)	Agadir (Cape Ghir, Imozzer Idaoutanan, Tmanar) [8]	Aerial parts	Hot extraction by PE and Chl using Soxhlet; aqueous extraction by maceration	Complete MGI of *B. cinerea* was observed at 2000 ppm by Chl and PE plant extracts.	2000 (ppm) using organic solvents against *B. cinerea*	2000 (ppm)	Agar discs method	ND	*In vivo,* the antifungal activities of plant aqueous and organic extracts against *B. cinerea* spores on infected tomato fruits seven days after incubation show gray mold incidence reduction by 70% at 50000 ppm and 85% at 5000 ppm, respectively.
	Errachidia area [35]	NF	Plant EO	Plant EO inhibits MG of *Alternaria* spp. and *P. expansum* by 100% and by 87,36 % for *Rhizopus stolonifer* at 2000µL/L.	2 µL/mL against *Alternaria* sp., and *P. expansum* (by PF method). 20 µL/disc and 40 µL/disc against *Alternaria* sp., *P. expansum* and	ND	The poisoned food technique (PF) and the volatile activity (VA) to determine MGI and MIC	Carvotanacetone strongly dominated the oil composition with 87.3 g/100 g. This molecule may be the responsible of the antifungal activity of the tested plant.	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
					Rhizopus stolonifer, respectively (by VA method).				
	SMD valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder inhibits *P. italicum* MG by 10,77%.	ND	ND	Incorporation in medium agar (IMG)	ND	NAD
40- *Origanum compactum* (Lamiaceae)	Different regions of Morocco[30]	Aerial parts	Plant was subjected to steam distillation. The oil was dried over anhydrous sodium sulfate, analyzed with GC-MS	Plant EO completely inhibits *B. cinerea* at 100 ppm. The IC_{50} was 35.1 ppm.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old *B. cinerea*	The inhibitory effect of the EO was mainly due to the most abundant components, namely thymol (9%) and carvacrol (58.1%).	NAD
	Ouezzanat the Moroccan north [22].	Aerial parts	Cold extraction by using methanol 80 % and DW; aqueous extraction by maceration	Extracts control the growth of *P. digitatum* with 100% of the inhibition percentage at 25g/l	ND	ND	Incorporation in medium agar (MGI): Aliquots of solution were dispensed to Petri dishes which were seeded mycelium from the edge of 7-day old *P. digitatum.*	ND	NAD
41- *Sanguisorba minor* Scop. (Rosaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 75.64% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
42- *Cistus villosus* Auct. (Cistaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted	The plant powder shows 72.31% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			PDA medium at 40℃.						
	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder inhibits completely MG of *P. italicum, P. digitatum* and *G. candidum.*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium; extraction by boiling DW	The plant powder shows 98.26% MGI of *G. candidum*	0.156 against *G. candidum*	>5	Incorporation in medium agar (MGI); agar dilution method of aqueous plant extract (MIC and MFC).	ND	*In vitro,* the plant aqueous extract reduces completely spore germination of *G. candidum* at 5mg/ml. *In vivo* test, percentage of sour rot incidence was reduced to 45 % after treatment of artificially inoculated “Mandarin” fruits during 7 days of storage at 26℃ and 95% relative humidity by the aqueous plant extract at 50 mg/ml. This extract reduces the disease severity to 32% by the end of storage period. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
	Souss Valley, Agadir [40]	S + L	Plant powder (20g) was extracted with hexane by maceration. After evaporationthe remain of the plant material was extracted EA and M, sequentially	21 mm for EA plant extract at 10 mg/ml. 24 mm for M plant extract at 10 mg/ml. against *G. candidum*	0.625 for M plant extract	2.5 for M plant extract	Well-plate diffusion method (MGI); agar dilution method (MIC and MFC)	The M plant extract showed a highest amount of phenolic compounds (136.13 mg GAE/g extract) which may be responsible of the antifungal effect.	*In vitro,* the plant M extract reduces completely spore germination of *G. candidum* at 1.25mg/ml. *In vivo* test, percentage of sour rot incidence and severity were reduced completely after treatment of artificially inoculated “Mandarin” fruits (*Citrus reticulata* Blanco cv. Clementine) during 7 days of storage at 26℃ and 95% relative humidity by the M plant extract at 50 mg/ml. No visible symptoms of phytotoxicity were detected on treated oranges at the same concentration.
43- *Teucrium antiatlanticum*	SMD Valley [23]	S + L	10 g of plant powder were	The plant powder shows	ND	ND	Incorporation in medium agar (MGI)	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
(Lamiaceae)			added to 100 ml of melted PDA medium at 40℃.	71.03% MGI of *P. italicum*					
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 61.78% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
44- *Teucrium werneri* (Lamiaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 63.33% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	Plant powder inhibits 67.55% of MG of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
45- *Limoniastrum ifniense* (Plumbaginaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 65.64% MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 15.71% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
46- *Rhus pentaphylla* (Anacardiaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 59.49 % MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	SMD Valley [21]	L + seeds	10 g of plant powder were	The plant powder shows	ND	ND	Incorporation in medium agar (MGI).	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			added to 100 ml of melted PDA medium.	14.76% MGI of *G. candidum*					
47- *Trichodesma calcaratum* (Boraginaceae)	SMD Valley [23]	S + L + F	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 57.69 % MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
48- *Ruta chalepensis* (Rutaceae)	SMD Valley [23]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium at 40℃.	The plant powder shows 50.15 % MGI of *P. italicum*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
	Different regions of Morocco [36]	ND	Plant powder was subjected to steam distillation. The oil was analyzed with GC-MS. Identification of the compounds was achieved by comparing RT and MS with those of the standards in the library.	Plant EO showed 35.5% MGI of *Phyto-phthora citrophthora*at 250 ppm.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old colonies of the tested fungus.	The inhibitory effect might be due to its high levels of p-cymene (15.1%).	NAD
49- *Peganum harmala* (Zygophyllaceae)	SMD Valley, Agadir [38]	Seeds	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows complete MGI of *P. italicum, P. digitatum* and *G. candidum.*	ND	ND	Incorporation in medium agar (MGI)	ND	NAD
50- *Mentha pulegium* (Lamiaceae)	Different regions of Morocco[30]	Aerial parts	Plant was subjected to steam	Plant EO shows inhibits 58.5% of *B. cinerea* at	ND	ND	Agar dilution method (MGI): PDA mixed with the essential	The inhibitory effect of the EO may be due to most abundant	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			distillation. The oil was dried over anhydrous sodium sulfate, analyzed with GC-MS	250 ppm. The IC_{50} was 233.5 ppm.			oils, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old *B. cinerea*	component; pulegone (85.4%).	
	Different regions of Morocco [36]	ND	Plant powder was subjected to steam distillation. The oil was analyzed with GC-MS. Identification of the compounds was achieved by comparing RT and MS with those of the standards in the library.	Plant EO showed 51.9% and 58.5% MGI of *P. digitatum* and *B. cinerea*, respectively, at 250 ppm.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old colonies of the tested fungi.	The inhibitory effect might be due to its high levels of pulegone (85.4%).	NAD
	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 59% MGI of *P. digitatum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
51- *Mentha rotundifolia* (Lamiaceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 59% MGI of *P. digitatum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
52- *Crataegus monogyna* (Rosaceae)	SMD Valley [21]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 61.96% MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
53- *Trichodesma calcarata* (Boraginaceae)	SMD Valley [21]	S + L + F	10 g of plant powder were added to 100	The plant powder shows 58.04% MGI of	ND	ND	Incorporation in medium agar (MGI).	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			ml of melted PDA medium.	*G. candidum*					
54- *Eucalyptus globulus* (Myrtaceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows complete MGI of *G. candidum* and *P. digitatum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
	Different regions of Morocco [36]	ND	Plant powder was subjected to steam distillation. The oil was analyzed with GC-MS. Identification of the compounds was achieved by comparing RT and MS with those of the standards in the library.	Plant EO showed 38.2% MGI of *Phyto-phthora citrophthora*at 250 ppm.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old colonies of the tested fungus.	The inhibitory effect might be due to its high levels of 1,8-cineole (70.6%) and α-pinene (12.9%).	NAD
55- *Juglans regia* (Juglandaceae)	SMD Valley, Agadir [38]	Bark	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows complete MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
56- *Myrtus communis* (Myrtaceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows complete MGI of *G. candidum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
57- *Arenaria rubra* (Caryophyllaceae)	SMD Valley, Agadir [38]	Whole plant	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows complete MGI of *P. digitatum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
58- *Echium horridum* (Boraginaceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were	The plant powder shows	ND	ND	Incorporation in medium agar (MGI).	ND	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			added to 100 ml of melted PDA medium.	79% MGI of *P. digitatum*					
59- *Rosmarinus officinalis* (Lamiaceae)	SMD Valley, Agadir [38]	S + L	10 g of plant powder were added to 100 ml of melted PDA medium.	The plant powder shows 56% MGI of *P. digitatum*	ND	ND	Incorporation in medium agar (MGI).	ND	NAD
	Kenitra [45]	S + L	Extracted by DW	ND	ND	ND	-	ND	*In vivo* test, the plant aqueous extract tested at 5% on tomato seeds of the variety campbell 33 inoculated with *Xanthomonas fragariae Dw.* A significant bacterial reduction (1.16 log_{10} CFU) was observed compared to control (2.43 log_{10} CFU).
60- *Chrysanthemum viscidehirtum* (Asteraceae)	Different regions of Morocco [36]	ND	Plant powder was subjected to steam distillation. The oil was analyzed with GC-MS. Identification of the compounds was achieved by comparing RT and MS with those of the standards in the library.	Plant EO showed a complete MGI of *Phyto-phthora citrophthora, P. digitatum, G. citri-aurantii* and *B. cinerea* at 150 ppm after 7 days.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old colonies of the tested fungi.	The EO effectiveness was due either to its high levels of ß-farnesene (25%), limonene (21.8%), sabinene (3.9%) and many oxygenated sesquiterpenes, or to the fact that these compounds acted synergistically.	*In vivo* trial, the plant EO tested at different concentrations on Clementine fruits (*Citrus reticulata* Blanco cv. Nules) inoculated with *Phytophthora citrophthora, P.digitatum and G. citri-aurantii* (10^5 conidia ml^{-1}). Symptoms appeared on treated fruits 7 days after treatment, while on the control fruits they appeared after only 3 days of storage. Exposure to oil volatiles at 2000 ppm reduced brown rot, green mould and sour rot incidence by more than 77% after 10 days of storage. No visible symptoms of phytotoxicity due to the oils were detected on the fruits.
61- Lippia citriodora (Verbenaceae)	Different regions of Morocco [36]	ND	Plant powder was subjected to steam distillation. The oil was analyzed with GC-MS. Identification of the compounds	Plant EO showed 68.2% and 69.3% MGI of *Phyto-phthora citrophthora* and *B. cinerea*, respectively, at 250 ppm.	ND	ND	Agar dilution method (MGI): PDA mixed with the EO, poured into petri dishes, which were then seeded with mycelial plug from edge of 7-day-old colonies of the tested fungi.	The inhibitory effect might be due to its high levels of geraniol (15.4%), spathulenol (13.1%), nerol (11.9%) and limonene (10.1%).	NAD

Scientific name of plant (Family)	Region	Used part	Extraction/ EO	ABA / AFA (MGI %)	MIC (mg/ml)	MBC / MFC (mg/ml)	Used method (s)	Bioactive component (s)	Application (s)
			was achieved by comparing RT and MS with those of the standards in the library.						
62- - *Chenopodium ambrosiodes* L (amaranthaceae)	Kenitra [45]	S + L	Extracted by DW	ND	ND	ND	-	ND	*In vivo* test, the plant aqueous extract tested at 5% on tomato seeds of the variety campbell 33 inoculated with *Xanthomonas fragariae Dw.* A significant bacterial reduction (1.49 log_{10} CFU) was observed compared to control (2.43 log_{10} CFU).

ABA: antibacterial activity; AFA: antifungal activity; B.: Botrytis; C.: Clavibacter; CAE/ g CFU: colony-forming unit; Chl: chloroform; CAE/g DW: caffeic acid equivalent per gram dry weight; DW: distilled water; EA: Ethyl acetate; EO: essential oil; F: flowers; G: Geotrichum; GAE: gallic acid equivalent; GC: gas chromatography; L: leaf; M: methanol; MBC: minimum bactericidal concentration; MFC: minimum fungicidal concentration; MGI: Mycelia growth inhibition; MIC: minimum inhibitory concentration; MS: mass spectra; ND: not determined; NAD: no application has been done; NF: not found; P: Penicillium; Ps.: Pseudomonas; PE: petroleum ether; PF : poisoned food technique; R:root; ER/ g: rutin equivalent per gram dry weight; RT: retention times; S: stem; SMD: Souss-Massa Draa; VA: volatile activity

3. CONCLUSION

Although it has been highlighted that plants could be used as potential biocontrol agents to fight phytopathogenic diseases that cause significant economic losses; very few antimicrobial studies have focused on application models in Morocco. On account of this, chemical pesticides polluting the environment remain the principal measure to treat infected crops. In this regard, further investigations are required to purify the natural bioactive metabolites responsible for the antimicrobial effect of plants and to assess their impact on wide range of diseases in the field or in warehouses in order to evaluate their cost and safety to use them for crop protection.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. El Amraoui B, El Wahidi M, Fassouane A. *In vitro* screening of antifungal activity of marine sponge extracts against five phytopathogenic fungi. Springer Plus. 2014;3(1):629-633.
2. Zahir I, Houari A, Ibnsouda S. Antibacterial effect of *Pseudomonas aeruginosa* isolated from a moroccan hot spring discharge and partial purification of its extract. Bri Biotech J. 2014;4(10):1123-1140.
3. Ameur A, Ennaji MM, Cesbron S, Manceau C, Rhallabi N, Achbani EL. Characterization of moroccan population of *Erwinia amylovora*, the causal agent of fire blight on *Rosacea*. Int J Biosci Biochem Bioinforma. 2014;4(3):200-203.
4. Parent JG, Lacroix M, Pagé D, Vézina L, Végiard S. Identification of *Erwinia carotovora* from soft rot diseased plants by random amplified polymorphic DNA (RAPD) analysis. Plant Dis. 1996;80: 494-499.
5. Talibi I, Amkraz N, Askarne L, Msanda F, Saadi B, Boudyach EH, Boubaker H, Bouizgarne B, Ait Ben Aoumar A. Antibacterial activity of Moroccan plants extracts against *Clavibacter michiganensis* subsp. *michiganensis*, the causal agent of tomatoes' bacterial canker. J Med Plant Res. 2011;5(17):4332-4338.
6. Amkraz N, Talibi I, Boubaker H, Msanda F, Saadi B, Boudyach EH, Ait Ben Aoumar A. Antioxidant activity, phenols and flavonoids contents and antibacterial activity of some Moroccan medicinal plants against tomato bacterial canker agent. Afr J Biotech. 2014;13(49):4515-4522.
7. Maejima K, Oshima K, Namba S. Exploring the phytoplasmas, plant pathogenic bacteria. J Gen Plant Pathol. 2014;80:210–221.
8. Senhaji B, Chebli B, Mayad EH, Ferji Z. Antifungal activity of medicinal plants extracts against *Botrytis cinerea* the causal agent of gray mold on tomato. J Biol Agric Healthcare. 2014;4 (26):141-147.
9. Abdolahi A, Hassani A, Ghosta Y, Bernousi I, Meshkatalsadat MH. Study on the potential use of essential oils for decay control and quality preservation of tabarzeh table grape. J Plant Prot Res. 2010;50(1):45-52.
10. Boussaber E, EL Idrissi Sidi Brahim S, Meftah Kadmiri I, Hilali L, Hilali A. Screening of actinomycete bacteria producing antifungal metabolites which could be used in biological control against a phytopathogenic fungus (*Rhizopus stolonifer*). Am J Biol Life Sciences. 2014;2(4):84-89.
11. Camele I, Altieri L, De Martino L, De Feo V, Mancini E, Gian Luigi Rana GL. *In Vitro* Control of post-harvest fruit rot fungi by some plant essential oil components. Int J Mol Sci. 2012;13:2290-2300.
12. Scholth of KB, Adkins S, Czosnek H, Palukaitis P, Jacquot E, Hohn T, Hohn B, Saunders K, Candresse T, Ahlquist P, Hemenway C, Foster GD. Top 10 plant viruses in molecular plant pathology. Mol Plant Pathol. 2011;12(9):938-54.
13. Berrada H, Farah A, FADIL M, Benbrahim KF. Anti-bacterial activity of *Coriaria myrtifolia* against *Agrobacterium tumefaciens*: Plant pathogen responsible for crown gall. Afr J Microbiol Res. 2013;7(48):5529-5532.
14. Patel MK, Kamat MN, Padhye YA. *Bacillus subtilis* causing soft rot of mango. Indian Phytopath. 1951;3(2):153-154.
15. Pérombelon MCM. Potato diseases caused by soft rot erwinias: An overview of pathogenesis. Plant Pathol. 2002;51:1-12.
16. Deljou A, Mousaviehzad M, Ghasemi A, Rahimian H. Indentification of *Mycobacterium* sp. as an alfafa root bacterial endophytes using 16S rRNA gene sequence analysis. Int J Pharm Bio Sci. 2010;1(2):1-7.

17. Ali A, Haider MS, Hanif S, Akhtar N. Assessment of the antibacterial activity of *Cuscuta pedicellata* Ledeb. Afr J Biotechnol. 2014;13(3):430-433.
18. Talibi I, Boubaker H, Boudyach EH, Ait Ben Aoumar A. Alternative methods for the control of postharvest citrus diseases. J Appl Microbiol. 2014;117:1-17.
19. Bouizgarne B. Chapter 2: Bacteria for plant growth promotion and disease management. Bacteria in Agrobiology: Disease Management. Maheshwari D.K. (Ed.). 2013;12:495. ISBN:978-3-642-33638-6.
20. Hossain MA, Ismail Z, Rahman A, Kang SC. Chemical composition and anti-fungal properties of the essential oils and crude extracts of *Orthosiphon stamineus* benth. Ind Crops Prod. 2008;27:328–334.
21. Talibi I, Askarne L, Boubaker H, Boudyach EH, Msanda F, Saadi B, Ait Ben Aoumar A. Antifungal activity of some moroccan plants against *Geotrichum candidum*, causal agent of postharvest citrus sour rot. Crop Prot. 2012;35:41-46.
22. Fadel F, Ben Hmamou D, Salghi R, Chebli B, Benali O, Zarrouk A, Ebenso EE, Chakir A, Hammouti B. Antifungal activity and anti-corrosion inhibition of *Origanum compactum* extracts. Int J Electrochem Sci. 2013;8:11019–11032.
23. Askarne L, Talibi I, Boubaker H, Boudyach EH, Msanda F, Saadi B, Serghini MA, Ait Ben Aoumar A. *In vitro* and *in vivo* antifungal activity of several Moroccan plants against *Penicillium italicum*, the causal agent of citrus blue mold. Crop Prot. 2012;40:53–58.
24. Alilou H, Akssira M, Hassani L, Chebli B, El hakmoui A, Mellouki F, Rouhi R, Boira H, Blàzquez MA. Chemical composition and antifungal activity of *Bubonium imbricatum* volatile oil. Phytopathol Mediterr. 2008;200847:3e10.
25. Valois D, Fayad K, Barasubiye T, Garon T, Dery C, Brzezinski R, Beaulieu C. Glucanolytic actinomycetes antagonistic to *Phytophthora fragariae* var. *rubi*, the causal agent of raspberry root rot. Appl Environ Microbiol. 1996;62:1630–1635.
26. Dissanayake MLMC, Jayasinghe JAN. Antifungal activity of selected medicinal plant extracts against plant pathogenic fungi; *Rhizoctonia solani*, *Colletotrichum musea* and *Fusarium oxysporum*. Int J Sci Invent Today. 2013;2(5):421-431.
27. Murphy JF, Zehnder GW, Schuster DJ, Sikora EJ, Polston JE, Kloepper JW. Plant growth-promoting rhizobacterial mediated protection in tomato against Tomato mottle virus. Plant Dis. 2000;84:779-784.
28. Elkhalfi B, Essari A, Serrano A, Soukri A. Antibacterial activity of plant methanolic extracts on a field isolate of *Pseudomonas syringae* pv tomato from the Casablanca region (Morocco). Adv Biosci Biotechnol. 2013;4:1-9.
29. Yuan B, Wang Z, Qin S, Zhao GH, Feng YJ, Wei LH, Jiang JH. Study of the antisapstain fungus activity of *Bacillus amyloliquefaciens* CGMCC5569 associated with *Ginkgo biloba* and identification of its active components. Bioresour Technol. 2012;114:536-41.
30. Chebli B, Achouri M, Idrissi Hassani LM, Hmamouchi M. Chemical composition and antifungal activity of essential oils of seven Moroccan Labiatae against *Botrytis cinerea* Pers: Fr. J. Ethnopharmacol. 2003;89:165–169.
31. Gibbons S. Anti-staphylococcal plant natural products. Nat Pr od Rep. 2004;21:263-277.
32. Abouri M, El Mousadik A, Msanda F, Boubaker H, Saadi B, Cherifi K. An ethnobotanical survey of medicinal plants used in the Tata Province, Morocco. Int J Med Plants Res. 2012;1(7):99-123.
33. Boudkhili M, Greche H, Bouhdid S, Zerargui F, Aarab L. *In vitro* antioxidant and antibacterial properties of some Moroccan Medicinal Plants. Int J Pharm Tech Res. 2012;4(2):637-642.
34. Hafsé M, Fikri Benbrahim K, Saidi A, Farah A. Volatile Components and Antibacterial Profile of Essential Oils Extracted from Leaves and Twigs of *Pistacia lentiscus* L. Br Microbiol Res J. 2013;3(4):602-611.
35. Znini M, Cristofari G, Majidi L, Desjobert JM Costa J. Essential oil composition and antifungal activity of *Pulicaria mauritanica* Coss. Against postharvest phytopathogenic fungi in apples. LWT Food Sci Technol. 2013;54:564-569.
36. Chebli B, Achouri M, Idrissi Hassani LM, Hmamouchi M. Antifungal activity of essential oils from several medicinal plants against four postharvest *Citrus* pathogens. Phytopathol Mediterr. 2003;42:251-256.
37. Halawani, E. Antibacterial activity of thymo- quinone and thymohydroquinone of *Nigella sativa* L. and their

interaction with some antibiotics. Adv Biol Res. 2009;3: 148-152.
38. Ameziane N, Boubaker H, Boudyach EH, Msanda F, Jilal A, Ait Ben Aoumar A. Antifungal activity of Moroccan plants against citrus fruit pathogens. Agron Sustain Dev. 2007;27:273-277.
39. Sisti M, De Santi M, Fraternale D, Ninfali P, Scoccianti V, Brandi G. Antifungal activity of *Rubus ulmifolius* Schott standardized *in vitro* culture. LWT Food Sci Technol. 2008;41:946-950.
40. Talibi I, Askarne L, Boubaker H, Boudyach EH, Msanda F, Saadi B, Ait Ben Aoumar A. Antifungal activity of Moroccan medicinal plants against citrus sour rot agent *Geotrichum candidum*. Lett Appl Microbiol. 2012;55:155-161.
41. Askarne L, Talibi I, Boubaker H, Boudyach EH, Msanda F, Saadi B, Serghini MA, Ait Ben Aoumar A. Phytochemical screening and *in vitro* antifungal activity of several moroccan medicinal plants against *Penicillium italicum*, the causal agent of citrus blue mold. Proc. 12th Intl. Citrus Congress. Eds.: B. Sabater-Muñoz et al. Acta Hort. 1065. ISHS. 2015. 2012;1585-1592.
42. Askarne L, Talibi I, Boubaker H, Boudyach EH, Msanda F, Saadi B, Serghini MA, Ait Ben Aoumar A. Use of moroccan medicinal plant extracts as botanical fungicide against citrus blue mould. Lett Appl Microbiol. 2012;1-7. DOI:10.1111/lam.12012.
43. Kanan GJM, Al-Najar RAWK. *In vitro* and *in vivo* activity of selected plant crude extracts and fractions against *Penicillium italicum*. J Plant Prot Research. 2009;49(4):341-352.
44. Alilou H, Asdadi A, Idrissi Hassani LM, González-Mas MC, Blázquez MA, Akssira M. Antifungal and Antioxidant Activity of *Asteriscus graveolens* subsp. *odorus* Essential Oil. J Nat Sci Res. 2014;4(10): 1-10.
45. Djassinra T, Abderahim Kribii A, Ounine K. Evaluation de l'effet protecteur des extraits aqueux de *Chenopodium ambrosioides* L et de *Rosmarinus officinalis* L vis-à-vis des plantes de tomate inoculées par la souche *Xanthomonas fragariae* Dw. Int J Innovat Sci Res. 2015;15(1):30-38.

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