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Distribution and Changes in Occurrence of Fingerprint Stem Blight of *Eleocharis kuroguwai* Caused by *Epicoccosorus nematosporus* in Korea

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***Epicoccosorus nematosporus* was detected in all 22 counties surveyed, but the frequency of occurrence of fingerprint stem blight disease (FSBD) on *Eleocharis kuroguwai* caused by the fungus varied with fields and regions. The disease occurred more frequently in mountain areas than in plain areas. *E. nematosporus* was detected in less than 20% of plain areas such as Gimjae and Milyang, whereas, it occurred in 40-60% of mountain areas such as Sangju and Jangsoo. In Milyang, mean temperature in July to August 1993 ranged from 17 to 27°C with 14.3 h of dew period. Meanwhile, in the mountain area such as Sangju, Gyeongbook, temperature ranged from 17 to 24°C with 16.1 h of dew period. Plant mortality was 61% in Milyang and 82% in Sangju. Underground tuber formation was highly suppressed at 16 and 33 tubers per plot in Sangju and Milyang, respectively. In 1992 and 1995, plants infected ranged from 40 to 78% in July to September. This sharply decreased to an average of 15% in 1999.**

Keywords : *Eleocharis kuroguwai, Epicoccosorus nematosporus,* distribution, natural occurrence.

Eleocharis kuroguwai is widely distributed in Korea and has caused major weed problem in rice in the country. It is a perennial sedge that propagates mainly by terminal tuber of rhizome (Chang and Kusanagi, 1982; Kim et al., 1977; Kim and Kwon, 1985). The weed is difficult to control because the tuber overwinters in the soil and sprouts irregularly. The most effective control method is hand weeding.

In the summer of 1990, diseased water chestnut plants were observed in rice fields in Sangju and Gyeongbook. The causal organism was identified as *Epicoccosorus nematosporus*, which was subsequently named as fingerprint stem blight disease (FSBD) (Hong et al., 1996). The present study revealed that the fungus is widely distributed in Korea, and seemed to be well adapted in rice fields in the country. Infected *E. kuroguwai* plants showed blighting and ultimately died during the whole season. It has been recorded that the pathogen survived in infected stems of *E. kuroguwai* from the previous year's infection period, and re-infects the host plant (Hong et al., 1996). The effects of dew and temperature on the control efficacy of mycoherbicide have been reported (Elwakil et al., 1990; Kirkpatrick et al., 1982; Makowski and Mortensen, 1990; TeeBeest and Templeton, 1985; Walker, 1981). During the period of new infections due to unfavorable environmental conditions, effectiveness of mycoherbicide depends on the dispersal and secondary infections of these pathogens, which have a functional relationship with the increase in pathogen population. To use an organism as a biological control agent, selection of the promising isolate is most important (Auld et al., 1990; Hong et al., 1996). It must be highly pathogenic to target organisms but not to othercrops. Like other anthracnose diseases (Leonard and Thomson, 1976; Nutman and Roberts, 1960), water chestnut fingerprint shoot blight develops rapidly over a wide range of temperature. Promising biological control agents of pests should be isolated and studied in areas where the target organisms were suppressed naturally (Agrious, 1978).

This research investigated the occurrence of *E. nematosporus* and changes in natural occurrence in rice fields.

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Materials and Methods

Occurrence of *E. nematosporus*. Occurrence of FSBD caused by *E. nematosporus* on *E. kuroguwai* was surveyed in about 220 rice fields in 22 counties during the summer of 1992, 1995, and 1999. Percent (%) of infected plants was obtained after measuring ten fields, with five randomly selected points (0.3 m×2.0 m) per field, in each county.

Experimental design. Field experiments were conducted in two locations: the National Yeongnam Agricultural Experiment Station (NYAES) representing the plain area; and Milyang and Sangju representing the mountain areas. In 1993, 2 m×2 m plots separated by 0.5-m border line were prepared in each location and planted with 100 tubers which were sprouted by presoaking at 25°C for 7 days (Hong et al., 1997). Treatments were arranged in a completely randomized block design with four replications at the end of May. Rice (var. Sangjubyeo) was cultivated and other weeds were hand weeded.

Assessment of the weeding efficacy. The number of diseased shoots and the mortality were counted within 50×50 cm of subsampling site in each plot on August 30. Tuber formation was counted from 50×50×30 cm subplots in each plot at the end of September.

Statistical analysis. Analysis of variance was done using the ANOVA procedure of Statistical Analysis System (SAS Software Co.). All data were analyzed statistically, and treatment means were separated by Duncan's new multiple range test for significance at p=0.05.

Monitoring the meteorological conditions. The average temperatures and dew period were recorded daily from July to August using an agricultural meteorological equipment (Hitachi, Model, AMR 17204). Duration of plant surface wetness was also recorded daily from the start of dew formation until the end the following morning.

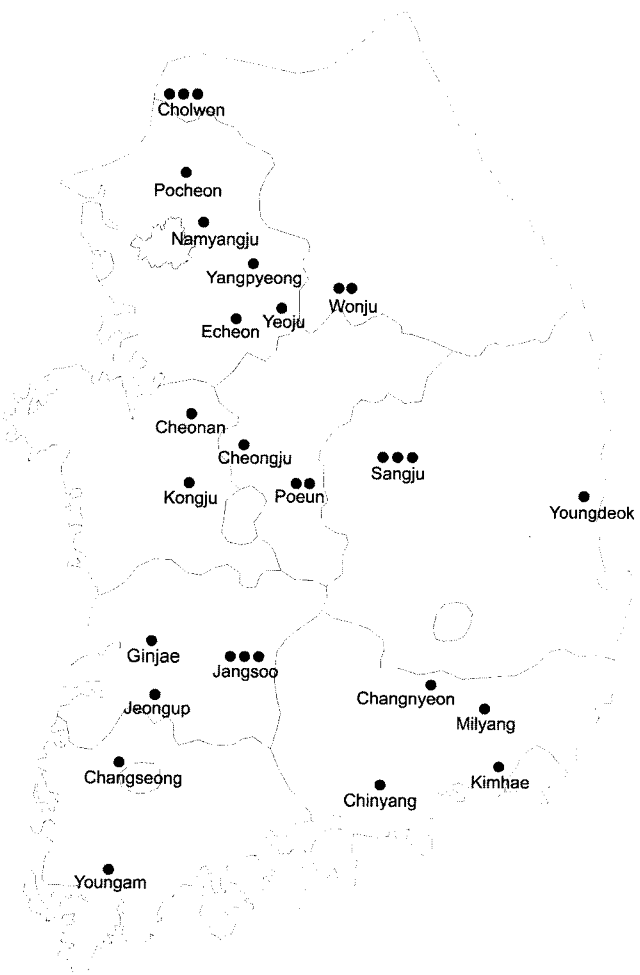

Fig. 1. Distribution of water chestnut fingerprint stem blight disease (FSBD) in rice paddy fields in Korea. ● = Number of fields infected by FSBD: < 20% of the 10 fields surveyed in each site; ●●= 30-50% and; ●●●= > 60%. Fields were surveyed from August to September of 1990-1992.

Results and Discussion

Occurrence of water chestnut FSBD in rice paddy fields in Korea. The disease occurred in all 22 counties surveyed, and the causal fungus was isolated from all surveyed regions. However, the frequency of occurrence varied with fields and regions (Fig. 1). The frequency of occurrence was higher in mountain areas than in plain areas. *E. nematosporus* occurred in less than 20% in plain areas such as Gimjae and Milyang, whereas, it occurred in 40-60% in mountainous areas such as Sangju and Jangsoo. Occurrence of the disease over wide areas suggests that the causal fungus has adapted successfully in rice fields in Korea. The fungus isolated from water chestnut matched previous description of *E. nematosporus* (Hong et al., 1996; Suzuki, 1991).

Effect of geograpical differences on the control of *E. kuroguwai*. In Milyang, mean temperature from July to August 1993 ranged from 17 to 27°C with 14.3 h of dew period. Meanwhile, in the mountain area of Sangju, Kyoungpook, it ranged from 17 to 24°C with 16.1 h of dew period (Table 1).

The percentage of plant mortality was 61.3% in Milyang and 82.8% in Sangju. Underground tuber formation was highly suppressed at 16 and 33 tubers per plot at Sangju and Milyang, respectively. Temperature and dew period affected the disease development (Table 2). These results are consistent with previous reports on mycoherbicide field tests (Elwakil et al., 1990; Kirkpatrick et al., 1982;

Table 1. Temperature and dew period at the two experimental fields, Milyang and Sangju, in 1993

Experimental fields	July-August		
	Temp. (°C) during dew period		Dew period (h)
	Max.	Min.	
Milyang	27.1	17.6	14.3
Sangju	24.1	17.4	16.1

Table 2. Control of *Eleocharis kuroguwai* naturally infected by *Epicoccosorus nematosporus* in different geographic locations

Experimental fields	Percent of infected plants[a]	Percent of plant mortality[b]	No. of tubers[c]
Milyang	70.4 a	61.3 a	33 b[d]
Sangju	92.7 b	82.8 b	16 a

[a] The number of diseased shoots in a plot measured in three 50×50 cm sample site in each plot.
[b] Plant mortality was recorded on August 30, 1993.
[c] The number of tubers was recorded 2 months after inoculation.
[d] Numbers in each column followed by the same letter are not significantly different by Duncan's new multiple range test (p=0.05).

Table 3. Natural occurrence of fingerprint stem blight disease (FSBD) of *Epicoccosorus nematosporus* in rice paddy fields in 1992-1999

Region		Percent of Disease Incidence		
		1992	1995	1999
Mountain Area	Cheolwon	62.5	59.3	–[a]
	Wonju	40.4	45.2	–
	Boeun	50.3	48.5	9.8
	Jangsoo	78.2	69.4	20.3
	Jinan	69.7	70.1	18.9
	Jeongup	43.6	51.5	–
	Sangju	78.5	75.3	11.2
	Average	60.4	59.9	15.1
Plain Area	Pocheon	15.3	18.2	–
	Namyangju	7.8	10.1	–
	Yangpyeong	5.9	5.5	–
	Echeon	10.3	13.9	–
	Yeoju	19.3	–	–
	Cheonan	4.1	–	1.8
	Cheongju	3.6	–	3.5
	Gongju	13.1	16.1	–
	Gimjae	18.1	9.8	2.9
	Jangseong	8.4	–	3.1
	Youngam	5.3	5.6	–
	Jinyang	6.2	3.9	1.9
	Gimhae	5.9	5.6	7.6
	Milyang	11.5	3.8	2.1
	Changnyeong	9.1	10.1	3.6
	Youngdeok	15.3	3.2	3.8
	Average	13.2	8.8	3.4

[a] Not examined

Makowski and Mortensen, 1990; TeeBeest and Templeton, 1985).

Because of the limited scope of this study, the higher incidence of diseases in mountain areas than in plain areas cannot be completely explained. However, it is interesting to note this observation, which may be important in future studies. Mountain areas are known to have higher temperature fluctuation between day and night and longer dew period than in plain areas (Auld et al., 1990) because of higher humidity. Britton (1993) observed that anthracnose infection of dogwood seedlings was very severe in mountain areas than in any other plain area. Thus, different climatic conditions may result in disparity in disease occurrence as shown in this study.

Results also show that FSBD infection may be higher during summer when temperature is favorable and with over 12 h of dew period. Hong et al. (1996) reported that the first symptoms on water chestnut at paddy rice field in Korea appeared in late July and early August. Twenty to thirty (20-30) day old water chestnuts are the most heavily infected which usually occurs in mid-July. When hot and dry conditions prevail after field application of *E. nematosporus,* infection rates are low, and disease development is slow, giving poor control of water chestnut. Therefore, application should be properly timed to achieve optimum conditions in the field (Makowski and Mortensen, 1989; Mortensen, 1988). Environmental factors directly affect the interactions between host and pathogen, and their presence, absence, amount, and duration may be important (Colhoun, 1973). Understanding the effects of dew periods on *E. nematosporus* will help determine the application and suitable formulation to provide a consistent level of weed control.

Natural occurrence of FSBD of *E. nematosporus*. In the mountain area, plant infection ranged from 40 to 78% from July to September 1992. The occurrence level of FSBD was at an average of 59% in 1995. The incidence sharply decreased to an average of 15% in the mountain areas in 1999. The disease incidence in the plain areas of Gimjae and Gimhae was relatively very low, whereas, in the mountain areas of Cheolwon, Jangsu and Sangju, it was very high. It was observed that the incidence of FSBD was significantly reduced as time went by. In the farmer's field, weed control was usually focused on *E. kuroguwai*. Thus, the shelter of the pathogen (mycoherbicide) may be reduced. Another reason could be that since agrochemicals are frequently and continuously used to control rice blast, sheath blight and other diseases, FSBD may be suppressed by the application these agrochemicals. A previous study showed that two fungicides, tricyclazole (WP 75%) and neoasozin (SL 6.5%), applied for 3 consecutive years reduced the development of FSBD (Hong et al., 1999).

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