Strategies for Biological Control of Soilborne Diseases in Economic Crops in Korea

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MAJOR SOILBORNE DISEASES IN ECONOMIC CROPS

Current researches centers on the Phytophthora blight in hot pepper(*Capsicum annum* L.) and sesame (*Sesamum indicum* L.) of the economic crops in the Department of Plant Pathology, Institute of Agricultural Sciences, Rural Development Administration, Suwon, Korea. From 1986, a research project was initiated by the Special National Development Research fund of the Ministry of Science and Technology for development of a biological control measure. Along the research approach, an interdisplinary research project was organized under RDA Master research development planning. The team was constituted with researchers in the Department of Vegetable Cultivation, Horticulture Experiment Station, researchers in the Departments of Soil Chemistry, Soil Physics, Entomology, and Plant Pathology, IAS. The team members visited the major hot pepper cultivation fields several times during crop season in order to investigate factors affecting hot pepper cultivation. In this presentation, data and information obtained during the disease survey by the interdisciplinary research team will be incorporated for discussion of strategies on the biological control of the Phytophthora diseases.

Korean farmers usually cultivate the same crop in their field continuously so as to bring cultivation hazards especially due to incidences of soilborne diseases. In hot pepper, the Phytophthora blight is one of the most important diseases, which sometimes destroyed the whole plants in the field. In sesame, the causal organism of the Phytophthora blight was identified as caused by *P. nicotianae* var. *parasitica* in 1981. The disease occur severely in southern part of Korea and during late stage of growth after raining season, late July and early August, showing 60% severity in some fields.

In addition, the fusarium wilt in cucurbits and the brittle root rot in the Chinese cabbage will be discussed briefly as one of the serious diseases in vegetable cultivation in Korea(Table 1). The fusarium wilts generally occur in cucurbits such as cucumber, watermelon and melon especially when cultivated in the vinyl house. The brittle root rot occur in chinese cabbage growing in alpine area during summer. The etiological study of the Chinese

Table 1. Major soilborne diseases in economic crops in Korea

Host Crop	Pathogen
Hot pepper (*Capsicum annum*)	*Phytophthora capsici*
Sesame (*Sesamum indicum*)	*Phytophthora nicotianae* var. *parasitica*
Cucurbits	*Fusarium oxysporum*
(*Cucumis sativus*)	f.sp. *cucumerinum*
(*Citrullus vulgaris*)	f.sp. *niveum*
(*Cucumis melo*)	f.sp. *melonis*
Chinese cabbage (*Brassica campestris* subsp. *napus* var. *peckinensis*)	*Aphanomyces raphani*

Table 2. Seasonal incidence of the Phytophthora blight in hot pepper

Disease Severity	Percentage of fields investigated							
	July 1, 1986				September 25, 1986			
	Euiseong	Chungwon	Imsil	Total	Euiseong	Chungwon	Imsil	Total
0	30.0	75.0	20.0	41.7	0.0	40.0	15.0	18.3
0.1−5.0	20.0	5.0	40.0	21.7	20.0	10.0	20.0	16.7
5.1−10.0	20.0	5.0	6.7	15.0	5.0	10.0	15.0	10.0
10.1−20	10.0	10.0	10.0	13.3	10.0	10.0	0.0	6.7
20.1−30	5.0	0.0	0.0	1.7	10.0	10.0	10.0	10.0
Subtotal				*93.3				*61.7
30.1−40	0.0	5.0	0.0	1.7	5.0	0.0	5.0	3.3
40.1−50	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1.7
50.1−100	5.0	0.0	10.0	5.0	50.0	20.0	30.0	33.3
Subtotal				*6.7				*38.3

cabbage disease revealed that the causal organism was *Aphanomyces raphani* Kendrick rather than a complex nature of soilborne pathogens caused it. Since the Chinese cabbage does not grow well in the low land during summer, cultivation of Chinese cabbage in the alpine area had been gradually increased until they came across to the disease problem.

PHYTOPHTHORA BLIGHT IN THE HOT PEPPER

Severity of the Phytophthora blight was investigated in three major production area of Chungwon, Chunbgbuk province, Euiseong, Kyungbuk province and Imsil, Chunbuk province in 1986 crop season. Twenty fields in each area were observed for disease incidence around July 1, 1986 and September 25, 1986. The 93.3% of 60 fields observed showed less than 30% of severity of the disease around July 1, but it was decreased to 61.7% around September 25. However, the fields showing more than 30% of severity was increased from 6.7% to 38.3%(Table 2). The survey results indicated that the primary inoculum sources possibly originated from soilborne pathogens are important in epidemics of the Phytophthora blight. Farmers sow the hot pepper in seed−bed in February and transplanted one or two times temporarily, and transplanted to the field in early May. Therefore, the primary inoculum might orginat during early plant growth; from the contaminated soil, temporary transplanting or after transplanting to the field.

Field observation strongly suggested that severity of the Phytophthora blight could be under economic threshhold if the rate of disease incidence was less than one % until June. The results lead us to investigate the seasonal incidence of the disease. Diseased plants can occur either by infection with the soilborne pathogen or by the spread of the pathogen from the diseased plants under favorable environment. Disease reading was made 10 days after transplanting at 10 days interval in five selected fields at Euiseong(Table 3), at Chungwon (Table 4) and at Imsil(Table 5) in 1987. The

Table 3. Seasonal incidences of the Phytophthora blight in hot pepper (*Capsicum indicum* L.) caused by *P. capsici* at Euiseong, Kyungbuk province in 1987

Field number	No. of plants observed	Disease Severity in 1986	Disease severity(%)				
			M−MAY	E−June	M−June	L−June	E−July
1	2,244	60.10	0.00	0.13	0.45	0.31	0.04
2	2,257	80.00	0.00	0.13	0.93	0.80	0.54
3	2,014	100.00	0.00	0.10	1.14	0.45	0.00
4	6,991	−	0.06	0.44	1.16	1.16	0.00
5	10,493	−	0.00	0.36	2.09	1.81	1.50
Subtotal	23,999		0.06	1.16	5.77	4.53	2.09

Table 4. Seasonal incidences of the Phytophthora blight in hot pepper (*Capsicum indicum* L.) caused by *P. capsici* at Chungwon, Chungbuk province in 1987

Field number	No. of plants observed	1986	Disease severity (%)				
			M-May	E-June	M-June	L-June	E-July
1	7,591	No data	0.00	0.39	4.04	0.91	0.33
2	9,700	100.00	0.00	0.00	0.07	0.09	0.00
3	5,878	No data	0.00	0.01	2.18	3.78	0.42
4	4,700	0.00	0.00	0.00	0.00	0.00	0.00
5	7,800	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal	35,669		0.00	0.40	6.29	4.78	0.55

Table 5. Seasonal incidences of the Phytophthora blight in hot pepper (*Capsicum indicum* L.) caused by *P. capsici* at Imsil, Chunbuk province in 1987

Field number	No. of plants observed	1986	Disease severity (%)				
			M-May	E-June	M-June	L-June	E-July
1	4,730	70.0	0.04	0.14	0.95	1.65	0.32
2	3,562	1.3	0.00	0.00	0.03	0.00	0.00
3	2,451	98.0	0.00	0.00	0.00	0.00	0.16
4	7,800	No data	0.04	0.25	0.93	1.41	0.15
5	8,248	No data	0.00	0.01	0.01	0.06	0.09
Subtotal	26,791		0.08	0.39	1.89	3.12	0.72

diseased plants were found from mid-May at Euiseong and Imsil but not at Chungwon. The total % of diseased plants reached 3.2% until early July at Euiseong, 1.5% at Chungwon, and 1.4% at Imsil. Most of diseased plants appeared to be infected with soilborne pathogens, since it did not rain much until mid-July in 1987. It will be important to determine what level of the primary inoculum plays a significant role in epidemics of the Phytophthora blight under favorable environment. The final disease severity reading will help understanding the relationship between inoculum potential and disese severity.

The rainy season starts from late June and continues until late July. Heavy rainfall comes in August frequently. So rapid spread of the disease might happen during heavy raining by the splashed rain and temporary flooding of the field. Another factor appeared to be the susceptibility of most cultivars to the Phytophthora blight. Some cultivars have been known as resistant to the *P. capsici*, but vulnerability of the cultivar depending upon location of cultivation makes extension personnel hesitate to recommend cultivars to the farmers.

STRATEGIES FOR BIOLOGICAL CONTROL

Chemical control is one of essential control measure for the Phytophthora blight. However, increased inoculum potential can make the efficacy of fungicides so low or inefficiently due to rapid spread nature of the disease, that development of a biological control measure appears to be a must in integral control measure. The main goal of the research was directed for artificial establishment of suppressive soil by using antagonists present in hot pepper or sesame field. The research of the 1st year was focused on isolation and identification of microorganism candidate from soil samples where farmers cultivate hot pepper or sesame continuously. Researches were initiated to find out what organisms are present in soil and which organisms can be used as a biological agent. The micro organism should be isolated purely and identified for further use. For selection of antagonists, to *P. capsici*, 96 fungal isolates, 576 bacterial isolates and 174 isolates in actinomycetes were isolated from soil samples collected from six locations (Table 6). Similarly, 487 microorganisms were obtained from soil samples for selection of antagonists to *P. nicotianae* var. *parasitica* (Table 7).

Table 6. Isolation of soil microorganisms and selection of antagonists to *Phytophthora capsici*

Soil Samples from	Number of isolates				Number of antagonistic isolates			
	Fungi	Bacteria	Others	Total	Fungi	Bacteria	Others	Total
Kyungbuk, Euiseong	0	204	0	204	0	1	1	2
Kangweon, Kangreung	30	84	51	165	0	1	3	4
Kangweon, Samcheok	15	87	51	141	0	1	4	5
Kangweon, Jinbu	18	114	51	183	0	1	3	4
Chungnam, Cheonan	18	18	3	39	0	0	3	3
Chunbuk, Imsil	15	87	39	141	0	1	3	4
Total	96	576	174	846	0	5	17	22

Table 7. Isolation of soil microorganisms and selection of antagonists to *Phytophthora nicotianae* var. *parasitica* (Dastur) Waterhouse

Soil samples from	Number of isolates				Number of isolates			
	Fungi	Bacteria	Others	Total	Fungi	Bacteria	Others	Total
Chungbuk, Chungwon	30	9	6	45	2	0	0	2
Chungnam, Asan	51	68	0	119	0	0	0	0
Kyunggi, Hwaseong	35	21	0	56	0	1	0	0
Kyunggi, Pyeongtaek	10	5	0	15	0	0	0	0
Kyunggi, Suweon	49	24	0	73	0	1	0	1
Kyungbuk, Yecheon	46	40	0	106	0	0	0	0
Jeju	25	21	27	73	4	12	0	16
Total	246	188	33	487	6	14	0	20

Each isolate was tested on PDA by growing *P. capsici* first and by transferring the isolate a few days later in a Petri dish. This test aimed to find out whether there is a antagonistic effect of the test isolate to the growth of the pathogen. The inhibition of mycelial growth of the pathogen might be nothing more than an interesting phenomenon, however, no alternatives appeared to be feasible in selectio of antagonists from numerous soil microorganisms.

Five bacterial isolates and 17 isolates in actinomycetes were selected as antagorists to *P. capsici* from 846 isolates obtained from the soil. Six fungi and 14 bacterial isolates were selected as antagonists to *P. nicotianae* var. *parasitica* (Table 7). The selected isolates showed inhibition zone between the test isolates and *P. capsici* and P. *nicotianae* var. *parasitica*. The most promising antagonists were identified as *Pseudomonas cepacia*, *Bacillus polymixa* and *Bacillus* sp. Three bacterial isolates were identified based on Gram reaction, morphology, cultural and physiological characteristics. For example, the isolate of *Pseudomonas cepacia* was a rod shape(2.3×0.85um), Gram negative, positive in five physiological tests such as oxidase, and O/F tests, and negative in 11 physiological tests such as catalase and methyl red tests.

Inhibition of mycelial growth of *P. capsici* was variable not only depending upon isolates but also upon experimental condition(Table 8). However,

Table 8. Inhibition of growth of *Phytophthora capsici* in potato dextrose agar

Antagonist	Isolate designation	Inhibition of growth(mm)
Pseudomonas cepacia	JC-4	3.2
Bacillus sp.	S-9	3.5
Bacillus polymixa	LH-3	2.8
	UB-7	2.2
	KB-7	0.7
Other actinomyces (17 isolates)		0.9

Table 9. Suppressive effects on the Phytophthora blight in pepper by antagonistic bacteria

Phytophthora capsici plus with	Percentage of Infection
Pseudomonas cepacia	0
Y-5	0
KB-11	0
S 9 and 5 isolates	33
BD 1 and 4 isolates	66
Control and 3 isolates	100

there were differences in suppressive effects on disease development when applied to the soil(Table 9). Although the suppressive effects on symptom development was obtained in the greenhouse tests, it might be encouraging for development of a biological mean with antagonists.

Of course, the results are far behind conclusion of the success of the biological control with antagonists. However, the survey results showed that most fields infested with the Phytophthora blight were deficient of organic compost and in no sufficient application of Ca fertilizer. In the future, and approach will be pursued to develop either a formulate with antagonists or a mixture of antagonists with materials which can also be beneficial as soil amendments.