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A Pedological Approach to Mulberry Root-Rot Incidences in Northeast Thailand

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Abstract

The soils of mulberry fields infected with and without root-rot, were examined to identify pedological causes, if any, in the incidences of root-rot in Nakhon Ratchasima of Northeast Thailand. The results obtained showed that the causes of mulberry root-rot were associated with topographical factors and physical and chemical properties of soils. Among them, the following factors were of particular significance: one was the location near the foot of a gentle concave slope, where water tends to stagnate; and the other was the existence of an impermeable layer in the subsoil, which interfered percolation of water to a lower part of the profile. These factors caused a serious air-deficiency under the extremely wet condition after heavy rainfalls. In addition, a large amount of exchangeable Al appeared to adversely affect the root growth. It is therefore concluded that the root-rot incidences in Northeast Thailand are closely related to pedological status.

Discipline: Soils, fertilizers and plant nutrition
Additional key words: impermeable layer, physical and chemical properties, soil morphology, topography

Introduction

Mulberry root-rot incidences take place frequently in most of Thailand during the rainy season lasting from May to October. The primary diagnostic of the symptom is: the diseased leaves wither and their color turns dark brown due to the depressed growth of root system (Plate 1). In the experimental field of Korat Sericultural Research Center in Nakhon Ratchasima, the symptom has been noticed since the 1970's. The incidences of root-rot sometimes reached nearly 30% of the mulberry growing area in the region. Intensive studies on mulberry root-rot have been carried out in the field of pathology[1,2] and agronomy[6,7]. However, the causes of root-rot have not been identified yet and any proper countermeasure has not been taken, accordingly. The recent study on nematode[5] showed that no nematode was relevant to mulberry root-rot.

The present paper attempts to identify pedological causes affecting mulberry root-rot, which has severely limited the production of mulberry in Northeast Thailand.

Materials and method

Six mulberry fields were selected for the study in

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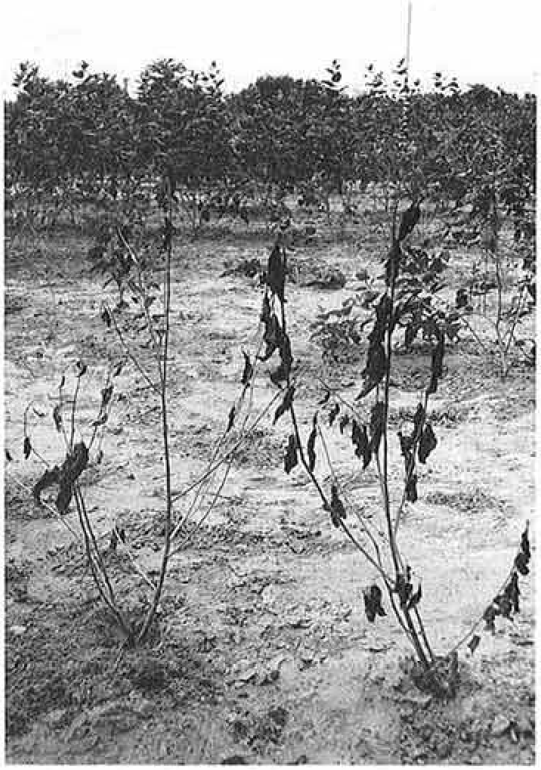

Plate 1. Symptoms of the mulberry trees infected with root-rot at Korat Sericultural Research Center, Thailand

Nakhon Ratchasima province, which is located about 250 km northeast from Bangkok. The six fields included three root-rot infected stites; i.e. sites 1, 2, and 3, and three uninfected sites; i.e. sites 4, 5, and 6.

In each site, a pit was dug and the profile was described. A sample from each horizon was collected for laboratory analyses, which included investigations on physical properties such as particle size distribution, bulk density, three-phase distribution at pF 1.5, and saturated permeability, and on chemical properties such as pH (H_2O), total carbon and nitrogen, and exchangeable cations.

Results and discussion

1) Location, topography and soil morphology

Location, topography and soil classification according to the system of the U.S. Soil Taxonomy[3] are presented in Table 1, and soil morphology is in Table 2.

(1) Root-rot infected sites

Site 1 was located near the foot of a gentle concave slope, adjoining the paddy field. The soil in this site had thick, compact layers under the surface layer. The ferruginous and manganese mottles were observed in the subsoil, indicating the presence of "aquic" moisture regime; i.e. saturation with water and development of reduced state in the rainy season.

Site 2 was placed near the top of the gentle slope. The substratum of this soil was red in color.

Table 1. Location, topography and soil classification of sampling sites

Site	Location	Topography	Soil classification	
			Series	Great group
(Root-rot infected)				
Site 1	Korat Seric. Res. Cen.	Near the foot of a gentle slope	Roi Et series	Paleaquult
Site 2	Phimai Seric. Settlement Project	Near the summit of a gentle slope	Yasothon series	Paleustult
Site 3	Chok Chai Seric. Extension Cen.	Middle of a gentle slope	Nam Phong series	Quartzipsamment
(Root-rot uninfected)				
Site 4	Korat Seric. Res. Cen.	Middle of a gentle slope	Korat series	Paleustult
Site 5	Nong Kok Noi Field of Korat Seric. Res. Cen.	Near the summit of a hill	Warin series	Paleustult
Site 6	Pak Thong Chai Field	Middle of a gentle slope	Chatturat series	Haplustalf

Table 2. Soil morphology of sampling sites

Site	Horizon	Depth (cm)	Color	Texture[a)]	Structure[b)]			Mottling
					Grade	Class	Type	
(Root-rot infected)								
Site 1	Ap	0–20	7.5YR 4/3	LS	1	m	gr	
	B1	20–32	7.5YR 3/3	LS	1	m	sbk	
	B21	32–43	7.5YR 5/4	LS	1	c	sbk	
	B22 tir	43–54	7.5YR 5/4	SL	1	c	sbk	Fe mottles
	B23 tmn	54+	7.5YR 3/4	SL	1	c	sbk	Mn mottles
Site 2	Ap	0–15	2.5YR 3/3	LS	1	m	gr	
	B1 t	15–47	2.5YR 3/6	SL	1	m	sbk	
	B2 t	47+	2.5YR 4/8	SL	1	m	sbk	
Site 3	Ap	0–19	7.5YR 4/3	LS	1	m	gr	
	A3	19–31	7.5YR 4/2	LS	1	m	sbk	
	C11	31–53	7.5YR 6/3	LS	1	m	sbk	
	C12	53–72	7.5YR 7/4	LS			—	
	C13	72+	7.5YR 7/4	LS			—	
(Root-rot uninfected)								
Site 4	Ap	0–24	7.5YR 4/3	SL	1	m	gr	
	B1	24–30	7.5YR 5/3	SL	1	f	sbk	
	B21 t	30–49	7.5YR 5/4	SL	1	m	sbk	
	B22 t	49+	7.5YR 5/4	SL	1	m	sbk	
Site 5	Ap	0–17	5YR 4/4	SL	1	m	gr	
	B2 t	17+	5YR 5/8	SL	1	m	sbk	
Site 6	Ap	0–12	5YR 2/2	L	2	m	gr	
	A3	12–28	5YR 3/3	L	2	m	sbk	
	B1 t	28–49	5YR 4/6	L	2	m	sbk	
	B2 t	49+	5YR 3/6	L	2	m	sbk	

a): Textural class following the system of U.S. Dept. of Agr.
b): Grade: 1–weak; 2–moderate.
Class : f–fine; m–medium; c–coarse.
Type : gr–granular; sbk–subangular blocky.

However, the compact layer and mottlings could not be observed in the profile.

Site 3 was at the middle part of the gentle slope. The experimental field of the Extension Center was divided into several plots of 0.4 ha each by roads of 6 m wide and 40 cm high. Site 3 was placed at the lower edge of a plot. The soil was characterized by a very thick, sandy layer, which was more than 72 cm below the surface.

(2) Uninfected sites

Site 4 was at the middle of the gentle slope. The compact layer and mottlings did not exist in the profile. Site 5 was near the top of the hill. The soil in site 5 was characterized by a reddish brown color under a well-drained condition. Site 6 was at the middle of the gentle slope. The soil was formed from dark reddish brown materials, which were rich in organic matters and clay.

2) Physical properties of soil

Physical properties of the sampled soils and root distribution of the mulberry plants are shown in Table 3.

(1) Root-rot infected sites

In the soil of site 1, the compact layers that were deeper than 20 cm below the surface had an extremely high bulk density and a relatively high solid ratio. Accordingly, the air ratio was very low, i.e. less than 1.5% at pF 1.5. In addition, the saturated permeability was considerably low, i.e. 10^{-6} to 10^{-7} cm/sec. In regard to the root distribution, only a few roots could be seen in the part of 20–43 cm below the

Table 3. Physical properties of the sample soils and root distribution

Site	Depth (cm)	Bulk density (g/cm³)	Three-phase dist. (%) Solid	Liquid	Air	Sat. permeab. (cm/sec)	Abundance of roots[a)]
(Root-rot infected)							
Site 1	0–20	1.49	57.9	31.7	10.4	2.7×10^{-4}	Common
	20–32	1.87	71.4	27.1	1.5	3.3×10^{-6}	Few
	32–43	1.85	66.4	33.5	0.1	1.6×10^{-6}	Few
	43–54	1.78	68.3	31.4	0.3	1.4×10^{-6}	None
	54+	1.77	67.5	32.0	0.5	5.4×10^{-7}	None
Site 2	0–15	1.59	59.8	29.9	10.3	1.3×10^{-3}	Few
	15–47	1.62	62.4	24.5	13.1	5.6×10^{-4}	Few
	47+	1.59	60.0	26.8	13.2	2.0×10^{-3}	None
Site 3	0–19	1.44	55.5	35.8	8.7	1.0×10^{-3}	Common
	19–31	1.59	59.3	30.7	10.0	4.4×10^{-4}	Few
	31–53	1.55	57.2	31.0	11.8	4.2×10^{-4}	Few
	53–72	1.56	58.8	28.5	12.7	5.7×10^{-4}	None
	72+	1.60	58.2	30.6	11.2	6.1×10^{-4}	None
(Root-rot uninfected)							
Site 4	0–24	1.54	55.5	35.8	8.7	8.0×10^{-3}	Common
	24–30	1.58	61.3	33.1	5.6	3.8×10^{-5}	Common
	30–49	1.67	64.4	31.9	3.7	7.0×10^{-5}	Few
	49+	1.61	61.7	32.5	5.8	1.0×10^{-4}	Few
Site 5	0–17	1.57	60.6	31.1	8.3	5.6×10^{-4}	Many
	17+	1.64	61.8	30.4	7.8	7.7×10^{-4}	Common
Site 6	0–12	1.49	56.3	37.5	6.2	7.9×10^{-5}	Common
	12–28	1.56	57.7	34.1	8.2	1.3×10^{-4}	Common
	28–49	1.55	58.1	35.3	6.6	1.1×10^{-4}	Common
	49+	1.60	61.0	35.8	3.2	1.4×10^{-4}	Few

a): The number of roots per square decimeter: None, 0; Very few, 1–20; Few, 20–50; Common, 50–200; Many, >200.

surface, but there were no roots in the deeper part of the profile. It is very likely that the rain water would have frequently stagnated on the soil surface in the rainy season, due to the very low saturated permeability of the compact layers. As a consequence, the air ratio might have been maintained for several days at the critical level for root growth, which was seriously hindered due to severe air-deficiency. The study on cassava root-rot in Northeast Thailand[4] shows a similar result to the above-noted outcomes.

In the soil of sites 2 and 3, there were no deficiencies of physical properties. The causes of root-rot could therefore not be attributed to any physical properties. At site 3, however, some occurrence of root-rot was observed at the lower part of each plot neighboring roads. This suggested that the cause of the disease be associated with excess water stagnating without any outlet in the rainy season.

(2) Uninfected sites

In the soils of the uninfected plots, i.e. sites 4, 5, and 6, no problems could be identified in terms of their physical properties; in other words, no impermeable layers were seen in the profile and water drain was good even in the rainy season.

3) Chemical properties of soil

Chemical properties of the soils are presented in Table 4. Except in the soil at site 6, the nutrient status was generally very low due to their sandy nature.

(1) Root-rot infected sites

In the soil of site 1, the pH (H_2O) value was extremely low, varying from 3.3 to 3.6, except in the depth over 54 cm below the surface. In the low-pH layers, exchangeable Al predominated. Its contents

Table 4. Chemical properties of the sample soils

Site	Depth (cm)	pH (H_2O)	Total C (%)	Total N (%)	Exchangeable cation (me/100 g)				
					Ca	Mg	K	Na	Al
(Root-rot infected)									
Site 1	0−20	3.3	0.51	0.054	0.90	0.16	0.21	0.38	1.37
	20−32	3.5	0.31	0.044	0.46	0.13	0.13	0.31	1.03
	32−43	3.3	0.23	0.033	1.03	0.32	0.08	0.17	1.62
	43−54	3.6	0.23	0.039	1.73	0.72	0.12	0.33	1.91
	54+	6.5	0.19	0.026	5.00	0.83	0.15	0.85	—
Site 2	0−15	5.0	0.55	0.014	1.08	0.29	0.07	0.23	0.34
	15−47	5.4	0.22	0.018	1.19	0.44	0.04	0.07	0.15
	47+	4.8	0.15	0.015	0.49	0.53	0.04	0.12	0.78
Site 3	0−19	6.0	0.69	0.056	3.75	0.78	0.41	0.14	—
	19−31	5.9	0.51	0.049	3.33	0.79	0.43	0.17	—
	31−53	6.6	0.10	0.010	1.19	0.26	0.03	0.21	—
	53−72	7.4	0.12	0.076	1.96	0.19	0.05	0.26	—
	72+	7.2	0.11	0.069	1.21	0.28	0.03	0.18	—
(Root-rot uninfected)									
Site 4	0−24	4.9	0.63	0.056	2.67	0.74	0.38	0.27	0.20
	24−30	5.8	0.36	0.038	3.72	0.81	0.04	0.37	—
	30−49	5.6	0.23	0.027	3.18	0.83	0.08	0.45	—
	49+	4.6	0.19	0.021	3.24	0.81	0.06	0.60	—
Site 5	0−17	6.3	0.19	0.024	2.51	0.53	0.12	0.20	—
	17+	6.7	0.15	0.021	1.29	0.65	0.13	0.12	—
Site 6	0−12	6.4	1.12	0.081	11.45	0.83	0.13	0.21	—
	12−28	6.9	1.10	0.075	11.70	0.83	0.36	0.10	—
	28−49	6.9	0.67	0.051	11.41	0.80	0.43	0.17	—
	49+	6.5	0.44	0.041	12.45	0.62	0.38	0.19	—

were over 1.0 me/100 g, thereby excess of Al as well as deficiency of Ca and Mg was incurred.

Regarding the soil of site 2, exchangeable K contents were relatively low in the profile, possibly adversely affecting the normal growth of mulberry plants. In the soil of site 3, no particular deficiencies in chemical properties were identified.

(2) Uninfected sites

In the soils of the uninfected sites, no deficiencies could be observed in terms of chemical properties.

Conclusion

As seen in the case of site 1, the presence of thick, compact layers with very low permeability below the surface layer may primarily be related to the occurrence of root-rot. The water, stagnating in the surface layer after heavy rainfalls during the rainy season, depressed root growth. In addition, the high content of exchangeable Al may seriously hamper root growth due to the toxicity. To alleviate these problems, drainage of surface water and correcting of acidity would be effective at site 1.

In the case of site 2, very low contents of exchangeable K seemed to limit the mulberry growth. However, a relationship between the root-rot incidences and the low contents of K is not identified yet.

The occurrence of root-rot at the lower edge of each plot neighboring roads in site 3 again suggests that excess water be associated with the disease incidences. Therefore, a drainage system must be urgently improved in the case of site 3.

The studies on mulberry root-rot that were undertaken in the past have never taken into account its relevance to pedological aspects, which might be one of the key factors to identify direct causes of mulberry root-rot in Thailand.

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