

Review Article

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

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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].

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 we have cited for each disease the main symptoms and their of control.

Keywords: *Lycopersicon esculentum*; Fungal disease; Control; Climatic conditions and symptoms

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

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 defolia-

tion 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 lycopersici* [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 *Oidium neolyopersici* (*Pseudoidium neolyopersici*) [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	<ul style="list-style-type: none"> Use certified seeds Provide optimal growth conditions (Fertilization and irrigation) Crop rotation Eliminate diseased plants [76] 	<ul style="list-style-type: none"> Soak the seeds with 0.2% copper oxychloride or 1% Bordeaux mixture. Spray seeds with 0.2% metalaxyl on cloudy days [76] 	Use of <i>Bacillus spp.</i> and <i>Trichoderma Harzianum</i> KRL-AG2 [111]
Mildew	<ul style="list-style-type: none"> 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% metalaxyl [49]	Use of plant extracts against <i>Phytophthora infestans</i> [39]
Early blight	<ul style="list-style-type: none"> 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 <i>Trichoderma</i> sp against Alternation of tomato [20]
Gray mold	<ul style="list-style-type: none"> Reason fertilization Reduce plant density Eliminate crop residues Use resistant cultivars [105] 	Use anti-botrytis fungicides: Benzimidazoles, Dicarboximides and triazole [55]	Spray plants with <i>Trichoderma Harzianum</i> or <i>Gliocladium roreum</i> fungus and <i>Clonostachys rosea Gliocladium</i> [91]
Septoria	<ul style="list-style-type: none"> 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 <i>Conidia oleophila</i> , <i>Conidia tenuis</i> and <i>Pseudomonas puitida</i> against septriosis [87]
Tomato powdery mildew	<ul style="list-style-type: none"> 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 <i>Trichoderma asperellum</i> and <i>Metarhizium anisopliae</i> against this disease [85]
Root and crown rot	<ul style="list-style-type: none"> 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 <i>Pseudomonas spp. fluorescent</i> and non-pathogenic <i>Fusarium</i> against the disease [13,4]

Fusarium wilt	<ul style="list-style-type: none"> 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 <i>Trichoderma harzianum</i> , <i>Streptomyces griseoviridis</i> K61 against Fusarium wilt [111]
Verticilliose	<ul style="list-style-type: none"> Long rotations (4 years) Weed removal Use of healthy transplants Ensure adequate fertilization [14] 	<ul style="list-style-type: none"> Spot soaking with Carbendazim (0.1%) or Benomyl (0.05%) Soil fumigation with methyl bromide plus chloropicrin [54] 	Use of <i>Trichoderma asperellum</i> , <i>Trichoderma virens</i> , <i>Trichoderma harzianum</i> , <i>Trichoderma atroviride</i> against verticillium wilt [29,40]
Cladosporiosis	<ul style="list-style-type: none"> Remove plant debris Use resistant varieties Ventilate shelters Crop rotation [18] 	Use of fungicides: Chlorothalonil, Mancozeb and Copper fungicide [18]	Use of <i>Trichoderma harzianum</i> , <i>Hansfordia pulvinata</i> and <i>Bacillus subtilis</i> strains against <i>Passalora fulva</i> [16]
Corky root	<ul style="list-style-type: none"> 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 <i>Trichoderma harzianum</i> and <i>Streptomyces griseoviridis</i> K61 against corky root [111]
Sclerotiniosis	<ul style="list-style-type: none"> Prefer well-drained and aerated soils Rotate crops (3 to 5 years) Effective weed control Reduce plant foliage density [86] 	<ul style="list-style-type: none"> Use copper-based fungicides (Cuprex garden, Bordeaux mixture Naturen) Carbendazim is a fungicide widely used to control disease [116] 	Use of <i>Bacillus subtilis</i> and <i>Bacillus spp.</i> against <i>Sclerotinia</i> [51, 83, 93,109]
Anthracoze	<ul style="list-style-type: none"> 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 <i>Streptomyces sp.</i> A1022, <i>Streptomyces spp.</i> , <i>Bacillus spp.</i> 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 <i>Ajuga bracteosa</i> , <i>Taraxacum officinale</i> , <i>Mentha arvensis</i> and <i>Iris kashmiriana</i> Against this disease [75]
Stemphyliosis	<ul style="list-style-type: none"> 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]

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