Austin Journal of Plant Biology

Open Access

Austin Publishing Group

Review Article

Symptomology of the Main Fungal Diseases of the Tomato (Lycopersicon Esculentum) and Its Management

Meryama Moustaine[1]; Benkirane Rachid[1]; El Kahkahi Rahal[2*]

[1]Laboratoire des Productions Végétales, Animales et Agro-industrie, Equipe de Botanique, Biotechnologie et Protection des Plantes, Faculté des Sciences, Université-Ibn Tofail- Kénitra-Maroc, Morocco

[2]Laboratory of Plant Biotechnology and Molecular Biology, Department of Biology, Faculty of Science, University Moulay Ismail, Morocco

***Corresponding author: El Kahkahi Rahal**
Laboratory of Plant Biotechnology and Molecular Biology, Department of Biology, Faculty of Science, University Moulay Ismail, Morocco.
Email: elkahkahirahal1998@gmail.com

Received: June 07, 2023
Accepted: July 05, 2023
Published: July 12, 2023

Abstract

The tomato (*Lycopersicon esculentum*) is the second most important vegetable crop after the potato in the world. It is a hot season crop; it requires a warm and cool climate. The plant is strongly affected by unfavorable climatic conditions. The warm and cool climatic conditions offer an ideal condition for the development of many diseases of leaf plants, stems and soils. The main fungal diseases of the tomato are: Damping of seedlings, Downy mildew, Alternaria, Gray mold, Septriosis, Powdery mildew, Root and crown rot, Fusarium wilt, Verticillium wilt, Cladosporiosis, Corky root, Sclerotiniosis, Anthracnosis, Pink rot and Stemphyliosis. In our work wa have cited for each disease the main symptoms and their of control.

Keywords: *Lycopercicon esculentum;* Funal disease; Control; Climatic conditions and symptoms

Introduction

Market gardening is considered a main food resource on a global scale. The current food situation in Morocco requires better management of the improvement of the agricultural production of large consumption of tomatoes, from an agronomic point of view these crops are easy and from a commercial point of view, they are very appreciated by the Moroccan populations. In Morocco, tomato cultivation ranks second among crops for export, which gives it great economic importance for the country. It comes among vegetable crops, first occupying an overall area of 15,239 ha, which gives the country a total production of 1,231,250 tons per year [45]. The tomato plays an important socio-economic role. Economically, tomato exports occupy an important place since they bring in nearly 1.1 billion Dirhams in foreign currency. On the social level, the sector generates jobs since it creates an average of 9 million working days per year, at the level of production but also packaging and processing [7].

Worldwide, tomato ranks second after potato in both production and consumption [81]. The consumption of tomato fruits contributes to a healthy and balanced diet. Fruits are rich in minerals, vitamins, essential amino acids, sugars and dietary fiber. Tomato contains a lot of vitamins B and C, iron and phosphorus [34]. Tomatoes are eaten fresh in salads or cooked in sauces, soups or meat or poison dishes. It is possible to process them into puree, juice and ketchup [92].

Several works have been carried out to identify the procession of tomato enemies and estimate the losses caused [6, 44, 2, 33,113, 8, 56, and 70]. Diseases associated with tomato cultivation can attack different plant organs (leaves, fruits or roots) and cause considerable damage to the harvest. Fungi, viruses and pathogenic bacteria lead to a significant reduction in the quality and yield of this culture [52]. Fungal diseases are contagious diseases and can spread from plant to plant in the field, often very quickly when environmental conditions are right. Some of the most common fungal diseases that infect tomatoes include Damping off, Downy mildew, Alternaria, Gray mold, Septriosis, Powdery mildew, Root and crown rot, Fusarium wilt, Verticillium wilt, Cladosporiosis, corky root, sclerotinia, anthracnose, pink rot and stemphyliosis.

Damping off: can appear from germination, as soon as the radicle has taken some development, and continues to threaten seedlings in various stages of development for one or two months, from spring to the end of June. The dangerous period corresponds above all to the phase during which the tissues of the stem and the root are not yet lignified. Usually the first symptom of the disease is the appearance near the surface of the soil, at the junction of the stem and the root, of a black spot which extends upwards, at this level the damaged tissues and softened lose their rigidity, the seedling bends, then sags on the

Citation: Moustaine M, Rachid B, Rahal EK. Symptomology of the Main Fungal Diseases of the Tomato (Lycopersicon Esculentum) and Its Management. Austin J Plant Bio. 2023; 9(1): 1035.

ground, withers and dries up. Simultaneously, as the disease progresses downward, the roots become soft and rot. The evolution of the disease is rapid, the still very tenuous seedlings become, once dried, difficult to see: they "melt" in a way. Damping off can be caused by various fungi including *Pythium spp., Rhizoctonia spp, Fusarium spp* and *Phytophthora spp* [28,63,82].

Mildew (Late Blight): caused by Phytophthora infestans, formerly classified as a fungus (Berkeley, 1846; de Bary, 1876). This disease can devastate tomato crops during cool, rainy periods. Mildew can attack all aerial organs of the plant. It manifests as necrotic, irregular, rapidly expanding spots surrounded by a livid margin. On the stems we see brown areas that can encircle them. Marbled brown mildewed fruits, irregularly bumpy on the surface[57]. The disease develops when nights are cool and crops are wet from rain. The risks are greatest at the end of the rainy season around May-June [57].

Early blight: the fungus responsible is *Alternaria dauci f. sp. solani* or *Alternaria tomatophila.* Early blight is a widespread disease in field tomatoes and sometimes in greenhouse tomatoes grown in soil and in artificial substrates. Alternaria solani also infects potato, eggplant and nightshade family weeds [110]. In greenhouse tomatoes, this disease affects older leaves, but it is also found on stems and ripening fruits [101]. The leaf spots are round, dark brown to black, about 1cm in diameter and are easily recognized by the concentric rings or zones (zone spots) they form. Rings may not appear on lesions at the edge of the leaf. On stems, twigs and peduncles, the lesions are black, enlarge, later lengthen and sometimes encircle them. On the fruit, the lesions first appear around a stalk, wound or crack, rapidly enlarge and form black, sunken, leathery patches. If the defoliation is significant, unprotected fruits may suffer sunscald [101].

Gray mold: caused by *Botrytis cinerea*, gray mold is a common disease in tomato crops under cover [30,42]. The symptoms observable on flowers, fruits, stems, leaves, generally result in rotting of the infected tissues, followed by the appearance of a gray felting due to a significant production of spores [41,112,18]. *Botrytis cinerea* can cause significant yield losses by weakening plants and destroying them [35].

Septoria leaf spot: This disease caused by *Septoria hycopersici* [88]. This pathogen manifests itself as small spots with angular outlines, pale in the centers, bordered by a brown line. Small black dots presented by pycnidia are found on their surface. Affected leaves first curl, then dry out and fall off, leading to severely hampered vegetation [85,77]. The disease is favored by rain, which disperses the germs of the fungus. It is especially important in the rainy season [43].

Oidium: caused by *Leveillula taurica* (Arnaud) and *Oïdium neolycopersici* (*Pseudoidium neolycopersici*) [23,11,96,32,26,78, 74,66], which causes spots on leaves quite characteristic of oidium [66]. These are powdery and white and rather cover the upper side of the tomato leaflets. The affected tissues become chlorotic, brown locally and eventually become necrotic. Comparable spots can be seen on the stem[31,108,95]. The fruits do not seem to be affected [18].

Fusarium wilt (Fusarium wilt): caused by *Fusarium oxysporum f.sp. lycopersici* [104]. This fungus only attacks certain cultivars. Plants infected with this soil fungus show leaf yellowing and wilting spreading from the base of the stem [19]. Initially, symptoms are only visible on a set.

Table 1: Integrated management of the main fungal diseases of tomato.

Diseases	Prophylactic control	Chemical control	Biological control
Damping off	▪ Use certified seeds ▪ Provide optimal growth conditions (Fertilization and irrigation) ▪ Crop rotation ▪ Eliminate diseased plants [76]	▪ Soak the seeds with 0.2% copper oxychloride or 1% Bordeaux mixture. ▪ Spray seeds with 0.2% metalaxyl on cloudy days [76]	Use of *Bacillus spp*. and *Trichoderma Harzianum* KRL-AG2 [111]
Mildew	▪ Eliminate sources of inoculum ▪ Control weeds ▪ Remove and bury infected tissue ▪ Use certified and healthy seeds [107]	Spraying with 0.2% mancozeb or captafol 0.2% matalaxyl [49]	Use of plant extracts against *Phytophthora infestans* [39]
Early blight	▪ Crop rotation should be long (3 to 4 years) ▪ Use more resistant cultivars ▪ Good ventilation of the plantations ▪ Good soil drainage [50]	The use of fungicides, including azoxystrobin, maneb, potassium bicarbonate or hydrogen peroxide [50]	Use of *Trichoderma* sp against Alternatiosis of tomato [20]
Gray mold	▪ Reason fertilization ▪ Reduce plant density ▪ Eliminate crop residues ▪ Use resistant cultivars [105]	Use anti-botrytis fungicides: Benzimidazoles, Dicarboximides and triazole [55]	Spray plants with *Trichoderma Harzianum* or *Gliocladium roreum* fungus and *Clonostachys rosea Gliocladium* [91]
Septoria	▪ Destroy weeds ▪ Use of resistant cultivars ▪ Crop rotation (1 to 2 years) ▪ Good fertilization [68]	Seed treatment with Thiram or Dithane M-45 (2g/kg seed), Spraying Mancozeb 0.2% in the field [87]	Use of *Condida oleophila, Condida tenuis* and *Pseudomonas puitida* against septriosis [87]
Tomato powdery mildew	▪ Destroy infected tissue ▪ Choose resistant varieties ▪ Avoid watering at the end of the day ▪ Remove crop residues ▪ Avoid excess nitrogen [46]	Acrobat WG, Sandomyl WP and FolioGold for effective disease control [81]	Use of *Trichoderma asperellum* and *Metarhizium anisopliae* against this disease [85]
Root and crown rot	▪ Ensure balanced fertilization ▪ Crop rotation should be long (3 to 4 years) ▪ Use of more resistant cultivar [10]	Soil disinfection using fungicides, the most used of which triazole and its derivatives + Seed are soaking with carbendazim (0.1%) [55]	Use of *Pseudomonas spp. fluorescent* and non-pathogenic Fusarium against the disease [13,4]

Fusarium wilt	▪ Use resistant varieties ▪ Soil solarization ▪ Rationalize fertilization and irrigation [60]	Several fungicides are used to fight against this disease (Benomyl, Carbendazim, Prochloraz, Fludioxonil, bromuconazole and azoxystrobin [5]	Use of *Trichoderma harzianum, Streptomyces griseoviridis* K61 against Fusarium wilt [111]
Verticilliose	▪ Long rotations (4 years) ▪ Weed removal ▪ Use of healthy transplants ▪ Ensure adequate fertilization [14]	▪ Spot soaking with Carbendazim (0.1%) or Benomyl (0.05%) ▪ Soil fumigation with methyl bromide plus chloropicrin [54]	Use of *Trichoderma asperellum*, *Trichoderma virens, Trichoderma harzianum, Trichoderma atroviride* against verticillium wilt [29,40]
Cladosporiosis	▪ Remove plant debris ▪ Use resistant varieties ▪ Ventilate shelters ▪ Crop rotation [18]	Use of fungicides: Chlorothalonil, Mancozeb and Copper fungicide [18]	Use of *Trichoderma harzianum, Hansfordia pulvinata* and *Bacillus subtilis* strains against *Passalora fulva* [16]
Corky root	▪ Avoid successions favorable to maintaining the inoculum (Lettuce-Tomato) ▪ Use resistant varieties [48]	Use of fungicides: Acibenzolar-S-methyl, Strobilurins, Azoxystrobin and Trifloxystrobin against this disease [22]	Use of *Trichoderma harzianum* and *Streptomyces griseoviridis* K61 against corky root [111]
Sclerotiniosis	▪ Prefer well-drained and aerated soils ▪ Rotate crops (3 to 5 years) ▪ Effective weed control ▪ Reduce plant foliage density [86]	▪ Use copper-based fungicides (Cuprex garden, Bordeaux mixture Naturen) ▪ Carbendazim is a fungicide widely used to control disease [116]	Use of *Bacillus subtilis* and *Bacillus spp.* against *Sclerotinia* [51, 83, 93,109]
Anthracnose	▪ Use certified healthy seeds ▪ Encourage rotation (3 to 5 years) ▪ Effective weed control ▪ Deep plowing after harvest helps bury crop residues and promote their decomposition [3]	Benzimidazoles, Strobilurins, Dicarboximides and Demethylation are fungicides used against the disease [113]	Use of *Streptomyces sp.*A1022, *Streptomyces spp*., *Bacillus spp*. against anthracnose [71, 93, 24]
Pink rot		Azoxystrobin, Dimethomorph, Tebuconazole and Triflumizole are fungicides used against the disease [113]	Use of extracts from the leaves of Ajuga bracteosa, *Taraxacum officinale*, Mentha arvensis and Iris kashmiriana Against this disease [75]
Stemphyliosis	▪ Destroys plant debris ▪ Use resistant varieties ▪ Long spin	Flusilazole, flusilazole famoxadone and mancozeb are very effective against the disease [117]	Use of extracts of fifty plants to fight Stemphyliosis [9]

References

1. Abdeljalil NQB, Vallance J, Gerbore J, Rey P, MD Remadi. Biosuppression of Sclerotinia Stem Rot of Tomato and Biostimulation of Plant Growth Using Tomato associated rhizobacteria. J Plant Pathol Microbiol. 2016; 7: 331.
2. Adejumo TO, Hettwer U, Karlovsky P. Occurrence of Fusarium species and trichothecenes in Nigerian maize. Int J Food Microbiol. 2007; 116: 350-7.
3. Agrios GN. Plant pathology. St. Louis: Academic Press. 2005.
4. Alabouvette C, Olivain C, Steinberg C. Biological control of plat diseases: the European situation. Eur J Plant Pathol. 2006; 114: 329-41.
5. Amini J, Sidovich DF. The effects of fungicides on Fusarium oxysporum f. sp. lycopersici associated with fusqrium wilt of tomato. J Plant Prot Res. 2010; 50: 172-3.
6. Ariño A, Juan T, Estopañan G, González-Cabo JF. Natural occurrence of Fusarium species, fumonisin production by toxigenic strains and concentration of fumonisins B1, and B2 in conventional and organic maize grown in Spain. J Food Prot. 2007; 70: 151-6.
7. Anonyme. situation de l'agriculture marocaine - n°10. Novembre 2012.
8. Babadoost M. Powdery mildew of tomato. Report on plant disease. Univ. of Illinois, RPD. 2014; 974: 2.
9. Balkan B, Balkan S, Aydoğdu H, Güler N, Ersoy H, et al. Evaluation of antioxidant activities and antifungal activity of different plants species against pink mold rot-causing trichothecium roseum. Arab J Sci Eng. 2017; 42: 2279-89.
10. Barna B, Sarhan ART, Kiraly Z. The influence of nitro gennutrition on the sensitivity of tomato plants to culture filtrates of Fusarium and to fusaric acid. Physiol Plant Pathol. 1983; 23: 257263.
11. Bélanger RR, Jarvis WR. Occurrence of powdery mildew (Erysiphe sp.) on greenhouse tomatoes in Canada. Plant Dis. 1994; 78: 640.
12. Dal Bello GD. First report of trichothecium roseum causing postharvest fruit rot of tomato in Argentina. Australas Plant Dis Notes. 2008; 3: 103-4.
13. Benchabane M. Caractérisation des effest d'antagonisme microbienne et de promotion de croissance végétale de souche de Pseudomonas spp. fluorescents [thèse du doctorat d'état]. FSB. UTHB, Alger, page. 2005; 235.
14. Besri M. Effect of salinity on the development of tomato Verticillium wilt in Morocco. In: Proceedings of the "Fifth International Verticillium Symposium. Leningrad. 1990; 61.
15. Berkeley MJ. Observations, botanical and physiological on the potato murain. J Hortic Soc Lond. 1846; 1: 9-34.
16. Blancard D. Les maladies de la tomate, Edition INRA, Paris. 2015; 23.

17. Blancard D. Tomato diseases: identification, biology and control: a colour handbook. CRC Press; 2012.

18. Blancard D, Laterrot H, Marchoux G, Candresse T. Les maladies de la tomate. (Eds) Quae. France: Vairaille. 2009; 690.

19. Blancard D. Les maladies de la tomate. [Edition INRA, Paris, 212 p]; 1997.

20. Boutoumou H, Boumaza M, 2016. Etude de l'activité de Trichoderma sp. contre l'alternariose de la tomate, Mémoire de Master, Faculté des Science de la Nature et de la Vie, Algérie.

21. Butler EJ, Jones SG. Tomato leaf mould, Cladosporium fulvum Cooke. London: Macmillan. 1949.

22. Bubici G, Amenduni M, Colella C, D'Amico M, Cirulli M. Efficacy of acibenzolar-s-methyl and two strobilurins, azoxystrobin and trifloxystrobin, for the control of corky root of tomato and Verticillium wilt of eggplant. Crop Prot. 2006; 25: 814-20.

23. Burgerjon A, Nicot PC, Bertrand F, Blancard D. Early powdery mildew of greenhouse-grown tomatoes in France [abstr]. Phytopathology. 1990; 80: 1063.

24. Bressan W. Biological control of maize seed pathogenic fungi by use of actinomycetes. Bio Control. 2003; 48: 233-40.

25. Braun U, Crous PW, Dugan F, Groenewald JZ, de Hoog GS. Phylogeny and taxonomy of Cladosporium-like Hyphomycetes, including Davidiella gen. nov., the teleomorph of Cladosporium s. str. Mycol. Progr. 2003; 2: 3-18.

26. Braun U. A monograph of the Erysiphales (powdery mildews). Nova Hedwigia Beih. 1987; 89; 700.

27. Byrne JM, Hausbeck MK, Hammerschmidt R. Conidial germination and appressorium formation of Colletotrichum coccodes on tomato foliage. Plant Dis. 1997; 81: 715-8.

28. Carisse O, Bernier J, Benhamou N. Selection of biological agents from composts for control of damping-off of cucumber caused by Pythium ultimum. Can J Plant Pathol. 2003; 25: 258-67.

29. Carron IC, Trapero-Casas JL, Olivares-Garcia C, Monte E, Hermosa R, et al. Trichoderma asperellum is effective for biocontrol of Verticillium wilt in olive caused by the defoliating pathotype of Verticillium dahliae. 2016; 88: 45-52.

30. Coertze S, Holz G. Epidemiology of Botrytis cinerea on grape: wound infection by dry, airborne conidia. S Afr J Enol Vitic. 2002; 23: 72-7.

31. Correll JC, Gordon TR, Elliott VJ. Host Range, Specificity, and Biometrical measurements of Leveillula taurica in California. Plant Dis. 1987; 71: 248-51.

32. Correll JC, Gordon TR, Elliott VJ. Powdery mildew of tomato: the effect of planting date and triadimefon on disease onset, progress, incidence, and severity. Phytopathology. 1988; 78: 512-9.

33. Crous PW, Braun U. Mycosphaerella and its anamorphs: 1. Names published in Cercospora and Passalora. Utrecht: Centraalbureau voor Schimmelcultures. 2003; 453.

34. Davies JN, Hobson GE, McGlasson WB. The constituents of tomato fruit: the influence of environment, nutrition, and genotype. Crit Rev Food Sci Nutr. 1981; 15: 205-80.

35. Dean R, Van Kan JA, Pretorius ZA, Hammond-Kosack KE, Di Pietro A, et al. The Top 10 fungal pathogens in molecular plant pathology. Mol Plant Pathol. 2012; 13: 414-30.

36. DeBary A. Researches into the nature of the potato-fungus – Phytophthora infestans. J R Agric Society. 1876; 12: 239-68.

37. Dillard H. Colletotrichum coccodes: the pathogen and its hosts. In: Bailey J, Jeger M, editors. Colletotrichum: Biology, Pathology and Control. Wallingford, UK: CA B International. 1992; 225-36.

38. Dillard HR. Effect of temperature, wetness duration, and inoculums density on infection and lesion development of Colletotrichum coccodes on tomato fruit. Phytopathology. 1989; 79: 1063-6.

39. Djeugap JF, Fontem DA, Tapondjou AL. Efficacité in vitro et in vivo des extraits de plantes contre le mildiou (Phytophthora infestans) de la morelle noire. Int J Biol Chem Sci. 2011; 5: 2205-13.

40. Druzhinina IS, Seidl-Seiboth VS, Herrera-Estrella A, Horwitz BA, Kenerley CM, Monte E et al. Trichoderma: the genomics of opportunistic success. Nat Rev Microbiol. 2011; 9: 749-59.

41. Elad Y, Yunis H, Katan T. Multiple fungicide resistance to benzimidazoles, dicarboximides and diethofencarb in field isolates of Botrytis cinerea in Israel. Plant Pathology. 1992; 41: 41-6.

42. Elmer PA, Michailides TJ. Epidemiology of Botrytis cinerea in orchard and vine crops. In Botrytis: Biology, pathology and control. Berlin, Heidelberg, Germany: Springer. 2007; 243-72.

43. Elmer WH, Ferrandino FJ. Influence of spore density, leaf age, temperature, and dew periods on Septoria leaf spot of tomato. Plant Dis. 1995; 79: 287-90.

44. Fandohan P, Gnonlonfin B, Hell K, Marasas WF, Wingfield MJ. Natural occurrence of Fusarium and subsequent fumonisin contamination in preharvest and stored maize in Benin, West Africa. Int J Food Microbiol. 2005; 99: 173-83.

45. STAT FAO; 2019 - http:. Available from: faostat3.fao.org.

46. Muller F. Maladie du blanc de Tomate. Fiche Tech Synthèse. 2015; 1-2. MAPAQ Ste-Martine.

47. Fernando WG, Nakkeeran S, Zhang Y. Ecofriendly methods in combating Sclerotinia sclerotiorum (Lib.) de Bary. Recent res. Devel. J Environ Biol. 2004; 81: 7736-217.

48. Fiume F, Fiume G. Use of culture filtrates of Pyrenochaeta lycopersici in tests for selecting tolerant varieties of tomato. J Plant Pathol. 2003; 85: 131-3.

49. Fontem DA, Olanya OM, Tsopmbeng GR, Owona MAP. Pathogenicity and metalaxyl sensitivity of Phytophthora infestans isolates obtained from garden huckleberry, potato and tomato in Cameroon. Crop Prot. 2005; 24: 449-56.

50. Fry WE. The canon of potatp science: 10. Potato Res. 2007; 50: 243-5.

51. Gao X, Han Q, Chen Y, Qin Huqiang, Huang L, Kang Z. Biological control of oilseed rape Sclerotinia stem rot by Bacillus subtilis strain Em7. Biocontrol Sci Technol. 2014; 24: 39-52.

52. Gartemann KH, Kirchner O, Engemann J, Gräfen I, Eichenlaub R, et al. Clavibacter michiganensis subsp. michiganensis: first steps in the understanding of virulence of a Gram-positive phytopathogenic bacterium. J Biotechnol. 2003; 106: 179-91.

53. Grove GG, Campbell RN. Host Range and Survival in Soil of Pyrenochaeta lycopersici. Plant Dis. 1987; 71: 806-9.

54. Gullino ML, Minuto A, Gilardi G, Garibaldi A, Ajwa H, et al. Efficacy of preplant soil fumigation with chloropicrin for tomato production in Italy. Crop Prot. 2002; 21: 741-9.

55. Hamoir J, Goret M, Mignon B, Gustin P. Actualité sur les antifongiques enregistrés en Belgique dans le cadre du traitement des dermatophytoses. Ann. Med Vet. 2001; 145: 226-32.

56. HAO JJ, SUBBARAO KV, DUNIWAY JM. Germination of Sclerotinia minor and S. sclerotiorum under various soil moisture and temperature combinations. Epidemiology. 2003; 93: 443-50.

57. Hu CH, Perez FG, Donahoo R, McLeod A, Myers K, et al. Recent genotypes of Phytophthora infestans in eastern USA reveal clonal populations and reappearance of mefenoxam sensitivity. Plant Dis. 2012; 96: 1323-30.

58. Huang CJ, Tsai WS. Occurrence and identification of Stemphylium lycopersici causing Stemphylium leaf spot disease on tomato in Taiwan. Eur J Plant Pathol. 2017; 148: 35-44.

59. Inácio CA, Pereira-Carvalho RC, Morgado FGA, Fonseca MEN, Boiteux LS. A tomato fruit rot caused by trichothecium roseum in Brazil. Plant Dis. 2011; 95: 1318.

60. Islam Z. Control of rice insect pests. In: Atkinson AD, editor. International rice research institute, Phillipines. 2001; 4-20.

61. Jacob D, David DR, Sztjenberd A, Elad Y. Conditions for Development of Powdery Mildew of Tomato Caused by Oidium neolycopersici, Ecology and Epidemiology. 2008; 98N° 3: 270-81.

62. Janda-Ulfig K, Ulfig K, Markowska A. Further studies of extracellular enzyme profiles of Xerophilic fungi isolated from dried medicinal plants. Pol J Environ Stud. 2009; 18: 627-33.

63. Jeyaseelan EC, Tharmila S, Niranjan K. Antagonistic activity of Trichoderma spp and Bacillus spp against Pythium aphanidermatum isolated from tomato damping off. Arch Appl Sci Res. 2012; 4: 1623-7.

64. Johansson A, Staal J, Dixelius C. Early responses in the Arabidopsis-Verticillium longisporum pathosystem are dependent on NDR1, JA- and ET-associated signals via cytosolic NPR1 and RFO1. Mol Plant Microbe Interact. 2006; 19: 958-69.

65. Jones JB, Jones JP, Stall RE, Zitter TA. Compendium of tomato diseases and pests. APS Publishing; 2014.

66. Jones HJ, Whipps JM, Gurr SJ. The tomato powdery mildew fungus oidium neolycopersici. Mol Plant Pathol. 2001; 2: 303-9.

67. Jones JB, Jones JP, Stall RE, Zitter TA. Compendium of tomato diseases. St. Paul, MN: APS Publishing; 1997.

68. Karen D, Walt S. Tomato disorders:early blight and Septoria leaf spot; 2004.

69. Katan T, Shlevin E, Katan J. Sporulation of Fusarium oxysporum f. sp. lycopersici on stem surfaces of tomato plants and aerial dissemination of inoculums. Phytopathology. 1997; 87: 712-9.

70. Kenneth WS. Late blight of tomato. Plant pathology fact sheet, University of Kentucky, PPFS-VG-13; 2011.

71. Kim HJ, Lee EJ, Park SH, Lee HS, Chung N. Biological Control of Anthracnose (Colletotrichum gloeosporioides) in Pepper and Cherry Tomato by Streptomyces sp. A1022. J Agric Sci. 2014; 6: 54-62.

72. Kim JT, Park IH, Ryu KY, Cheon JU, Yu SH. Corky root of tomato caused by Pyrenochaeta lycopersici in Korea. Plant Pathol J. 2003; 19: 181-3.

73. Kim JT, Park IH, Lee HB, Hahm YI, Yu SH. Identification of Verticillium dahliae and Verticillium albo-atrum causing wilt of tomato in Korea. Plant Pathol J. 2001; 17: 222-6.

74. Kiss L, Cook RTA, Saenz GS, Cunnington JH, Takamatsu S, et al. Identification of two powdery mildew, Oidium neolycopersici sp. nov. and Oidium lycopersici, infecting tomato in different parts of the world. Mycol Res. 2001; 105: 684-97.

75. Koka JA, Wani AH, Bhat MY, Parveen S, Fazili MA, et al. Antifungal activity of selected plant extracts against trichothecium roseum (Pers.) Link (1809) (Sordariomycetes: Hypocreales), causal organism of fungal rot of Solanum melongena L. (Solanales: Solanaceae) in Kashmir, India. Braz J Biol Sci. 2019; 6: 123-32.

76. Kumar SP, Srinivasulu A, Babu KR. Symptomology of major fungal Diseae and its management. J Pharmacogn Phytochem. 2018; 7: 1817-21.

77. Kumar S, Sugha SK. Over seasoning of Septoria lycopersici and incitant of leaf spot disease in tomato. J Mycol Plant Pathol. 1999; 29: 83-6.

78. Lamondia JA, Smith VL, Douglas SM. Plant Dis. Host range of Oidium lycopersici on selected Solanaceous species in Connecticut. 1998; 83: 341-4.

79. Laterrot H, Rouxel F, Davet P, Mineau R, Nourrisseau JG, Jonan B. La fusariose vasculaire de la tomate en France. Rev PHM. Horticol. 1978; 137: 35-40.

80. LeBoeuf J. Identifying the species causing anthracnose of pepper and tomato in Southern Ontario. OMAFRA; 2007. Available from: http://www.omafra.gov.on.ca/crops/html.

81. Lemoines G. Guide des légumes du monde, les légumes de nos régions, les variétés exotiques. Ed. Delachaux et Niestlé. Paris. 1999; 184.

82. Lin H, Chumpookam J, Shiesh C, Chung W. Smoke-water controls Pythium damping-off in papaya seedling. Hortic Sci. 2012; 47: 1453-6.

83. Liu B, Qiao HP, Huang LL, Buchenauer H, Han QM, et al. Biological control of take-all in wheat by endophytic Bacillus subtilis E1R-j and potential mode of action. Biol Control. 2009; 49: 277-85.

84. Lopes CA, Reis A, Boiteux LS. Doenças fúngicas. In: LOPES CA, ÁVILA AC, editors. Doenças do tomateiro. Brasília: Embrapa Hortaliças. 2005; 17-51.

85. Lopez CG, Castellanos LNM, Ortiz NAF, Gonzalez JAG. Control of powdery mildew (Leveillula taurica) using Trichoderma asperellum and Metarhizium anisopliae in different pepper types. Bio Control. 2019; 64: 77-89.

86. Guihua L. Engineering Sclerotinia sclerotiorum resistance in oilseed crops. Afr J Biotechnol. 2003; 2: 509-16.

87. Blum LEB. Reduction of incidence and severity of Septoria lycopersici leaf spot of tomato with bacteria and yeasts. Cien Rural. 2000; 30:761-5.

88. MacNeill BH. Studies in Septoria lycopersici Speg. Can J Res. 1950; 28c: 645-72.

89. Mansoori B, Smith CJ. Elicitation of ethylene by Verticillium alboatrum phytotoxins in tomato. J Phytopathol. 2005; 153: 143-9.

90. Messiaen CM. Les variétés résistantes. Méthodes de lutte contre les maladies et ennemies des plantes. Edition INRA. Paris. 374. 1981.

91. Mouekouba LDO, Zhang ZZ, Olajide EK, Wand AJ, Wang AX. Biological control of Botrytis cinerea in Tomato Leaves. International Conference on Agriculture and Biotechnology IPCBEE. 2013; 60.

92. Naika S, Van Dam B, Florinj A. La culture de la tomate: production, transformation et commercialisation, cinquième édition révisée, Agromisa Foundation, Coll. ”Agrodok”,. Wageningen. 2005; 105.

93. Ongena M, Jacques P. Bacillus lipopeptides: versatile weapons for plant disease biocontrol. Trends Microbiol. 2008; 16: 115-25.

94. Ongena M, Duby F, Jourdan E, Beaudry T, Jadin V, et al. Bacillus subtilis M4 decreases plant susceptibility towards fungal pathogens by increasing host resistance associated with differential gene expression. Appl Microbiol Biotechnol. 2005; 67: 692-8.

95. Palti J. The Leveillula mildews. Bot Rev. 1988; 54: 423-535.

96. Paulus AO, Correll JC. Powdery mildew. In: Jones JB, Jones JP, Stall RE, Zitter TA, editors. Compendium of Tomato Diseases, Australian Psychological Society Press. 1991; 19.

97. Pegg GF, Brady BL. Verticillium Wilts. New York: CABI Publishing; 2002.

98. Puia CE, Popovici EJ, Viorel F. The evolution of the fitosanitary status of the stored apples in natural conditions. J Cent Eur Agric. 2003; 4.

99. Sanogo S, Pennypacker SP, Stevenson RE, MacNab AA. Weather variables associated with infection of tomato fruit by Colletotrichum coccodes. Plant Dis. 1997; 81: 753-6.

100. Schneider R, Gerlach W. Pyrenochaeta lycopersici. CMI Description of Pathogenic Fungi and Bacteria. 1973; 398.

101. Shankar J, Singh BP, Gaur SN, Arora N. Recombinant glutathione-S-transferase a major allergen from Alternaria alternata for clinical use in allergy patients. Mol Immunol. 2006; 43: 1927-32.

102. Shamsi S, Sultana R. Trichothecium roseum link—a new record of hyphomycetous fungus for Bangladesh. Bangladesh J Plant Taxon. 2008; 15: 77-80.

103. Snissi A, Ezzouhri B, Rossi D, Lairini K. Contrôle biologique de la fusariose de la tomate causée par le Fusarium oxysporum f. sp. lycopersici et Fusarium oxysporum f. sp. radicis-lycopersici. Biochimie, Substances Naturelles et Environnement. 2006; 352-356.

104. Snyder WC, Hansen HN. The species concept in Fusarium with reference to Discolor and other Sections. Am J Bot. 1945; 32: 657-66.

105. Smahi A. Controle biologique de la fusariose vasculaire de la Tomate causée par Fusarium oxysporum f.sp.licopersici. Thèse de Magister. Université d'Oran. Algérie. 2008.

106. Smith SN, Snyder WC. Relationship of inoculum density and soil types to severity of Fusarium wilt of sweet potato. Phytopathology. 1971; 62: 273-7.

107. Stevenson WR. Management of early blight and late blight. In: Rowe RC, editor. Potato health management. St. Paul, MN: American Phytopathological Society Press. 1993; 141-7.

108. Thomson SV, Jones WB. An epiphytotic of Leveillula taurica on tomatoes in Utah. Plant Dis. 1981; 65: 518-9.

109. Tjalsma H, Antelmann H, Jongbloed JD, Braun PG, Darmon E, et al. Proteomics of protein secretion by Bacillus subtilis: separating the ”secrets” of the secretome. Microbiol Mol Biol Rev. 2004; 68: 207-33.

110. Vieira BS. Alternaria euphorbiicola comomico herbicida para leiteiro (Euphorbia heterophylla). produçãomassal e integração com herbicidasquímicos [tese] de Doutorado. Viçosa, MG: Universidade Federal de Viçosa; 2004.

111. Whipps JM. Microbial interactions and biocontrol in the rhizosphere. J Exp Bot. 2001; 52: 487-511.

112. Williamson B, Tudzynski B, Tudzynski P, van Kan JA. Botrytis cinerea: the cause of grey mould disease. Mol Plant Pathol. 2007; 8: 561-80.

113. Young JR, Tomaso-Peterson M, Tredway LP, de la Cerda K. Occurrence and molecular identification of azoxystrobin-resistant Colletotrichum cereale isolates from golf course putting greens in the Southern United States. Plant Dis. 2010; 94: 751-7.

114. Yonghao L. Anthracnose of tomato. New Haven, (CT): The Connecticut Agricultural Experiment Station; 2013.

115. Yun YH, Son SY, Choi CW, Hong JK, Kim YS, Kim SH. The occurrence of pink mold rot fungus trichothecium roseum on tomatoes in Korea. Afr J Microbiol Res. 2013; 7: 1128-35.

116. Zhang XL, Sun XM, Zhang GF. Preliminary report on the monitoring of the resistance of Sclerotinia libertinia to carbendazim and its internal management. Pestic Sci Admin. 2003; 24: 18-22.

117. Zheng L, Lv Rujing, Huang Junbin, Jiang D, Liu X, et al. Integrated control of garlic leaf blight caused by Stemphylium solani in China. Can J Plant Pathol. 2010; 32: 135-45.