Occurrence Regularity and Control Measures of Powdery Mildew in Strawberry

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Abstract Powdery mildew is a major disease of strawberry. It harms both plants and fruits, seriously affecting the quality and yield of strawberry. This article briefly introduces the harms and occurrence regularity of powdery mildew in strawberry and summarizes the corresponding control measures, with a view to providing a certain scientific reference for the prevention and treatment of the disease.

Key words Powdery mildew in strawberry, Harm, Occurrence regularity, Control measure

1 Introduction

Strawberry (*Fragaria ananassa* Duch.) is delicious and nutritious. It is an important berry species in China, and occupies an important position in fruit production. In recent years, driven by high efficiency, the area of protected strawberry cultivation has gradually increased. However, facility cultivation is prone to problems such as high humidity, insufficient light and poor ventilation, which provide convenient conditions for the occurrence of powdery mildew. The pathogen of strawberry powdery mildew [*Sphaerotheca macularis* (Wallr ex Fr) Jacz. f. sp. *Fragariae peries*] (Ascomycota: Pyrenomycetes: Erysiphales: Erysiphaceae: *Sphaerotheca*) is an obligate parasite[1]. It is distributed all over the world, mainly in strawberry producing areas such as North America, Europe and East Asia[2-7]. Since 1990s, powdery mildew has been severe in China. In some areas, powdery mildew has become the most serious disease in strawberry[8]. Powdery mildew harms the blades, petioles, flowers, fruits and stems of strawberry. When the disease is severe, the diseased leaf rate can reach over 45%, and the diseased fruit rate can reach over 50%, seriously affecting the quality and yield of strawberry, and causing heavy economic losses[9-12]. This article introduces the harms and occurrence regularity of powdery mildew in strawberry, and summarizes the corresponding control measures.

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2 Harms of powdery mildew to strawberry

Powdery mildew is an important disease in cold areas and facility cultivation. Under suitable conditions, it can develop rapidly, flooding and causing serious losses. Powdery mildew mainly damages leaves, petioles, flowers, pedicels and fruits. In the early stage of disease on the leaves, small nearly circular star-shaped white powdery spots appear on the back of the leaves. As the condition worsens, the lesion gradually expands and spreads around into a white powder with inconspicuous edges. When the disease is severe in the later stage, multiple lesions are connected into a piece, the whole leaf is covered with white powder, and the edge of the leaf is also curled up and deformed, and finally the leaf is spoon-shaped. Once flower buds, flowers and receptacles are infected, the petals will become pink or light pink, the flower buds cannot open, and the receptacles cannot develop. Once young fruit is infected, the diseased part is red, and the fruit will be unable to expand normally, stopped in growth and withers. The fruits are generally infected in the later stage, and their will be covered with a layer of white powder, which seriously affects the quality of the berries and makes them lose commercial value.

3 Occurrence regularity of powdery mildew in strawberry

3.1 Infection cycle The pathogen of strawberry powdery mildew overwinters and oversummers with mycelia or conidia in diseased plants or diseased remains, becoming the first source of infection the following year. When the environment is suitable, the bacteria spread by airflow or rainwater and then invade directly from the host epidermis in the form of conidia or ascospores. After incubation, disease spots appear. In about 7 days, new conidia will be produced on the affected part, and the infection will be repeated and the damage will be aggravated.

3.2 Incidence conditions Strawberry powdery mildew likes low-temperature and high-humidity environment. The optimum

temperature for conidia formation and infection is about 20 ℃. They spread rapidly in the temperature range of 15 – 25 ℃, and do not develop disease below 5 ℃ or above 35 ℃. In the relative humidity range of 40% – 80%, it is suitable for the occurrence and spread of powdery mildew. Rain water has an inhibitory effect on powdery mildew, and spores cannot germinate in water droplets. The susceptible period of strawberry is from fruit setting to late harvest, and the incubation period of onset is 5 – 10 d. The onset in continuously cropped strawberries in greenhouses is earlier and more serious, and the onset of the disease is 18 – 20 d earlier than that of the newly built greenhouses. Strawberries grown in protected areas have an earlier onset and serious diseases than those grown in open fields. High planting density, extensive management, poor ventilation and light conditions, weak plant growth, high temperature and drought, high temperature and high humidity, *etc.* are all likely to cause the aggravation of strawberry powdery mildew. In addition, there is also a close relationship between fertilization and disease. Under the condition of partial application of nitrogen fertilizer, strawberry growth is vigorous, and large and tender leaves are prone to powdery mildew. The disease is the main disease of strawberry cultivation in solar greenhouses and greenhouses, and can lead to harvest failure in severe cases.

4 Control measures for powdery mildew of strawberry

4.1 Agricultural control

4.1.1 Selection of disease-resistant varieties. Disease-resistant varieties such as Sweet Charlie and Red Star can be selected.

4.1.2 Disinfection of soil under solar sunlight. During the high-temperature season from July to August, the soil is disinfected under sunlight. The greenhouses are first cleaned up. Usually after ridging, the soil is irrigated sufficiently and then mulched with plastic film. After covered with film, the greenhouses are sealed for 30 – 45 d to kill most of the pathogens in the soil. Before high-temperature treatment of the soil, 4 – 8 t/ha of crushed corn stalks or rice straw is applied. Rotary tillage is evenly carried out before watering and high temperature treatment, so that the sterilization effect is better.

4.1.3 Reasonable rotation and fertilization. Strawberry is more suitable for crop rotation with wheat and rice. As Solanaceae crops have common diseases with strawberry, they are not suitable for rotation with strawberry. Before planting, combined with deep tillage and soil preparation, sufficient base fertilizer is applied, dominated by decomposed organic fertilizer, supplemented with sulfur-containing compound fertilizer, superphosphate, *etc.* During the growth period, topdressing should be carried out reasonably, nitrogen, phosphorus and potassium compound fertility for the early stage and phosphorus and potassium fertilizer for the later stage. During the whole growth period, the fertilization rate of nitrogen fertilizer should be controlled appropriately, while those of phosphorus and potassium fertilizers should be increased appropriately to promote plant growth and improve fruit quality.

4.1.4 Cultivation of robust seedlings and reasonable dense planting. Robust and sterile seedlings should be selected. During the propagation of strawberry stolon ramets, diseased and weak seedlings must be eliminated to strictly prevent diseased seedlings from entering the greenhouses. During the growth period, old leaves, diseased leaves, diseased fruits and diseased stems should be removed in time and buried deeply or burned concentratedly to reduce the source of the pathogen. Plant and row spacing and planting density should be ensured at appropriate sizes. The wide row spacing, narrow row spacing, plant spacing and planting density can be controlled at 55 – 65, 25 – 30, 15 – 20 cm and 120 000 – 180 000 plants/ha. Field ventilation and light transmission should be enhanced.

4.2 Biological control Biological agents are mainly used for biological control. *Bacillus subtilis* wettable powder (10^{11} live spores/g, 500 × – 1 000 ×), Trichoderma harzianum wettable powder (3×10^8 live spores/g, 600 ×), 3% polyoxin aqueous solution (800 ×), 1.5% matrine · osthol aqueous solution (1 500 ×) can be sprayed evenly or applied to the affected part 2 – 3 times, with a safe interval of 5 – 7 d.

4.3 Chemical control

4.3.1 Disinfection of soil and seedlings. Before transplanting (5 – 7 d), 70% thiophanate-methyl WP or 50% carbendazim WP can be mixed with 8 – 10 kg of fine soil and sprinkled evenly according to a dose of 12 ~ 15 g/m^2 to disinfect the soil. When transplanting, the roots of the seedlings can be immersed in 70% thiophanate-methyl WP (300 ×) for 1 h to reduce the base of disease sources and alleviate the disease.

4.3.2 Disinfection of greenhouses. Sulfur fumigation can be used to prevent powdery mildew. Generally, prevention should be carried out around the end of October. A sulfur fumigator can be installed every 100 m^2. A certain amount (15 – 20 g) of 99.5% sulfur powder is placed in a fumigator. Fumigation is carried out 3 – 4 times a day, 2 h for each time. The safe interval is 2 – 3 d.

4.3.3 Chemical control. Chemical control is a timely and effective method to prevent and control powdery mildew, especially in the early and epidemic period of the disease. 25% azoxystrobin suspension (1 500 ×) or 50% kresoxim-methyl water dispersant (3 000 × – 5 000 ×) can be sprayed alternately at the beginning of the disease or before flowering. Spraying can be carried out once every 2 – 3 d, for 3 – 4 times, to reach remarkable control effect. It should be noted that the spray should be even and thorough. Both the leaf surface and leaf back should be sprayed. Chemical agents should be used alternately to prevent the occurrence of drug resistance. In addition, attention should be paid to the safe use of drugs and strictly enforce the safety interval of pesticides. Generally, the medication should be stopped in advance according to the effective residue period before harvest to control the pesticide residue.

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for nearby regions, architectural education in colleges and universities must be based on the law of architectural development, originate from the local area, and highlight the research and practice of local architectural culture. The development of architectural landscape education must adapt to local conditions, combine the characteristics of region, culture and history and combine the advanced concepts of Western landscape architecture, and only in this way can we make progress in cultivating students' artistic quality, aesthetic sentiment and design consciousness. The cultivation of design quality and consciousness should also vary from person to person. Good design quality is obviously not limited to this. Integrating regional cultural resources into the teaching of design majors in local colleges and universities is helpful for students to truly understand the artistry and practicality of regional cultural resources.

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