Journal of Global Agriculture and Ecology

11(4): 55-60, 2021
ISSN: 2454-4205

TECHNICAL DOCUMENT ON RUST OF *Mentha* Spp.

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AUTHORS' CONTRIBUTIONS
This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Received: 20 August 2021
Accepted: 20 September 2021
Published: 25 September 2021

Review Article

ABSTRACT

Mint plants (*Mentha* spp.) which belong to the family: *Lamiaceae* is one of the common vegetable crops which planted in different countries around the world. It's an important food source in addition to its medicinal and industrial uses. It was infected by many fungal diseases including rust disease which caused by the obligate parasite fungus *Puccinia menthae* which belongs to the class Pucciniomycetes and the phylum Basidiomycota. Mint rust disease symptoms were easily observed on the mint leaves represented by appearing small dusty bright orange, yellow or brown pustules and the leaves may die and drop from the infected plant. This disease is often a serious yield-reducing problem. Mint rust disease can be controlled by applying many agricultural methods and breaking the life cycle of the pathogen and by using different fungicides and resistant varieties. All methods achieved a significant controlling of the disease and reduced the disease severity with different degrees. In this technical document, we summarize the current knowledge of mint rust disease epidemiology symptoms and signs, disease cycle, ecology and disease management.

Keywords: Disease cycle; disease management; *Mentha* spp.; *Puccinia menthae*; rust.

1. IMPORTANCE

Mint plants (*Mentha* spp.) is an important genus in the family *Lamiaceae* which named mint family [1]. It's a sub cosmopolitan perennial crop which widely distributes in many different environments especially wet environment and moist soils across Asia, Africa, Europe, Australia and America [2,3]. All mints can well grow near rivers, lakes, pools and shade areas [4].

Mint can be infected with different fungal diseases like rust, anthracnose, powdery mildew, downy mildew, leaf blight, leaf spot and verticillium wilt, among them, rust disease is considered as a serious and important specific fungal disease which significantly effects on the plant and reduces the yield quality and quantity. Rust disease caused by the obligate parasite fungus *Puccinia menthae* and considered as a common disease of the mints and distributes throughout the world [5-8].

The host range is extensive, with hosts in 20 genera being listed (species of *Blephilia*, *Bystropogon*, *Calamintha*, *Clinopodium*, *Cunila*, *Hedeoma*, *Hyssopus*, *Lycopus*, *Melissa*, *Mentha*, *Micromeria*, *Monarda*, *Monardella*, *Nepeta*, *Ocimum*, *Origanum*, *Pycnanthemum*, *Satureja*, *Thymus* and *Ziziphora*) [9].

Mint rust was first reported from Europe in 1801. *P. menthae* was first found in Australia in 1884 on an indigenous mint, *Mentha laxiflora* Benth., and then in

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1904 on introduced pennyroyal, *M. pulegium* L., growing in Victoria [10], but the rust was not reported again until 1967 when it was recorded on commercially-grown spearmint, *M. spicata* L., near Sydney, New South Wales. This rust was found on commercial peppermint plantings in Oregon in 1948. The disease is now distributed widely throughout the world [11].

Economic losses occurred in some peppermint fields in Columbia County during the summer of 1949, and by November every mint field in the county was infested with rust. Mint rust appeared in Willamette Valley peppermint plantings in the spring of 1950, and by November every mint field examined in western Oregon was infested [12].

Bienvenu [5] documented that in the absence of mint rust, growers in north-east Victoria can achieve yields in excess of 90 kg/ha of top quality peppermint oil, but unfortunately the disease has commonly reduced yields to less than 40 kg/ha of inferior quality oil. Edwards et al. [13] showed that this disease can reduce the oil yields (< 50%).

The pathogen causes light-yellow spots on the upper side of the leaves, while it causes blister-like on the underside of the leaves, then the spots become brownish-red (rust pustules). So, the affected leaves may die and drop causing the plant to severely defoliated [5-7,14,15].

2. SYMPTOMS AND SIGNS

Rust symptoms appear in early summer as light yellow or brown spots on stems, petioles, and mid-veins of leaves. Upon close examination, the spots are powdery with rust spores. This disease can result in some defoliation, especially when plants are crowded (Fig. 1) [9,16,17].

Puccinia menthae causes light-yellow spots on the upperside of infected leaves and blister-like on the underside of the leaves and young shoots in the spring. Later in the season, brownish-red spots (pustules) surrounded by a yellow halo appear on the leaves. Affected leaves may eventually drop off, causing the plant to become severely defoliated. When rust infects young plants, the shoots usually become twisted and distorted, and break off easily at the point of infection. In late summer and fall, the spots on the leaves become deep-chocolate brown, as the overwintering spores of the fungus are produced. This disease can spread from nearby mint plants (Fig. 1) [5,6,18].

In summary, symptoms include small, dusty, bright orange, yellow or brown pustules were appeared on upperside and underside of leaves; new shoots may be pale and distorted; large areas of leaf tissue die and leaves may drop from plant (Fig. 1) [19].

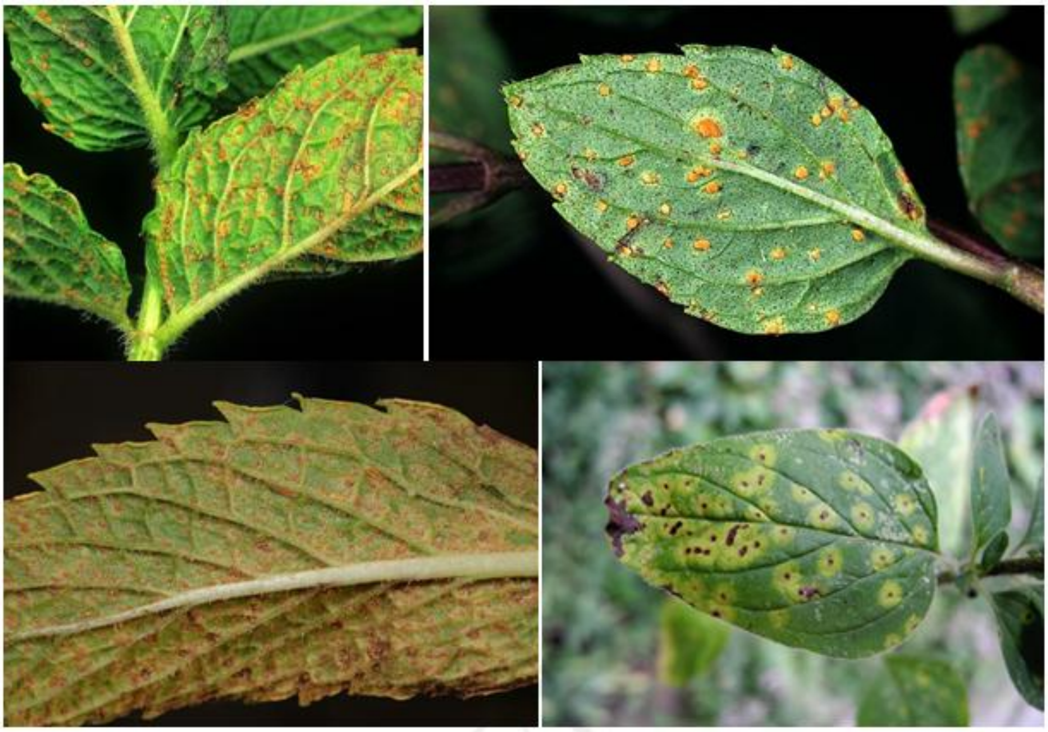

Fig. 1. Symptoms of rust disease on leaves of *Mentha* spp.

3. CAUSAL AGENT AND DISEASE DEVELOPMENT

The causal agent of the rust disease of mint is the obligate parasite fungus *P. menthae* which belongs to the family Pucciniaceae, the order Pucciniales, the class Pucciniomycetes and the phylum Basidiomycota [20]. The pathogen overwinters on mint stubble and on wild and escaped mint. It completes its complex life cycle on one host (autoecious) and it is macrocyclic, of which the aecial stage can be systemic in plants [9,16].

The disease cycle has been described by Baxter and Cummins [21] and Horner [22]. *P. menthae* is a rust fungus with a complicated life cycle, involving five spore stages produced in sequence on its host. During winter, the fungus survives on debris as tough-walled black teliospores. These teliospores germinate in spring, producing tiny colourless basidiospores which infect young host tissue as it emerges through the soil surface. Spermagonia result from this infection, and if cross-fertilisation occurs, yellow aeciospores are produced. These become foci of disease in the field, infecting nearby mint leaves, and resulting in the production of brown urediniospores, which are aerially dispersed and can travel large distances. Urediniospores infect mint leaves through the stomata and within two weeks, if conditions are favorable, thousands of new urediniospores are released from uredinia (rust pustules) formed on the undersides of the leaves [9]. Beresford and Mulholland [23] showed that the mint rust overwinters as teliospores, and these, on germination, produce basidiospores which infect shoots in late winter. These infections give rise to pycnia and, after spermatisation, develop into aecia. The aeciospores are dispersed over short distances and infect newly emerging leaves in spring, giving rise to the uredinial stage. The uredinial stage goes through successive cycles during summer, and in autumn teliospores are again produced [23]. The urediniospore stage is the very destructive summer phase of the disease. The sequence of these events and how they are influenced by the seasons of the year is known as the disease cycle [9].

High summer temperatures are thought to be a limiting factor for rust development on mint. The effects of temperature on germination of urediniospores and length of germ tubes of *P. menthae*, and on length of latent period were determined by Johnson and Cummings [17]. These authors revealed that the percent spore germination and length of germ tubes were significantly greater for the native spearmint isolate than the peppermint isolates; development of both types of rust isolates significantly decreased as temperature increased from 18°C to 30°C. Regression coefficients did not differ between the two types of rust for either percent germination or length of germ tubes. Length of latent period did not differ between isolates of native spearmint and peppermint rust at 18°C and 23°C, but latent period was significantly shorter for the native spearmint isolate than peppermint isolates at 28°C. The increased germination, growth of germ tubes and shorter latent period for native spearmint isolates infecting native spearmint would favour the rust development in relatively warm environments. Conversely, peppermint rust would be disfavoured in increasingly warm environments, further explaining its limitation in high temperature environments [17].

Johnson and Cummings [17] documented that high temperatures inhibited urediniospore germination and growth of germ tubes from urediniospores of the peppermint rust isolates more than those of the native spearmint isolate. Germ tubes need to be long enough to reach a stomata and form an appressorium for penetration to occur. Under favorable conditions, urediniospores will have germinated, reached a stomata and formed an appressorium within 24 h [24]. Urediniospore germination was previously reported to occur between 9°C and 27°C, with an optimum temperature for the greatest percentage of germination and germ-tube development at about 18°C [24].

The longer latent period (time for pustules to develop after initial infection) would disfavor the mint rust strain in relatively warm environments by substantially delaying epidemic build-up in the field. The reduced sporulation of uredinia and necrosis associated with uredinia would reduce inoculum available for secondary cycles of infection and further reduce epidemic build-up [17,18,25]. Necrosis associated with uredinia was greatly reduced at the shorter incubation periods at 28/13°C [22].

Edwards et al. [13] pointed out that urediniospores were capable of germination, infection and subsequent sporulation at temperatures as low as 5°C, and they concluded that low temperatures merely slow down infection and sporulation processes, allowing the fungus to persist until conditions become favorable. This helps explain the presence of viable urediniospores on mint growing during winter when daily average temperatures are between 5-10°C.

4. DISEASE MANAGEMENT

This disease can be minimized by cleaning up plant residues in the fall and by adequate spacing of the plants to promote good air circulation. Good weed control during planting and throughout the growing season protect mint crops against rust and other diseases. Tillage after harvest and before planting can help break down crop residue and destroy disease pathogens. Remove and destroy the infected plant tissues and debris that may serve as sources of this disease. Crop residues can also be incorporated into the soil to reduce sources of the pathogen. Healthy and vigorous plants grown under a good nutritional program and suitable sanitary conditions are less susceptible to rust infection than plants grown under nutritional stress. Early harvest may limit rust damage [7,10-13,16,21-26]. Beresford and Mulholland [23] showed that the autumn cultivation reduced the incidence of rust infection in the following spring.

Aecia, uredinia and spores can be present on mint rhizomes and transplants used to establish commercial mint fields. Immersing mint rhizomes and transplants in water at 35-55°C for varying times of 4 s to 80 min reduced viable spores and infected host tissue without marked host injury [24,26].

Flaming with propane in spring is absolutely necessary for rust control even if fields were flamed the previous fall. Flamer speed should be 2.5 to 3 mph; gas pressure should be 35 to 40 psi. Speeds less than 3 mph are wasteful; more than 3 mph reduces flamer's effectiveness. Complete flamer coverage is essential. It is not advisable to flame thin stands. To be most effective, flaming should be community-wide so rust will not spread from untreated to treated fields later in the season [6,27]. The timing of flaming for rust control is critical, because all susceptible foliage must be killed at the stage in the disease cycle when aeciospores must infect leaves or perish, i.e., before the uredinial stage appears [22,28].

Effective control of mint rust on peppermint crops in the USA depends on breaking the life cycle of *P. menthae* at the aecial stage in early spring. This is commonly achieved by burning the new mint growth with a tractor-drawn propane-gas flamer which destroys any aecia present and stimulates a second flush of growth into a subsequently rust-free field [16].

Genetic resistance to disease has protected plants from pathogens throughout evolutionary time and, today, it is one of the most practical and effective tactics for controlling rust mint [21,29-33].

The fungicides commonly used include copper, sulfur, mercury and nickel salts and other fungicides [34-36]. The use of contact fungicides is not very effective because of their short residual activity and the need for perfect foliage coverage for the entire vegetative period. With the discovery of systemic fungicides investigations were initiated to evaluate their use against mint rust. Good results have been reported for Saprol 19 EC (triforine) [37], Tilt 250 EC (propiconazole) [38], Baycor 300 EC (biloxasol/bitertanol), Folicur Plus (tebuconazol) [15,38,39], Bayfidan 250 EC (triadimenol) and Impact 12.5 CK (flutiafol) [40], Folicur 250 (tebuconazole) [15]. Edwards and Bienvenu [15] documented that bitertanol reduced rust severity from 67% to 5% in the first year and from 27% to 6% in the second year, compared to propiconazole which reduced it from 67% to 56% in year 1 and 27% to 18% in year 2. In addition, bitertanol increased oil yield by 112% and 111% respectively, whereas propiconazole increased it by only 57% and 28% respectively.

Clearly, further screening trials should be undertaken to investigate fungicides with different modes of action. Incorporation of two or more fungicides from different chemical groups into the growers' mint rust control program should be promoted to ensure that their effectiveness is not broken down and to reduce the likelihood of fungicide resistance arising in the local pathogen population [15].

5. CONCLUSION

It was concluded that the rust disease of mint which caused by the specific obligate parasite fungus *Puccinia menthae* is a common serious disease on this plant around the world and leads to reduce the plant yield quality and quantity. The disease distributes throughout the world especially the wet and moist environments near rivers, lakes, pools and shade areas. Disease severity can be minimized or reduced significantly either by using agricultural practices, flaming, chemical control or/and resistance varieties in an integrated pest management program. We recommend to apply this strategy for managing the mint rust disease, because it's considered as a promising program in sustainable development.

ACKNOWLEDGEMENTS

The authors are grateful to the review editor and the anonymous reviewers for their helpful comments and suggestions to improve the clarity of the research paper.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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