Diseases of Rice Seedlings Growing in the Nursery Box

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Introduction

Transplanting of rice seedlings by machines was practiced on 95% of the total rice-planted area of Japan in 1984. Rice seedlings raised in seedling boxes are used for mechanized transplanting. This method of raising seedlings is more artificial than conventional methods using protected semi-dry nurseries or dry nurseries.** The former gives an environment fairly different from that of the latter to seedlings: extremely dense sowing, and high temperature–high humidity and reduced sunshine at the time of seedling emergence. Furthermore, after greening the seedlings are easily affected by climatic fluctuations. At the beginning of the spread of this method, it was anticipated that such an environment might cause frequent occurrence of various diseases. Indeed, various diseases have been caused by miscellaneous microbes which showed no pathogenicity in the conventional methods of raising seedlings.

The diseases presently known to occur for rice seedlings raised in nursery boxes are listed in Table 1. Although they include various types of diseases such as seed-borne, soil-borne, or air-borne diseases, this paper deals with soil-borne diseases.

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** Dry nursery means the nursery without submerging irrigation. Semi-dry nursery is intermediate between dry and submerged nurseries.

Soil-borne diseases

1) Fusarium seedling blight

Fusarium seedling blight has been an important disease, but fortunately it seldom occurs lately after the control method using hymexazol was established.

(1) Pathogens: They are *Fusarium roseum* and *F. solani*. Of them, *F. roseum* caused wide occurrence of damages.

(2) Symptoms: Stunted growth and wilting to death. Leaf sheaths at around soil surface and roots become brown, and show white mold. Root growth is retarded. The profile of bed soil shows white or reddish mold around seed paddies. *F. roseum* causes red-colored paddies and roots.

(3) Factors for occurrence: Low temperature soon after the beginning of greening increases the occurrence. The use of soils on which the disease occurred in the previous year or upland farm soils (pH>5.5) increase the disease occurrence. Inadequate management such as too dry or too wet conditions during the nursery period[14], as well as seedlings lacking fertilizer[14] promotes the disease occurrence.

(4) Control measures: After the greening, seedlings must not be exposed to low temperature. During the hardening period, careful watering not to repeat too dry and too wet conditions is needed, because the bed soil is apt to dry due to advanced growth. As the pathogen inhabits the soil, paddy soils or virgin soils free from the pathogen should be used instead of upland farm soils. The pH of bed soils is adjusted at 4.5–5.0. Ferti-

Table 1. Kinds of diseases of rice seedlings growing in the nursery box, their pathogenic agents, and chemicals used to control them

Route of transmission	Diseases and pathogens	Effective chemicals
Seed-borne	Rice blast *Pyricularia oryzae*	Benomyl, Thiuram · Benomyl, Thiuram · Thiophanate-methyl, Captan · Thiabendazole
	Brown spot *Cochliobolus miyabeanus*	Thiuram · Benomyl, Thiuram · Thiophanote-methyl, Captan · Thiabendazole
	Baka-nae disease *Gibberella fujikuroi*	Benomyl, Thiuram · Benomyl, Thiuram · Thiophanate-methyl, Captan · Thiabendazole
	Phoma seedling blight *Phoma exigua* var. *exigua*	?
	Bacterial seedling rot *Pseudomonas glumae*	Kasugamycin
	Bacterial brown stripe *Pseudomonas avenae*	Kasugamycin
	Rice seedling blight *Pseudomonas plantii*	?
Soil-borne or air-borne	Fusarium seedling blight *Fusarium* spp.	Hymexazol, Chlorothalonil · Benomyl, Hymexazol · Metalaxyl, Methasulfocarb
	Pythium seedling blight *Pythium* spp.	Hymexazol, Hymexazol · Metalaxyl, Methasulfocarb
	Rhizopus seedling blight *Rhizopus* spp.	Chlorothalonil, Chlorothalonil · Benomyl, Methasulfocarb
	Mucor seedling blight *Mucor fragilis*	Chlorothalonil
	Trichoderma seedling blight *Trichoderma viride*	Benomyl, Chlorothalonil, Methasulfocarb
	Rhizoctonia seedling blight *Rhizoctonia solani*	Validamycin
	Corticium seedling blight *Corticium rolfsii*	Validamycin

lizer is applied at the standard rate not to cause fertilizer shortage. Seed paddies including many damaged paddies should not be sown.

2) *Pythium seedling blight*

The damage by *Pythium* was less than that caused by *Fusarium*. Recently, however, it was almost made clear that so-called "Murenae", which has been regarded as a physiological impediment, included the wilting type Pythium seedling blight. Therefore, the damage by *Pythium* is as important as that by *Fusarium* for seedling raising in the box.

(1) Pathogens: More than 10 species of *Pythium* are known to cause seedling rot in nurseries with submerging irrigation. In nursery boxes, it was made clear that *Pythium spinosum*, *P. irregulare*, and *P. sylvaticum* cause seedling blight with retarded emergence[6] and *P. graminicolum*, *P. graminicola* (as *P. graminicolum*) and *P. graminicola* complex are associated with the wilting type seedling blight occurring in the later period of seedling growth[2,5-7,11,12].

(2) Symptoms: Three different symptoms are observed. (a) Plumules and radicles decay or brown to death due to low temperature at the time of emergence. (b) Low temperature after the greening causes symptoms quite similar to the symptoms caused by *Fusarium*, except that the color of browned portions at around the soil surface is slightly lighter than that of the latter, and the browned portions decay, showing a water-soaked state. Thus, affected plants wilt to die. (c) At the 2–3 leaf stage, green leaves suddenly wilt, becoming rolled leaves, and discolor to yellowish-brown due to low tempera-

ture at the middle to the late period of the nursery. The leaves wither, and roots become a water-soaked state and decay with discoloration to light brown[1,6,7,12].

(3) Factors for occurrence: Low temperature at the time of emergence, greening, or middle to late stage of nursery is a predominant factor. As the pathogens inhabit the soil or water, the use of farm soils on which consecutive vegetable cropping was made, or the use of river or pond water for irrigation is liable to induce the disease. Too wet bed soil also promotes disease occurrence.

(4) Control measures: Attention in nursery management follows that for *Fusarium* damping-off. Particularly, low temperature and too wet bed soil should be avoided. Soils on which this disease occurred in the preceding year or vegetables were grown consecutively, water of rivers and ponds, or damaged seed paddies should not be used.

3) Rhizopus seedling blight

This disease is specific to the seedling-raising in nursery boxes. At the initial stage of the introduction of rice transplanting by machines, the damage by this disease was much greater than that by *Fusarium* and *Pythium*. However, after the establishment of control measures using Chlorothalonil, the occurrence of disease decreased.

(1) Pathogens: At present, the following 10 species are known to cause the damage; *Rhizopus arrhizus*, *Rh. chinensis*, *Rh. delemar*, *Rh. japonicus*, *Rh. hangcho*, *Rh. javanicus*, *Rh. niveus*, *Rh. oligosporus*, *Rh. oryzae*, and *Rh. stolonifer*[4]. Although the optimal temperature varies with species, it is around 30°C. Each species grows fast at the optimal temperature.

(2) Symptoms: At the beginning of the greening, the whole surface of the nursery box is covered with white mold, which then turned to grayish white. When severely damaged, no emergence occurred, and the mold spread to the layer of seed paddies. In case that emergence occurs, the growth of seedling is poor, with pale yellowish green leaves and short and less roots. In case of *Rh. chinensis*, which gives the greatest damage, the base of leaf sheaths and root tips show specific abnormal swellings[4].

(3) Factors inducing the disease: High temperature and high humidity at the time of emergence increase the occurrence. Low temperature after the start of greening promotes the occurrence. High seed rate, too wet bed soil, the use of soil with high water-holding capacity, and heavy application of nitrogen also promote the occurrence. Although the pathogenic *Rhizopus* spp. inhabit the soil, air-transmission easily occurs, so that infected seed paddies, or infested facilities and materials for raising seedlings often serve as infection sources.

(4) Control measures: Care is taken not to raise temperature at the time of emergence. After the greening, protect seedlings from extremely high and low temperature. Adequate watering to avoid excessive moisture of bed soil, standard seed rate (not denser seeding), and the use of seed paddies not containing many damaged paddies are practiced. Infested facilities and materials for raising seedlings are washed with water or sterilized with calcium hypochlorite (Chemichlon G) to keep the clean nursery condition.

4) Mucor seedling blight

This was first discovered in 1975 in Fukushima Prefecture. Genus *Mucor* belongs to *Mucoraceae*, like genus *Rhizopus*. As its hyphae and sporangia resemble those of *Rhizopus*, the disease by *Mucor* is apt to be confused with the damage by *Rhizopus*, judging from the appearance of mold multiplication.

(1) Pathogen: *Mucor* fragilis is the causal fungus. The temperature favorable to the growth of *M. fragilis* is 26–30°C. At this condition, *M. fragilis* is a fast-growing fungus, second to *Rhizopus*.

(2) Symptoms: The symptoms are similar to the case of *Rhizopus*; at the time of emergence, white mold covers bed soil surface, followed by damping-off, retarded emergence, and inhibited growth. Unlike the damage caused by *Rhizopus*, the damage by *Mucor* is

more remarkable on top growth than on roots.

(3) Factors for the occurrence: Many points are still unknown, but the damage occurs at lower temperature than in the case of *Rhizopus*.

(4) Control measures: This fungus inhabits the soil, so that the soil on which the disease occurred in the previous year should not be used. Cautions in nursery management should follow the case of *Rhizopus*.

5) Trichoderma seedling blight

White mold which looks different from that of *Rhizopus* covers the surface of bed soil at the time of emergence, and soon its color changed to blue-green, causing damping-off. This disease is specific to the nursery box. It occurred in many places throughout the country.

(1) Pathogen: Pathogenic fungus is *Trichoderma viride*[2]. Temperature favorable to its growth is 25–30°C. At this temperature range, it grows as fast as *Mucor*. The optimal pH is lower than 4.0. Growth is very poor in basic range.

(2) Symptoms: The damage of seedlings resembles that by *Fusarium*, but leaf yellowing is severer than the case of *Fusarium*. Roots are short, less in number, and browned. At the time of emergence, white mold covers bed soil surface and seed paddies, and soon masses of blue-green spores are formed. From the sign of the spore mass, this fungus can be distinguished from other fungi.

(3) Factors for the occurrence: Temperature around 30°C at the time of emergence promotes the disease occurrence. Soils with low water holding capacity or of pH lower than 4.0, soil moisture deficiency at the sowing time, and extremely dense sowing also promote the occurrence. This fungus inhabits the soil, but its infection occurs through air. It is highly possible that infested facilities and materials for raising seedlings can serve as infection sources.

(4) Control measures: Raising the temperature at the time of emergence can suppress the disease occurrence, but it has a risk of inducing severe occurrence of *Rhizopus*. Therefore, the most important is not to introduce the pathogen into the seedling-raising facilities. Soils on which the disease occurred in the previous year or infested soils should not be used, and cares must be taken to clean the nursery environment with the method as described for *Rhizopus*. Careful watering is made not to dry bed soils. For acidic soils, their pH must be adjusted to about 5.0 with calcium carbonate etc., before use.

6) Rhizoctonia seedling blight

In the usual season rice cropping in the warm southwest region of Japan, this disease suddenly occurs with the temperature rise about one week prior to transplanting. However, in the north, it occurs sporadically and locally.

(1) Pathogen: *Rhizoctonia solani* is pathogenic, but it is not clear what strain is involved.

(2) Symptoms: This disease suddenly occurs before transplanting. Seedlings growing at about the center of the nursery box turn yellow and wilt. Lower leaves and leaf sheaths show so-called "leaf-rot symptom", being discolored to grayish green, and hyphae in the form of a spider's web are observed. And soon after that, small sclerotia showing white–light brown color are produced.

(3) Factors for the occurrence: As this fungus inhabits the soil and is polyxeny, the use of upland farm soils to bed soil increases the disease occurrence. Extremely dense sowing, and heavy fertilization (nitrogen) promote the occurrence. As to the nursery environment, such a condition as that poor ventilation inside the vinyl house or vinyl tunnel induces high temperature, and high humidity promotes the disease occurrence.

(4) Control measures: As this disease is soil-borne, soils free from the fungus must be selected. Upland farm soils must not be used.

7) Corticium seedling blight

This disease was first discovered in 1970 in Kōchi Prefecture[13]. This is also specific to the seedlings in nursery boxes, like the

case of *Rhizopus* and *Trichoderma*.

(1) Pathogen: *Corticium rolfsii* is the pathogen. Favorable temperature for growth is 30°C. *C. rolfsii* prefers wetness. It is polyxeny and a soil-inhabiting fungus. In submerged soils, it dies in relatively short time.

(2) Symptoms: The hyphae climb leaf sheaths from the soil surface. Affected seedlings do not show "leaf rot symptom" which is observed in case of *Rhizoctonia*, but yellowing of lower leaves occurs. Infected portions become light brown, then white, and die. Silky hyphae twine round the basal portion of seedlings, seed paddies and roots, and then small, round-shaped sclerotia with white–chestnut color are formed.

(3) Factors for the occurrence: As this disease is soil-borne, the use of soils taken from upland farms such as vegetable fields is quite risky. High temperature and high humidity in vinyl houses or vinyl tunnels promote the disease occurrence.

(4) Control measures: As this fungus likes high temperature and high humidity, cautions of the nursery management similar to those required for *Rhizopus* are needed. It is better to use paddy field soils, instead of upland soils on which the disease occurred in the previous year.

Conclusion

The soil-borne diseases occurring in nursery boxes are briefly described in this article. Regarding the ecology of disease occurrence, there still remain many problems to be clarified.

For the diseases occurring in nursery boxes, too much emphasis is apt to be placed on chemical control. However, it is basically important to raise healthy seedlings by following the standard methods of nursery management as well as by making every effort to clean the nursery environment.

Regarding the nursery management, the most important is the temperature management. For example, the following is the standard: after soaking 30–32°C for 2–3 days for emergence, 25°C(daytime)–20°C(night) for 2–3 days for greening, and 20°C(daytime)–15°C (night) for 14–16 days for the hardening stage. In practice, however, it happens quite often that seedlings are exposed to extremely high or low temperature during the nursery period, resulting in severe occurrence of various diseases. The temperature in vinyl houses or vinyl tunnels must carefully be regulated to avoid daytime temperature higher than 30°C, and night temperature lower than 10°C.

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