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Investigation of Incubation Period of Neck Blast in Rice Plants

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목稻熱病의 潛伏期間究明 試驗

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ABSTRACT

Incubation period of rice neck blast was investigated by injection of conidial suspension of *Pyricularia oryzae* into young panicles inside the flag leaf sheath at booting stage. Eleven to fifteen days were taken for symptom appearance from the date of injection. About two days were taken from conidia germination until infection occurred, the incubation period was determined as nine to thirteen days for the symptom development of neck blast in rice plants.

INTRODUCTION

As one of the most serious rice diseases, the blast disease occurs at any growth stage of rice plants, leaf blast, neck blast, node blast, kernel blast, and so on. Rice blast disease has been thoroughly studied by many researchers on various aspects of pathogenesis and the causal organism *Pyricularia oryzae* (7, 10, 11, 13, 15).

Hemmi *et al.* (3) and Yoshino (14) studied the incubation period of leaf blast incidence at different temperature ranges. Hirano *et al.* (4) reported that the incubation period of neck blast was 8.3~12.1 days by spray inoculation under the greenhouse conditions and Kato *et al.* (6) studied the incubation period by spray inoculation under the field conditions.

Cultivation pattern of rice has been greatly changed since early 1970s when Indica x Japonica hybrid cultivars were released in Korea. The main objective of this research was to find out the incubation period for neck blast by artificial injection inoculation in the field conditions. The author is indebted to Dr. E.K. Cho for his advice in the preparation of this manuscript.

MATERIALS AND METHODS

Cultural Practices: Four rice cultivars, Milyang 23, Milyang 30, Akibare and Nagdongbyeo were used for field trials in 1981. Four rice cultivars, Milyang 23, Pungsanbyeo, Jinjubyeo and Dongjinbyeo were used for greenhouse trials in 1982. Rice was cultivated by the standard method but 50% of N fertilizer was more applied to induce disease development.

Inoculation: For field trials, races of *Pyricularia*

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Table 1. Infection status of panicle base by *Pyricularia oyzae* on four cultivars before and after heading.

Cultivar	Darte and number of panicle bases infected tby *P. oryzae*							
	Aug. 7	12[a]	17	22[b]	27	Sept. 1	6	11
Milyang 23	0[c]	1	3	10	9	9	—	—
Milyang 30	0	0	0	0	0	0	—	—
Akibare	—	—	3	1	2	0	1	0
Nagdongbyeo	—	—	0	0	0	0	0	0

[a] Date of heading for Milyang 23 and Milyang 30.

[b] Date of heading for Akibare and Nagdongbyeo.

[c] Number infected out of 10 panicle bases.

oryzae KI-307 and KI-315, pathogenic to Tongil type cultivars and races KJ-105 and KJ-301 pathogenic to Japonica type cultivars were mixed in the same ratio. Spore suspension at the concentration of 10^4 spores/ml was injected into the sheath of rice plants at booting stage. For greenhouse trials, race KI-307 pathogenic to Tongil type cultivars and race KJ-413 pathogenic to Japonica type cultivars were injected at the concentrations of 0.5×10^4, 1.0×10^4, 1.5×10^4 and 2.0×10^4 spores/ml, respectively.

Infection Status of Panicle Base Near Heading Time : Ten healthy looking panicles of each cultivar were collected by 5-day interval from the 5th day before heading to the 20th after heading. Infection of panicle base was checked by sporulation 7 days after treatment by Blotter method.

The Incubation Period and Time Required for Heading: Time required for heading (from first panicle tip visible until panicle base completely emerged out of the flag leaf sheath) was measured under the natural conditions and by artificial injection inoculation. Incubation period was measured based upon duration from completion of heading to the first symptom appearance of neck blast disease.

RESULTS

The rice cultivar Akibare only showed infection with *P. oryzae* before and after heading. Panicle bases of Milyang 23 showed infection from heading time and over 90% infection from 10 days after heading. However, cultivars Milyang 30 and Nagdongbyeo showed no infection at all throughout the investigation (Table 1).

Table 2. Days required for the completion of heading under the natural conditions.

Cultivar	Days required	Status of heading*	
		Complete	Incomplete
Milyang 23	4.7	11	9
Milyang 30	3.7	20	0
Akibare	3.4	20	0
Nagdongbyeo	3.2	20	0

*Figures indicate number out of 20 panicles per cultivar.

Time required for heading was compared with four cultivars under the natural conditions and by artificial inoculation. Period required for heading was variable depending upon rice cultivars tested: 4.7 days for Milyang 23, 3.7 days for Milying 30, 3.4 days for Akibare and 3.2 days for Nagdongbyeo under the natural conditions (Table 2). However, heading was delayed in all test cultivars by 0.3~2.2 days when artificial injection inoculation was made with conidial suspension of *P. oryzae* at booting stage (Table 3). Most of the panicle bases exserted completely out of the flag leaf sheath under the natural conditons except Milyang 23 (Table 2), while exsertion of paincle bases was greatly distur bed by injection inoculation before heading (Table 3). For instance, two panicle bases of Milyang 23 showed complete exsertion, five stopped heading at 1/3 or 1/2 of a panicle length, and panicle tips of two

Table 3. Days required for heading by artificial injection inoculation of *P. oryzae* suspension at booting stage.

Cultivar	Days required	Status of heading* (No./10 panicles)			
		Complete	Incomplete	Stopped	No exsertion
Milyang 23	5.0	2	1	5	2
Milyang 30	5.9	2	5	3	0
Akibare	4.5	5	1	4	0
Nagdongbyeo	3.8	4	1	5	0

*Complete : Panicle base completely emerged out the flag leaf sheath.
Incomplete : Panicle base not completely emerged out of the flag leaf sheath.
Stopped : 1/3-1/2 of a panicle exserted.
No exsertion : Panicle tip not visible from the flag leaf sheath.

Table 4. Days required for the symptom appearance of neck and branch blast after completion of heading under the natural condition.

Cultivar	Days required for symptom appearance of					
	Neck blast			Panicle branch blast		
	Total No.* of panicles	Mean	Range	Total No. of panicles	Mean	Range
Milyang 23	11	12.4	8~16	8	16.3	11~22
Milyang 30				1	14	
Akibare	1	8				
Nagdongbyeo				2	9	8~10

*Figures indicate number of panicle base/1st panicle branches showing blast symptom out of 20 panicles per cultivar.

Table 5. Days required for the symptom appearance of neck blast by artificial injection inoculation with *P. oryzae* suspension* at booting stage in the field conditions.

Cultivar	Days required for symptom appearance from		
	Inoculation date	First panicle tip visible	Panicle base Completely emerged
Milyang 23	10.9	9.0	5.0
Milyang 30	15.1	13.7	7.5
Akibare	12.7	11.0	4.4
Nagdongbyeo	13.4	10.0	7.3

*Spore suspension was adjusted to 10^4 spores/ml.
Races of *P. oryzae* for Tongil type cultivars: Mixture of races KI-307 and KI-315.
Races of *P. oryzae* for Japonica type cultivars: Mixture of races KJ-105 and KJ-301.

were not visible at all.

Period for symptom appearance of neck blast disease was investigated under the natural conditions and by injection inoculation. Under the natural conditions, neck blast symptom was not observed on Milyang 30 and Nagdongbyeo, but 11 panicle bases of Milyang 23 out of 20 samples were diseased (Table 4). Out of 11 panicle bases observed in Milyang 23, period for symptom appearance ranged from 8 to 16 days showing 12.4 days in average of the total 11 panicles. On the contrary, period for panicle branch blast development was in the range of 11 to 22 days with 16.3 days in average in Milyang 23.

When the young panicles inside the leaf sheath

Table 6. Days required for the symptom appearance of neck blast by artificial injection inoculation with different concentration of *P. orzyae* suspension[a] to potted rice plants at booting stage.

Cultivar	Days required for symptom appearance at the spore concentration of			
	0.5×10^4/ml	1.0×10^4/ml	1.5×10^4/ml	2.0×10^4/ml
Milyang 23	—[b]	10.5	—	—
Pungsanbyeo	—	9.0	—	12.0
Jinjubyeo	10.0	—	9.5	8.0
Dongjinbyeo	—	10.0	—	—

[a] Races used : KI-307 for Milyang 23 and Pungsanbyeo.
KJ-413 for Jinbyeo and Dongjinbyeo.
[b] Unable to check due to the ununiform heading.

were inoculated by injection method, the period for symptom appearance was variable depending upon cultivars tested and stage: the period ranged 10.9~15.1 days from the date of inoculation, 9.0~13.7 days from first panicle tip visible and 4.4~7.5 days from panicle base completely emerged (Table 5). When injection inoculation was made with different concentrations of *P. oryzae*, neck blast symptoms appeared on the panicle bases ranging from 9.0 to 10.5 days from the date of inoculation at 1.0×10^4 spores/ml (Table 6). However, period for symptom appearance was not able to be determined at the concentrations of 0.5, 1.5, 2.0×10^4 spores/ml because of the ununiform heading disturbed by artificial inoculation except Jinjubyeo.

The incubation period for symptom appearance of neck blast in the rice plants determined by artificial injection inoculation was nine to thirteen days, considering about two days necessary for conidia germination, appressorium formation, penetration and infection to occur.

DISCUSSION

In the life histroy of the rice blast fungus, *Pyricularia oryzae*, and the rice plant, infection of panicle bases at heading stage is the most critical for yield loss due to the blast disease. The tissue of panicle base near heading time is very soft and is easily attacked by the rice blast fungus(1, 2, 8) Ono *et al.* (8) reported that infection of panicle bases occurred mostly from the beginning of sheath opening until two days after heading, which finally led to empty panicles. In the present study, panicle bases of Akibare and Milyang 23 were infected before and after heading. Thus rice cultivars such as Milyang 23 and Akibare resulted in heavy infection with blast at the heading stage and severe yield losses at the ripening stage. Yamanuki *et al.* (12) also reported that early infection of panicle bases with *P. oryzae* resulted in a great damage at later stage.

Various factors are known to affect the incubation period for the symptom appearance of neck blast(1, 4, 5, 6, 9): susceptibility of the rice cultivar, combination between rice cultivar and races of *P. oryzae*, inoculm potential, and environmental conditions such as temperature, rainfall, artificial shading and cultural practices. Adachi (1) reported that the incubation period of neck or panicle branch blast was extended when the interval from heading to artificial inoculation was short. However, the incubation period for neck blast symptom development was shortened by later inoculation after heading (4) and artificial shading before or after inoculation (5). The incubation period was reported to be 5~6 days at 25±1C for leaf leaf blast (3), and for neck blast 8.3~12.1 days (4) or 9~12 days(6).

In the present study, periods taken for the first appearance of neck blast symptom were checked under natural conditions and by artificial inoculation to determine the incubation period for neck blast symptom appearance. As a result, neck blast symptom was firstly observed 8 days after complete exsertion of panicle base under the natural conditons, which

was similar to 6~7 days by Ono *et al.* (8) and 6~8 days by Kato *etal.* (6). It is, however, difficult to determine the incubation period from the above result, because the time of infection is unknown. Thus, the incubation period was determined based upon the results obtained by injection inoculation.

Periods taken for the first appearance of neck blast symptom by artificial inoculation ranged 10.9 ~15.1 days. Considering periods taken from conidia germination until infection occurred were about two days, the actual incubation period for the symptom appearance of neck blast was determined as nine to thirteen days. This was similar to the results obtained by Hirano *et al.*(4) and Kato *et al.*(6). Hirano *et al.* reported that the incubation period of neck blast was about 8.3~12.1 days under the greenhouse conditions at 26°C, varying with plant age or time of inoculation, while Kato *et al.* reported that the incubation period ranged 9~12 days by spray inoculation under the field conditions at 18.1~28.4°C of daily mean temperature.

Based upon these results, it was considered that the inocubation period for neck blast symptom appearance wasnine to thirteen days.

摘 要

穗孕期에 止葉葉鞘內의 幼穗를 稻熱病菌胞子懸濁液으로 注射接種後 목稻熱病病徵發現時의 潛伏期間을 究明하였다. 接種日로부터 病徵發現時까지 10.9~15.1日이 所要되었는데 病原菌의 發芽, 付着器形成, 侵入, 感染이 일어나기까지의 所要日數 約 2日間을 勘案할때 목稻熱病의 潛伏期間은 9日에서 13日 사이로 測定되었다.

LITERATURE CITED

1. Adachi, M. 1960. Studies on the infetion period of branch blast and neck blast of rice and its chemical control. Chugoku Agric. Res. 17 and Shikoku Agric. Res. 7 : 39~42. (In Japanese)
2. Goto, K. and K. Hirano. 1957. Panicle branch blast occurred by inoculation at different stage. Ann. Phytopath. Soc. Japan. 22 : 3. (Abstr. In Japanese)
3. Hemmi, T., T. Abe, J. Ikeya and Y. Inoue. 1936. Studies on the rice blast disease Ⅳ. Relation of the environment to the development of blast disease and physiologic specialization in the rice blast fungus. Rural Imporvement Material 105, Japan. 1~145 (In Japanese)
4. Hirano, K.and K. Goto. 1963. Pathogenesis and ecology of panicle branch blast of rice plant. Bull. Nat. Inst. Agr. Sci. 16. Series C: 1~66. (In Japanese, English summary)
5. Imura, J. 1940. Influence of sunshine on the incubation period and disease severity of rice blast disease and brown spot. Ann. Phytopath. Soc. Japan. 10 : 16~26 (In Japanese, English summary)
6. Kato, H. and T. Sasaki. 1974. Epidemiological studies of rice blast disease, with special reference to reproductive process in lesions on rice plants and disease forecast. Bull. Natl. Inst. Agr. Sci. 28. Series C: 1~61 (In Japanese, English summary)
7. Ohata, K., K. Goto and T. Kozaka. 1966. Effects of low air temperature on the susceptibility of rice plants to blast disease, with special reference to some chemical components in the plants. Bull. Natl. Inst. Agr. Sci. 20. Series C: 1~65. (In Japanese, English summary)
8. Ono, K. and H. Suzuki. 1960. Studies on the mechanism of infection and ecology of blast and stem rot of rice plant. Special Research Reports on Disease and Insect Forecasting No. 4. Ministry of Agriculture and Foresty, Japan. 1~56. (In Japanese, English summary)
9. Sakurai, Y. and S. Kano. 1958. Relationship between days after heading and infection of rice neck blast disease. Ann. Rept. Plant Port North Japan 9 : 47~49 (In Japanese)
10. Suzuki, Ha. 1940. The relationship between the difference of susceptibility of the rice plants to blast disease and penetration. Agriculture and Horticulture 15 : 1999~2010. (In Japanese)
11. Suzuki, Ho. 1969. Studies on the behaviour of rice blast fungus spore and application to outbreak forecast of rice blastgdisease. Bull. Hokuriku Agr. Exp. Sta. 10 : 1~118.
12. Yamanuki, S., T. Iwata and T. Narita. 1956. Observation on the early infection period and

position of rice neck blast. Ann. Rept. Plant Port. North Japan 7 : 30～31 (In Japanese)

13. Yoshii, H. 1936. Pathological studies of rice blast caused by *Piricularia oryzae*. Ⅱ. The mode of infection of the pathogen. Ann. Phytopath. Soc. Japan. 6 : 205～218. (In Japanese, English summary)
14. Yoshino, R. 1971. Influences of temperature on the incubation period of *Pyricularia oryzae*, and early detection of lesions by staining with iodine potassium iodide. Proc. Assoc. Plant Prot. Hokuriku 19 : 11～14. (In Japanese)
15. Yoshino, R. and T. Yamaguchi. 1974. Influences of sunshine and shade conditions on the occurrence of rice blast caused by *Pyricularia oryzae* Cavara. Bull. Hokuriku Agr. Exp. Sta. 16: 61～119 (In Japanese, English summary)