



TECHNICAL DOCUMENT ON DOWNY MILDEW OF SOYBEANS

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ABSTRACT

Downy mildew is a common problem in soybean [*Glycine max* (L.) Merrill] which grown in field conditions but is rarely seen in greenhouses. Soybean downy mildew, caused by fungus-like organism *Peronospora manshurica* (Class Oomycetes; Phylum Oomycota), is a widely spread disease and can survive in crop residues and on the seed surfaces. *P. manshurica* has zoospores (flagellate motile spores) and needs water or high humidity for infection. Spores are carried onto plants by wind and rain and infection can spread quickly through a field during periods of cool, wet, or high humid weather. *P. manshurica* produces saclike sporangia carried on sporangiophores emerge from the stomata of the lower surface of the leaves. On the upper surface of the leaves, they will have pale green to light yellow spots. As the spots enlarge, they become pale yellow and of irregular size and shape and may enlarge to lesions. In moist weather, a pale blue to gray downy growth of the mildew fungus appears on the lower surface of the leaves, directly opposite the lesions on the upper side of the leaves. The disease rarely causes serious damage to soybean, but some reports revealed that the disease reduced seed size and quality if present early in the season and at high levels. The objective of this technical document is to study soybean downy mildew: symptoms and signs, causal agent, epidemiology, disease development, disease cycle, ecology and disease management.

Keywords: Disease cycle; disease management; downy mildew; *Peronospora manshurica*; soybean.

1. IMPORTANCE

Soybean [*Glycine max* (L.) Merrill] is an annual legume of Fabaceae family which is considered as the third largest plant family in number of species with about 20,000 species. Soybean is the most economically important grain in the world due to its

productive potential, chemical composition and nutritional value [1]. Approximately forty diseases caused by many agents like fungi, bacteria, viruses and nematodes have been recorded on soybeans [2]. Among these, downy mildew is considered as important and most widespread leaf disease which can cause about 8-14% damage to susceptible genotype of

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soybean in USA [3]. It is frequently observed in Tunisia, but rarely causes yield losses. Under extremely favourable environmental conditions, the disease may become severe enough to cause premature defoliation contributing to lower seed quality and reduce seed size resulting in lower marketability [3-5]. Silva et al. [6] showed that the percentage of severity by downy mildew in soybean in Brazil ranged between 0-43% and the weight of 1000 seeds per plant was reduced linearly with increasing of downy mildew severity.

2. SYMPTOMS AND SIGNS

The initial symptom of downy mildew is the appearance of small pale green spots (not water-soaked) on the upper leaf surfaces. Younger leaves are more susceptible to downy mildew than older leaves, so the disease will generally appear first on the upper surface of young leaves. The spots swell and turn pale to bright yellow. They may aggregate into large, irregular and brown areas (Fig. 1) [2-8].

These are easily confused with other leaf spots, especially bacterial blight and septoria brown spots. Some soybean varieties express mild leaf distortion that may resemble symptoms caused by common soybean viruses (Fig. 1) [2-8].

Tan to gray tufts of fungal growth often develop on the lower leaf surfaces, especially under wet and humid conditions (Fig. 1) [2-8].

On the underside of the leaves, the spots have a gray, fuzzy appearance due to the presence of the pathogen. These fungal-like tufts are reproductive structures of the organism and their appearance is diagnostic for this disease. Symptoms frequently occur at low levels throughout the crop canopy. Early leaf spots are non-descript and are commonly confused with leaf spots and pustules caused by soybean rust (Fig. 1) [2-8].

The key to distinguish downy mildew is the formation of gray fungal-like tufts that develop on the underside of the leaves, directly opposite the lesions on the upper side of the leaves. These tufts represent the sporangiophores and sporangia of the pathogen. Younger leaves are more susceptible to downy mildew than older leaves (Fig. 1) [2-8].

Infection of pods and seeds can also occur. Infected seeds have a dull white appearance and are partially or completely covered with a pale coating of fungal hyphae and spores. When the pods are infected, inside the pods a covered mass of fungus-like growth appears. Infected seeds have a dull white appearance and are partially or completely encrusted with the pathogen. This sign can be confused with infection by the pod and stem blight fungi (Fig. 1) [2-8].



Fig. 1. Symptoms of downy mildew on leaves and seeds of soybeans

3. CAUSAL AGENT

The causal agent of downy mildew of soybean is the fungal-like organism with cell wall made of cellulose *Peronospora manshurica* which belongs to family Peronosporaceae, order Peronosporales, class Oomycetes, phylum Oomycota and kingdom Straminipila. Oomycota was excluded or removed from the true fungi and put in the kingdom Straminipila, because of the following reasons [9-11]:

1. The structural cell wall is cellulose, while it consists of chitin in the true fungi.
2. The inner mitochondrial membrane is tubular cristae, while it's lamellate cristae in the true fungi.
3. The Golgi stacks are present, while they are reduced in the true fungi.
4. They have biflagellate zoospores, one of them is whiplash and the other is tinsel, while the tinsel flagellum is absent in the true fungi.
5. The amino acid lysine is synthesized via α , ϵ -diaminopimelic acid (DAP) pathway, while it synthesized via the α -aminoadipic acid (AAA) pathway in the true fungi.

Peronospora manshurica (order Peronosporales; family Peronosporaceae) is an obligate biotrophic endoparasite pathogen causes economically significant diseases on the leaves of soybeans. It cannot grow on the artificial media and cannot be grown apart from the living host plant. It produces sporangia separate from the hyphae when they be matured, these sporangia are infective (Fig. 2). *Peronospora manshurica* has coenocytic (aseptate) intercellular mycelium which parasite endogenously in the plant. It reproduces asexually by producing

sporangia and sexually by producing oospores. Also, it overwinters as oospores on infected leaves, debris and seeds of soybean [12,13]. The sporangiophores are branching into two tapered branches which carry the sporangia individually (Fig. 2) [11,14]. About nine races belong to *P. manshurica* are found in Midwest of America [15,16].

4. DISEASE DEVELOPMENT

Downy mildew is caused by fungus-like organism *P. manshurica*. This fungus spends the winter as thick-walled resting spores (oospores) in leaf debris and on seeds. Oospores serve as the primary source of inoculum. While, wind dissemination of spores produced on the surface of lower leaf lesions represent the most important sources of intra-field and field-to-field dispersal. Conidia fall on new leaves and penetrate them through stomata or directly by germ tubes. Infected soybean leaves usually appear on top of plants [7,17,18]. The disease development is increased when humidity is high and the temperature degrees range between 20-24°C, whereas the sporulation occurs between 10-30°C [19]. The first infection happens by oospores which considered as a survival structure for the pathogen over the winter, while the secondary infection was accomplished by conidia or sporangia [20]. So, the secondary lesions occur after ten days and the fungus sporulates more, then the disease cycle can occur more than one time within the same season [21].

Infected soybean plants develop systemically and conidia that form on their leaves begin to infect the surrounding crops. Several studies documented that oospores on soybean seeds may remain a vital enemy for up to 8 years [7]. So, the disease can be transmitted successfully by the seeds [13].

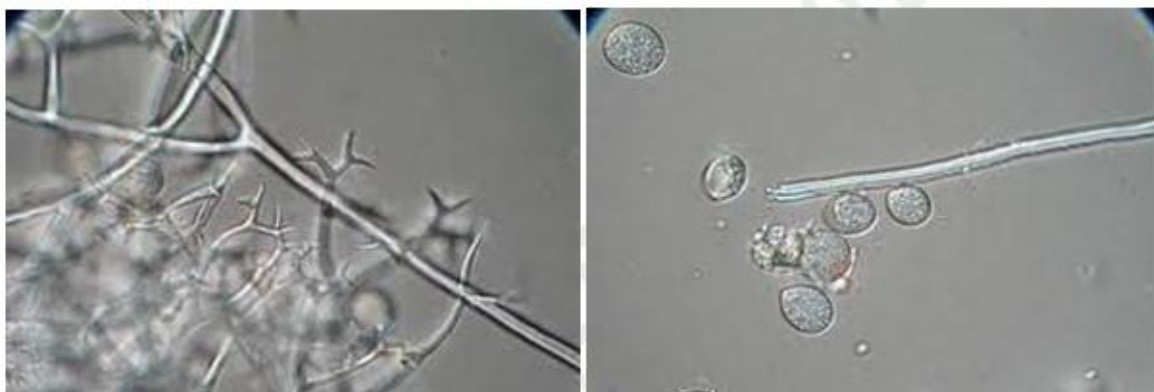


Fig. 2. *Peronospora manshurica*: Sporangiophores and sporangia

Planting downy mildew infected seeds may introduce the inoculum into the field. Under field and greenhouse conditions, the disease can infect the plants of all ages, although the disease is more common after flowering [7,17]. Oospores which found on the seeds or sometimes mycelium which found on the plant materials can be considered as a primary inoculum for disease [22].

High humidity and moderate temperatures (18.3-23.9°C) contribute to the development of downy mildew [23].

Usually, infection requires the presence of prolonged periods of dew and temperatures between 10°C and 26.67°C [23].

5. DISEASE MANAGEMENT

Farmers can manage the losses of downy mildew disease in soybeans through scouting, variety selection, cultivation and fungicides [18,24,25].

When scouting soybeans in greenhouses and fields for weeds, check for the presence of downy mildew and other foliar diseases. During cooler than normal seasons when the crop is in its middle to late reproductive stage, look for symptoms of downy mildew. Be sure to check the upper surfaces of the leaves. If you suspect downy mildew disease, take samples and send them to a diagnostic lab, or consult a pest identification guide [18,24,25].

No variety of soybean is completely resistant to downy mildew, but some varieties are more susceptible than others. It is difficult for companies to assess and breed resistance because, in most years, downy mildew pressure is low or nonexistent in soybean fields. If high levels of downy mildew appear in a variety, consider removing that variety from your line-up in future years. It is always wise to plant disease-free seed [6,16,26-28].

Good weed control during planting and throughout the growing season protect soybean crops against downy mildew disease and other pests [18,24].

Crop rotation is not an effective downy mildew management practice because the wind-borne fungus can spread over long distances. Nevertheless, other researchers have revealed that longer crop rotations will help to reduce future infections [18,24,25].

Tillage after harvest and before planting can help break down crop residue and destroy disease pathogens [24,25,28-30].

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 [24,25,28-30].

Healthy and vigorous plants grown under a good nutritional program and suitable sanitary conditions are less susceptible to downy mildew infection than plants grown under nutritional stress [18,24,25,31].

Because downy mildew infects the leaves of the plants and produce air-borne sporangia and conidia in large amounts, therefore the crop sanitation measures are not effective enough to control the disease [14].

The disease rarely reduces yield, so fungicides are not recommended for downy mildew management. Cultural controls implement to decrease the risk of downy mildew disease is generally all that is required [18,32]. However, there are some studies referred to use many fungicides to control downy mildew such as metalaxyl, metalaxyl+dithiocarbamate, fosetyl-Aluminum, kresoxim methyl, azoxystrobin, trifloxystrobin and pyrimidin amine [14,33-36]. Seeds, the seed treatment with fungicides such as azoxystrobin 0.9% may give a good [37]. Also, it was found that the application of alternative products like acibenzolar-S-methyl and micronutrients (Cu, Mn and Zn) reduced the disease severity of soybean downy mildew [24].

6. CONCLUSION

- 1- Downy mildew of soybeans, caused by fungus like organism *Peronospora manshurica*, is a leaf disease that also affects other legumes.
- 2- Downy mildew appears on the upper surface of young leaves as pale green to light yellow spots which enlarge into pale to bright yellow spots, gray tufts of fungal growth often develop on the lower leaf surfaces, directly opposite the lesions on the upper side of the leaf, especially under wet and humid conditions.
- 3- The disease requires cool air temperatures and high relative humidity, making it uncommon during summers.
- 4- Downy mildew rarely causes yield loss from common leaf infection. Occasional epidemics result in yield losses of 9 to 18%, depending on the soybean variety.
- 5- The downy mildew fungus survives as oospores in crop residues and on the surface of seeds. Therefore, crop rotation or deep burial of infested crop residues can reduce primary inoculum, and planting pathogen-free seeds is an effective practice. Some fungicides are

recommended for control of downy mildew disease.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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