한국식물보호학회지 : 제20권 제 3 호
Korean J. Pl. Prot. 20(3) : 146~151 (1981)

Ecological Studies of Bakanae Disease of Rice, Caused by *Gibberella fujikuroi*

Chang Kyu Kim*

벼 키다리病의 發生生態에 關한 硏究

金 章 圭*

ABSTRACT

Two rice cultivars infected by *Gibberella fujikuroi* were tested to investigate the sequential change of disease development in the field conditions. In the preliminary test, the seeds of Nongbaek and an unknown cultivar showed 21 and 31.7% infection by *G. fujikuroi.* At the late stage of water nursery bed, some seedlings produced typical elongation symptom of bakanae disease and most of the leaves were dried up within a few days after transplanting. Out of the healthy looking seedlings, some plants also developed bakanae symptoms from middle June being two week after transplanting and the number was increased until middle September.

INTRODUCTION

Since Hori had first observed and reported bakanae disease in 1898 in Japan, Sawada reported the disease being a seed-borne disease in 1917 and Kurosawa (1926) clarified that bakanae disease was caused by the toxic material excreted by the pathogen. This toxic material, known as gibberellin, was later discovered as a plant hormone by Yabuda et al. in 1940(Cited by Umehara, 1975).

A bulk of observations and researches on bakanae disease has been done in Japan since early 20th century. As a result, infection phase by conidiospore (Sasaki, 1971), infection phase at flowering stage (Furuta, 1970), epidemiological studies of bakanae disease(Kawase et al.; Kijima; Ishii; and Horiuchi et al., 1975), and effect of fungicides for disinfection of rice seed(Chugoku Natl. Agric. Exp. Sta., 1975) were reported.

Main source of inoculum for infection is known as conidiospore and dispersal of conidiospore is mostly accomplished at midnight or right after rainfall during daytime (Sasaki, 1971).

Recently a series of factors related with bakanae disease such as inoculum potential and disease severity, temperature favorable for bakanae infection, relative humidity in relation with conidial formation and release of *G. fujikuroi*, and survival of *G. fujikuroi* conidia in rice seeds was found by IRRI (1980).

Bakanae disease was observed from long time ago in Korea but the disease was not so serious until middle 1970s. One of the serious problems

* Plant Pathology Department, Institute of Agricultural Sciences, Suweon, Korea 170.
農業技術硏究所 病理硏究擔當官室, 水原, 韓國, 170.

for the control of bakanae disease is those healthy looking plants in the nursery stage, because they produce symptoms at different stages after transplanting (Kim, 1981). The main purpose of this experiment was to investigate the seasonal change of bakanae disease development with infected seeds.

MATERIALS AND METHODS

Varieties Tested: Two rice seeds infected by *Gibberella fujikuroi* were used. One was Nongbaek which is widely grown in Gangweon area and the other was an unknown cultivar collected from Unbong, Jeonbug province.

Mode of Seedbed: Pregerminated seeds were broadcasted in the water nursery bed on April 20 th of 1976 and the seedlings were transplanted on May 31st at $150m^2$ plot per variety.

Items for Observation: Percentage seed infection was preliminarily checked in the laboratory by blotter method. Plant height and number of tillers were periodically measured from June 28 until August 16. Disease development was observed by seven day interval from middle July until middle September.

RESULTS AND DISCUSSION

Percenatage seed infcetion by *G. fujikuroi* for Nongbaek was 21% and 31.7% for an unknown cultivar in the preliminary test using blotter method (Table 1).

At the late stage of seed nursery, some seedlings showed typical elongation symptom of bakanae disease. Therefore, the elongated ones and healthy looking ones were separately transplanted. When the elongated seedlings at the water nursery bed were transplanted, most of the leaves were dried up within a few days and abundant sporulation was observed on the remained culms. However, some seedlings produced new tillers and remained healthy until late crop season. Quite opposite opinion was reported by Isaka et al. (1974) and Horiuchi et al. (1975) stating that once the elongated seedlings were potted after collecton, new tillers did not exhibit the characteristics of bakanae symptom and became healthy. Isaka et al. (1974) thought that it was very difficult to consider those elongated seedlings as bakanae infected plants due to the recovery of elongated seedlings. But the author considers the elongated seedlings are bakanae infected because they produce conidiospores on the culms.

When the healthy looking seedlings at the water nursery bed were transplanted, some plants devel oped typical symptom of bakanae disease two week after transplanting. This same relationship was well observed by Aoki and Isaka(1975). As plant growth status, plant height and number of tillers were periodically measured for the healthy plants and infected ones (Table 2). The number of tillers was smaller in infected plants than healthy ones for the both varieties. It is common that plant height of infected plants by *G. fujikuroi* is taller than healthy ones. However, plant height of infected plants in unknown cultivar was shorter than healthy ones from August 2nd as in Table 2. This was mainly due to the drying up of the infected plant's leaves.

Table 1. Percentage detection of *Gibberella fujikuroi* from seeds of two rice cultivars.

Nongbaek				Unknown cultivar collected from Unbong			
I	II	III	Mean	I	II	III	Mean
15	24	24	21.0%	42	20	33	31.7%

Once the plants produced the elongation symptom, most of them were complectely dried up and very few plants remained partially dried up(Table 3).Out of completely dried up plants, majority were missing and the number was gradually increased, while the remained culms produced tremendous number of propagules of *G. fujikuroi*. Unknown cultivar produced more symptoms than Nongbaek and nonsporulationg plants for both varieties were present only in early stage after elongation.

The sporulation point of *G. fujikuroi* in the elongated plants in the nursery bed was measured after transplanting. As shown in Table 4, the height of sporulation point gradually went up until late growth stage in both completely and partially

Table 2. Plant height and number of tillers for healthy plants and infected plants by *Gibberella fujikuroi* in two rice cultivars.

Date observed		Unknown cultivar collected from Unbong				Nongbaek			
		Healthy plants		Infected plants		Healthy plants		Infected plants	
		Plant[a] height	No. of tillers	Plant height	No. of tillers	Plant height	No. of tillers	Plant height	No. of tillers
June	28	39.8	7.0	50.0	4.9	39.8	8.8	53.4	3.0
July	5	39.0	11.6	55.6	6.1	40.4	13.4	64.2	4.0
	13	47.6	16.2	56.6	8.5	47.2	16.6	65.9	5.0
	19	60.0	14.0	61.2	10.0	58.9	18.6	71.6	6.9
	26	66.5	14.6	71.1	8.0	65.5	14.6	82.8	6.9
Aug	2	83.4	14.6	80.1	5.6	74.0	13.2	92.5	6.3
	9	101.1	13.6	88.6	6.8	89.0	12.8	101.1	6.0
	16	103.5	14.0	97.1	7.3	106.5	14.0	106.2	8.8

[a]: Plant height is measured by centimeters.

dried up plants of unknown cultivar while in Nongbaek the elongated plants were missed in early stage.

At the same time the sporulation point of those plants elongated after transplanting also went up high until late growth stage in both varieties(Table 5). As a result, the percentage height of sporulation point vs. plant height was ranged from 25 to 60% for an unknown cultivar and 25 to 40% for Nongbaek in early August.

Table 3. Number of elongated plants infected by *Gibberella fujikuroi* in two rice cultivars.

Variety	Number of plants with different conditions	Date observed									
		July		August						September	
		14	21	27	3	10	18	25	31	7	14
	Completely dried up	59	106	129	148	155	156	159	172	177	183
	Missing plants	3	78	100	114	129	143	143	145	145	157
Unknown	Sporulating plants	18	25	28	34	26	13	16	27	32	26
cultivar	Non-sporulating plants	38	3	1	0	0	0	0	0	0	0
collected from	Partially dried up	8	21	21	14	10	9	13	7	6	0
Unbong	Sporulating plants	7	11	21	14	10	9	13	7	6	0
	Non-sporulating plants	1	10	0	0	0	0	0	0	0	0
	Completely dried up	5	9	18	19	25	26	27	31	31	31
	Missing plants	3	3	12	14	22	25	25	27	27	27
	Sporulating plants	2	5	6	5	3	1	2	4	4	4
Nongbaek	Non-sporulating plants	0	1	0	0	0	0	0	0	0	0
	Partially dried up	2	4	4	5	2	3	5	1	1	1
	Sporulating plants	2	4	4	5	2	3	5	1	1	1
	Non-sporulating plants	0	0	0	0	0	0	0	0	0	0

Based upon these results, it was concluded that the infected plants started sporulation about one week after symptom sppearance and the main soure of inoculum for seed infection was considered to be those plants elongated in middle July.

摘　要

벼 키다리病에 感染된 農白과 雲峰產種子를 물못자리에서 育苗하여 못자리徒長苗와 健全苗를 區分, 移秧

Table 4. The height of conidiospores of *G. fujikuroi* present in the elongated plants in the nursery bed.

Variety	Height of conidiospores present[a]	Date observed									
		July			August					September	
		14	21	27	3	10	18	25	31	7	14
	Completely idred up										
	Mean	—	32.3	31.4	24.0	—	47.4	41.9	53.9	46.0	48.1
Unknown	Top	—	47.5	40.6	—	—	—	50.6	57.0	49.5	61.4
cultivar	Bottom	—	22.0	24.0	—	—	—	37.2	48.8	42.5	41.0
collected	Partially dried up										
from	Mean	23.5	19.8	22.0	34.7	44.0	43.9	46.2	42.5	52.5	—
Unbong	Top	36.0	26.7	28.2	38.0	46.0	52.5	—	—	63.0	—
	Bottom	13.6	10.8	12.4	32.3	41.5	37.8	—	—	42.0	—
	Completely dried up										
	Mean	23.2	15.3	—	—	—	—	—	—	—	—
	Top	—	18.5	—	—	—	—	—	—	—	—
	Bottom	—	12.0	—	—	—	—	—	—	—	—
Nongbaek	Partially dried up										
	Mean	23.5	20.3	16.5	15.8	18.0	—	—	—	—	—
	Top	28.0	—	—	—	—	—	—	—	—	—
	Bottom	19.0	—	—	—	—	—	—	—	—	—

[a]: Height of conidiospores present was measured by centimeters.

Table 5. The height of conidiospores of *G. fujikuroi* present in the elongated plants of two rice cultivars after transplanting.

Variety	Height of conidiospores present[a]	Date observed									
		July			August					September	
		14	21	27	3	10	18	25	31	7	14
	Completely dried up										
	Mean	23.1	23.3	29.7	33.1	37.9	40.4	47.3	52.5	57.2	52.1
Unknown	Top	39.2	34.0	40.0	48.0	48.0	55.8	66.4	75.6	84.0	64.2
cultivar	Bottom	9.7	10.7	13.0	20.0	20.0	28.5	38.0	37.1	26.0	37.8
collected	Partially dried up										
from	Mean	16.5	20.2	22.7	29.2	39.2	45.4	49.5	62.7	58.2	—
Unbong	Top	25.7	45.8	37.2	42.5	54.2	60.6	71.0	72.2	73.0	—
	Bottom	7.0	8.0	10.0	8.8	34.0	31.4	31.8	35.3	34.0	—
	Completely dried up										
	Mean	14.9	22.7	33.0	33.7	34.6	46.0	42.0	54.7	64.2	62.9
	Top	17.5	29.4	39.2	41.0	39.2	—	47.5	60.5	72.0	67.0
	Bottom	12.2	18.0	21.8	22.6	28.0	—	36.4	41.7	56.2	55.0
Nongbaek	Partially dried up										
	Mean	17.0	17.8	26.6	30.5	35.7	36.7	47.5	70.5	64.0	54.8
	Top	19.5	27.8	31.0	39.5	36.4	53.2	64.6	—	—	—
	Bottom	14.4	12.2	21.2	21.8	35.0	22.4	39.0	—	—	—

[a]: Height of conidiospores present was measured by centimeters.

였하다. 못자리徒長苗는 移秧後 大部分의 잎이 短時日 안에 枯死하였으나 남은 줄기에서는 分生胞子의 形成이 많았다. 이보다 먼저 實施한 室內試驗에 雲峰產種子는 31.7% 農白은 21%의 種子感染率을 나타냈다.

한편, 못자리에서 健全하게 보였던 苗에서는 移秧後 約 2週되는 6月中旬부터 典型的인 病徵을 나타내기 시작하여 1週日後에는 胞子形成과 同時에 枯死하기 시작하였다.

徒長苗의 狀態를 完全枯死株와 部分枯死株로 區分하여 調査한 結果, 完全枯死株는 時日이 經過하면서 增加하지만 部分枯死株는 줄어 들었다. 또한 完全枯死株에서는 欠株數가 增加하고 分生胞子形成株는 큰 變動이 없으나 無形成株는 初期에만 存在하였다.

徒長苗에서의 分生胞子形成높이는 漸次 높아지는데 8月初旬 雲峰產은 胞子形成높이가 草長의 約 60%, 平均높이는 約 40%, 農白에서는 最高높이 約 40%, 平均 높이는 34% 前後였다.

結論的으로 못자리에서 徒長한 苗는 移秧後 大部分이 곧 枯死하지만 肉眼으로 識別不能의 保菌苗가 問題視되며 圃場에서 徒長하면 1週日 後에는 分生胞子形成이 시작되고 벼알感染의 主傳染源은 7月中旬의 徒長苗로 觀察되었다.

LITERATURE CITED

Aoki, M. and M. Isaka. 1975. Studies on"Bakanae" disease of rice plant. Some observations on the growing process and symptoms of elongated seeldlings in the paddy field. (In Japanese); Proc. Assoc. Pl. Prot. Hokuriku. 23 : 24-27.

Chugoku Natl. Agri. Exp. Sta. 1975. Report of the coperative research in Kinki-Chugoku region. (In Japaness). 6 : 23-79.

Furuta, T. 1970. Problems on the infection and control of rice bakanae disease.(In Japanese); Plant Prot. Japan. 24 : 141-144.

Horiuchi, S. and M. Ishii. 1975. Recovery of "Bakanae" diseased seedling after transplanting in paddy field. (In Japanese); Report of the cooperative research in Kinki-Chugoku region. Chugoku Natl. Agric. Exp. Sta. 6 : 18-22.

IRRI (The International Rice Research Institute). 1980. Bakanae disease infection and yield loss. Annual Report for 1979. 173-173.

Isaka, M. and M. Aoki. 1974. Development fo bakanae disease by transplanting elongated seedlings. (In Japanese); Proc. Assoc. Pl. Prot. Hokuriku. 22 : 108-109.

Ishii, M. 1975. Infection of healthy seeds from infected seeds of "Bakanae" disease in the course of seed soaking before germination and during raising period of rice seedlings. (In Japanese); Report of the cooperative research in Kinki-Chugoku region. Chugoku Natl. Agric. Exp. Sta. 6. 8-14.

Kawase, Y. and K. Goda. 1975. Severity and damage of "Bakanae" diseased rice plants raised in seedling box and planted with rice transplanter. (In Japanese): *Ibid.* 2-6.

Kijima, Y. 1975. Influence of nursery conditions on occurrence of "Bakanae" disease of rice plant. (In Japanese); *Ibid.* 6-7.

Kijima, Y. 1975. Occurrence of "Bakanae" disease in early and ordinary cultivation of rice plant. (In Japanese); *Ibid.* 16-18.

Kim, C.K. 1981. Ecological studies of bakanae disease of rice, caused by *Gibberella fujikuroi*. (Abstract); *IN* Proceedings of seed pathology workshop. Inst. of Agri. Sci and Development. College of Agriculture, Seoul National University. Suweon, Korea. 107-108.

Sasaki, T. 1971. Dispersal of conidiospore of rice bakanae disease. (Abstr., In Japanese); Ann. Phytopath. Soc. Japan. 37-163.

Umehara, Y. 1975. Infection of "Bakanae" disease of rice plant. (In Japanese); Proc. Assoc. Pl. Prot. Hokuriku. 23 : 10-14.