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Studies on the Mechanism of "Kresek" Induction of Rice Plant Caused by *Xanthomonas oryzae* (Uyeda & Ishiyama) Dowson

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ABSTRACT

The study has been carried out to investigate the mechanism of "kresek" induction caused by *Xanthomonas oryzae* (Uyeda & Ishiyama) Dowson.

The results are summarized as follows:

1. K-isolate could always induce "kresek" symptom on susceptible varieties when the pathogenic bacteria were introduced either way through the leaves or roots, while N-isolate could not induce.
2. Milyang 23 which showed "kresek„ symptom had significantly smaller diameter of vessel elements than those of other two varieties examined.
3. The bacterial number of K-isolates in the extract of Milyang 23 was higher than N-isolates but there was no diffrenece in bacterial number between K-and N-isolates when they were grown in the extract of Tongil.
4. N and K-isolates reached to death phase after 3 days and 9 days, respectibly, when they were grown in the extract of Milyang 23. Both isolates, however, reached to death phase at the same time after 3 days of incubation in the extract of Tongil.
5. Heavy precipitation was observed in the extract of Milyang 23 at PH 3.0-4.0 range, while only traceable precipitation colud be observed in the extract of Tongil at the same pH range under room temperature.

INTRODUCTION

The "kresek" symptom was first discovered at Indonesia (16). Later Goto (8) identified the causal bacterium as *X. oryzae* through cross inoculation, physiological and biological studies on *X. oryzae* including blight, "Kresek" and pale yellow-inducing isolates. Through these studies Goto confined that "kresek" was an another symptom caused by *X. oryzae*. After then "kresek" symptom has been recognized not only in tropic area but also in temperate area such as in Korea (2) and in Japan (19, 21, 22). In Korea, "kresek" was first recognized on Milyang 23 in Chungnam province, which was a new recommended variety of Indica-Japonica hybrid in 1976. Since then it was rapidly spreaded up to Kyunggi and Kangweon province even on the varieties Jinheung, Akibare, Suweon 327, Milyang 21 in addition to Milyang 23 in 1977.

In tropic area the leaf tips of rice seedling are often cut before transplanting(16, 17). The bacteria are attracted by the broken roots caused when seedlings are pulled out from the seedbed (13), which facilitate infection.

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These are important infection court for "kresek" found in the tropics (16). Tabei demonstrated that the primary infection for "kresek" occurred only through hydathode (water pore) of leaves, usually at from 2 to 4 leaf stages. Bacterial mass then translocated downward to the leaf base. Yoshimura and Iwata(22) and IRRI workers (9) demonstrated that possible infecion court is through broken roots that happened when seedlings are pulled from the seedbed. The root dipping method of inoculation is widely used with good results for bacterial wilt of several plants caused by *Pseudomonas solanacearum* (11). Since the "kresek" is a wilt disease,the root dipping inoculation is thought to be a reasonable method to induce it. In preliminary test, the root dipping inoculation yields higher percentage of "kresek" symptom and also is faster to occur "kresek" symptom than by foliage inoculation method. As "kresek" is a wilt disease some workers suggested that the symptom may be caused by plugging of the vessel elements with bacteria themselves, as they disturb the movement of water in the plant(19, 22). Mechanism for plugging may be affected by 3 factors: A) diameter of vessel elements in plants. B) nutrition for bac terial growth in the plants. C) interaction of A and B. Although there are a few reports on the anatomy of the plant dealing with the resistance of plant to leaf blight symptom(15. 19), no one has reported any information on the effect of vessel element for "kresek" development.

Garber[6,7] suggested a nutritional theory in account of resistance; either the nutrients necessary for the pathogen are absent from the resistant host tissue or the required nutrients are unavailable to the pathogen. Mizukami & Murayama [12] noticed that when inoculated plants were treated with ether or immersed in water, the lesion size became larger than the plant those were not treated. He assumed that this was due to an increase of some amino acids. Fang, Lin & Shu (5) also reported that susceptible varieties tended to have higher contents of some free amino acid and lower contents of polyphenols and reducing sugar. IRRI (10) reported, however, that resistant varieties have higher rates of reducing sugar to total nitrogen than susceptible varieties.

The objectives of the present investigation were to note and confirm: 1) Whether "Kresek" was related to isolates, inoculation site, or varieties, 2) the anatomical difference between the "Kresek" inducing variety and blight inducing varieties and 3) the nutritional difference for bacterial growth in plant saps from different varieties.

The authors wish to express their deep gratitude to Mr. Yong Chull Choi, plant pathologist in Dept. of Plant Pathology, Institute of Agricultural science, ORD for allocation of isolates.

MATERIALS AND METHODS

INOCULUM

Eleven isolates of *X. oryzae* originated from 9 different areas: Hwasun, Damyang, Jinyang, Hongcheon,

Table 1. The source of isolates *X. oryzae* used in the study.

Isolates	Origin of iolates		Variety	Collecting date	Group of isolates
	Locality (prov.)				
K-01	Hwasun	Chunnam	Milyang 23	Aug. 10 '76	?
K-05	Damyang	Chunnam	〃	Jul. 28 '77	II
K-08	Damyang	Chunnam	〃	〃	II
K-09	Jinyang	Kyungnam	〃	Jun. 30 〃	II
K-10	Hongcheon	Kangwon	〃	Jul. 20 〃	I
K-11	Damyang	Chunnam	Milyang 21	Aug. 5 〃	I
N-16	Ahnsung	Kyunggi	Akibare	Aug. 5 〃	II
N-17	Wonsung	Kangwon	Milyang 23	Jul. 20 〃	II
N-12	Icheon	Kyunggi	Suweon 264	Aug. 5 〃	I
N-20	Hwasung	Kyunggi	Akibare	Aug. 5 〃	I
N-23	Suweon	Kyunggi	Jinheung	Aug. 15 '76	II

Wonsung, Ahnsung, Icheon, Hwasung and Suweon, and they were grouped into two types. Isolates K designated the pathogens from "Kresek" induced plants, and isolates N designated those from leef blighted plants.

According to the method of classification proposed by Ezuka et. al. (4) all the isolates used in the experiment except K-01 were belong to either group I or II. (Table. 1)

Nine of these isolates were allocated by Dept. of Pl. Path. Inst. of Agr. Science, ORD, and the other two isolates were from Dept. of Pl. Pathol. College of Agriculture, SNU.

All the isolates were raised through single colony culture on Suwa's medium[18], and then grown on the Wakimoto's medium at 28+1°C. The cultures were kept in sterilized liquid paraffin at 4°C.

INCOULATION TEST

Ten varieties of rice: Tongil, Yushin, Tetep, Hoyoku, Shin 2, Shiranui, Wase Aikoku, Jinheung, and Milyang 23, were grown in 40×40×10cm plastic tray under greenhouse condition. Ten plants of each variety were transplanted into the same type of trays at seven leaf stage after inoculating 10^8 cells/ml of inoculum by clipping method. All of trays then were kept under continuously saturated condition.

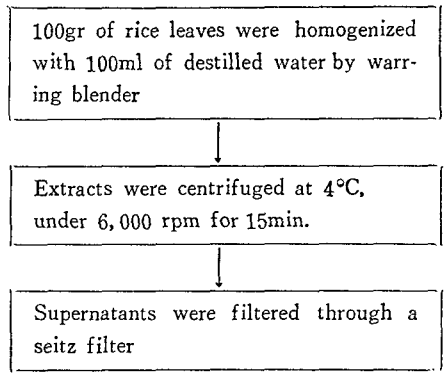
For the root inoculation, the root tips of the same aged plants were cut and then dipped into inoculum of the same concentration for 3 hours. The inoculum were prepared by growing on Wakimoto's agar medium at 28+1°C for 72 hours and made the suspension of about 10^8 cells/ml by adding surfactant "Twin-20" at 1 : 10,000 ratio.

HISTOLOGICAL TEST

Three indica-Japonica hybrids: Milyang 23, Tongil, and Yushin, were planted in 50×40×10cm plastic trays under greenhouse condition. The leaf sections were made by using a freezing microtom "CRYOSTAT" when the plants reached seven leaf stage. All sections were made from the seventh expanded leaves which were kept in tap water at 4°C during the period from harvesting to sectioning procedures. Cross sectioned materials from 90 plants for each varieties were mounted on microscopic slide glass and measured the diameter of vessel elements by using ocular micrometer under 620×compound microscope.

BACTERIAL GROWTH IN PLANT SAPS

Plant saps of two varieties: Milyang 23 and Tongil, were obtained by macerating the plants of seven leaf stage. The method of extracting plant saps can be illustrated as follows:



Each of 2×10^4 bacteria of 9 isolates, as determined by spectrophotometer, were introduced into three test tubes of each extracts and three tubes of each extracts were not inoculated as a control. After then all samples were incubated at 28+1°C for ten days. Every 12 hours of incubation, bacterial population was counted by spectrophotometer and then compared among the extracts statistically.

For counting bacterial population, standard curves were made by spectrophotometer, type SPECTRONICA 20, using 400, 450, and 500 nm wave length.

RESULTS

INOCULATION TEST

The symptom observed at Hwasun, Chunnam province were as follows; Outer leaves withered. Some upper leaves were rolled up along the midrib and then withered. As a results, the entire plants died. These symptom of "kresek" could be reproduced on some varieties by inoculating "kresek"-inducing isolate with either method of leaf-clipping and root-dipping, but it was unabled to produce "kresek" symptom by using blight inducing isolate.

A. CLIPPING INOCULATION

Small water-soaked lesions appeared just under the cut surface within 5 days. Rolling and withering developed from the infected tips of leaves and developed the symptom down to the sheath of Milyang 23,

Jinheoung and Hoyoku after 12 to 18 days of inoculation with K-01. After 19 to 20 days the newly developed leaf also was infected, showing the same symptoms as above. As the disease progressed the entire plants eventually died. While the other varieties did not show the "kresek" symptom (Table 2)

When N-23 isolate was used as the inoculum, none of "kresek" symptom was produced from any varieties but showing typical leaf blight symptoms on the same varieties.

Table 2. Disease development on 10 rice varieties when 10^8 cells/ml of "Kresek" inducing-isolate were inoculated at 7-leaf stage seedlings with clipping method.

Varieties \ days	4	12	18	19	20	21	22	23	24
Milyang 23	+/a	++	K(3)/b	K(5)	K(10)	*	*	*	*
Jinheung	+	++	++	K(1)	K(1)	K(6)	K(7)	K(9)	K(10)
Hoyoku	−	+	++	++	K(1)	K(1)	K(3)	K(3)	K(3)
Tadukan	−	+	+	+	+	+	+	+	+
Tetep	−	+	+	+	+	+	+	+	+
Yushin	−	+	+	+	+	+	+	+	+
Tongil	−	+	+	+	+	+	+	+	+
Shin 2	−	+	+	+	+	+	+	+	+
Shiranui	−	+	+	+	+	+	+	+	+
Waseaikoku	−	+	+	+	+	+	+	+	+

/a +:Normal symptom.
++:Develop to sheath part.
K:"Kresek" symptom.
/b : Numbers of plants with "Kresek" symptom.

DIPPING INOCULATION

Dipping inoculation brought at least 4 to 6 days earlier reaction than those brought by clipping inoculation to the susceptible varieties when the "kresek" inducing isolates were used as the inoculum. Other than these three varieties: Milyang 23, Jinheung and Hoyoku, there were no "kresek" symptom developed even with dipping inoculation. The same was true that the isolate N-23 could not induce "kresek" symptom to any varieties even with dipping method. (Table 3)

Table 3. Development of Kresek symptom on 10 rice varieties when 10^8cells/ml of "Kresek" inducing-isolate were inoculated at 7-leaf stage seedings with root dipping method./a

Varieties \ days	14	15	16	17	18	19	20	21
Milyang 23	6/b	6	10	*	*	*	*	*
Jinheung	1	3	4	4	8	8	8	10
Hoyoku	1	1	1	1	3	3	4	8
Tadukan	—	—	—	—	—	—	—	—
Tetep	—	—	—	—	—	—	—	—
Yushin	—	—	—	—	—	—	—	—
Tongil	—	—	—	—	—	—	—	—
Shin 2	—	—	—	—	—	—	—	—
Shiranui	—	—	—	—	—	—	—	—
Waseaikoku	—	—	—	—	—	—	—	—

/a : Roots were dipped into inoculum for 3hrs after cutting root tip
/b : Numbers of plants with "Kresek" symptom.

HISTOLOGICAL TEST

When infected leaves were cross-sectioned, vessel elements were plugged with bacterial mass (Fig 1). The number of vascular bundles ranged from 10-15 at 7 leaf stage. From the observation of 90 pitted

Table 4. Diameter of Xlyem Vessels in 7th leaf of 3 varietis when sections were made at portion of one third from the top of 7 leaf stage seedlings.

Varieties	Diameter(μ) of Vessels/a				Duncan's/b
	I	II	III	average	MRT
Yushin	25.7	23.2	25.9	24.9	A
Tongil	21.9	21.7	22.0	21.9	B
Milyang 23	17.0	15.8	18.9	17.2	C

/a : Numbers based on the observation of 3 vessels in each of 30 plants.
/b : Multiple range at 1%.

vessels at the same portion, average diameter of vessel elements in Yushin, Tongil and Milyang 23 were 24.0μ, 21.9μ, 17.2μ, respectibly (Table 4). Milyang 23 which induce "kresek" symptom had a smaller vessel elements than other two plants (Fig. 2). Statistical comparison indicated that there were highly significant defference among the plants.

BACTERIAL GROWTH IN PLANT EXTRACTS

To learn whether there were difference in bacterial multiplication between extracts from "kresek" inducing variety and blight inducing variety, the number of bacteria in each extracts were determined by spectrcphotometer at each stationary phase. In the extracts of Milyang 23, the bacterial number of k-isolates were measured after 9 days of incubation and n-isolates were measured after 4 days except N-17. In the extract of Tongil, all the isolates were measured after 3 days of incubation.

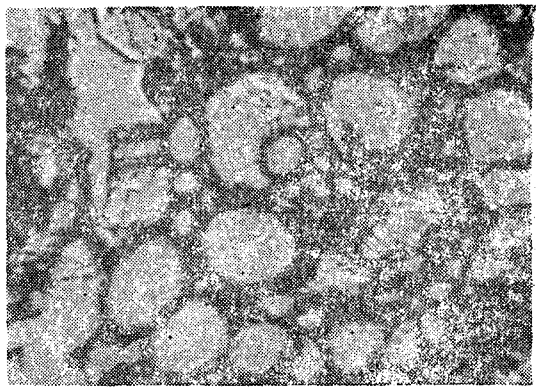
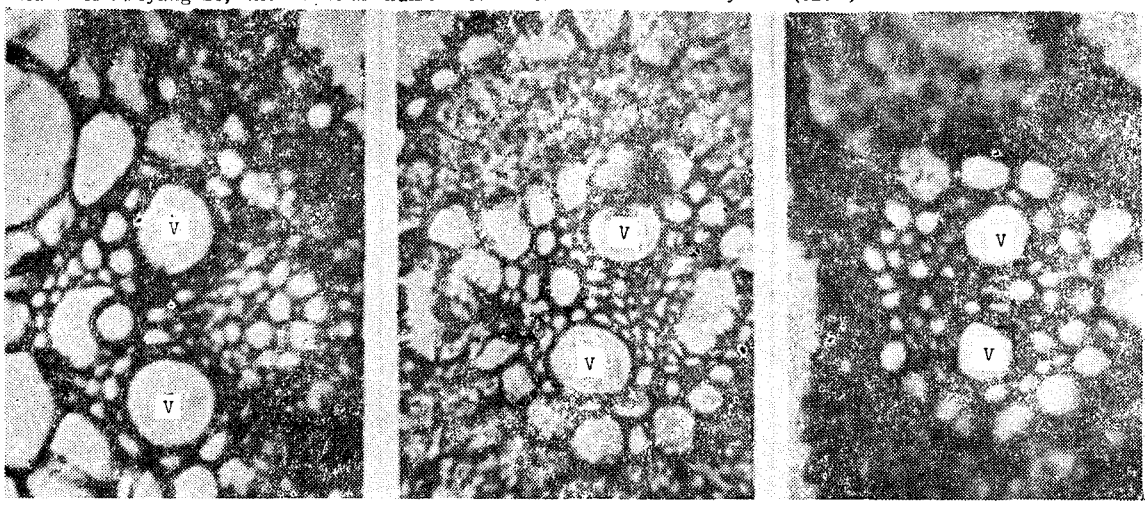


Fig. 1. Cross section of infected leaf of rice plant inoculated with *X. oryzae* showing the bacteria in xylem. (620X)



(A) (B) (C)

Fig. 2. Pitted vessels (V) of leaves when the section were made at portion one third from the leaf tip of Yushin(A), Tongil(B), and Milyang 23(C). (620X)

Table 5. Bacterial growth in fresh leaf extract from Milyang 23 after stand culture at 28±1°C, when 2×10^4cells/ml were inoculated.

Isolates	Numbers of bacteria(X 10^5/ml)/a				Duncan's
	I	II	III	average	MRT
K-05	284.0	228.0	228.0	247.7	A
K-11	228.0	200.0	200.0	209.3	A
K-10	140.0	200.0	170.0	170.0	A
K-09	125.0	200.0	170.0	165.0	A
K-08	155.0	170.0	155.0	160.0	A
N-16	35.0	20.0	13.4	22.8	B
N-17	35.0	13.4	20.0	22.8	B
N-20	0.2	13.4	20.0	11.2	B
N-12	0.2	20.0	6.4	8.8	B

/a : Bacterial populations were calculated at each stationary stage using spectrophotometer.
/b : Multiple range test at 5% level.

As shown in table 5, the bacterial number of K isolates presented in Milyang 23 were significantly higher than N isolates.

But in the extracts of Tongil there were statistcal

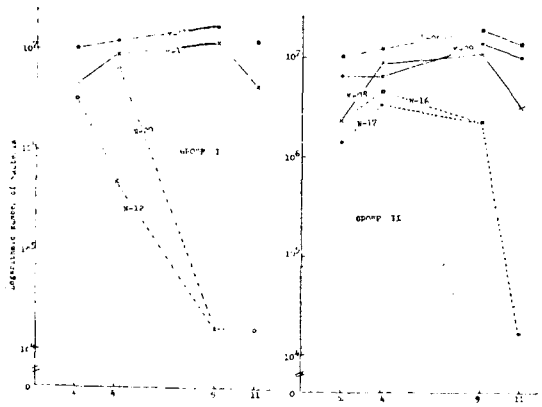
difference of bacterial number among the isolates, even though the baterial number of K-08 is more than two times of those of N-12, N-17, and N-20. (Table 6)

Table 6. Bacterial growth leaf extract from Tongil after stand culture at 28±1°C, when 2×10^4 cells/ml were inoculated.

Isolates	Numbers of bacteria($\times10^5$/ml)/a				Duncan's/b
	I	II	III	average	MRT
K-08	125	110	95	110	A
K-11	95	110	95	100	A
K-05	95	80	80	85	A
K-10	50	110	95	85	A
K-09	65	95	80	80	A
N-16	110	50	65	75	A
N-20	50	65	65	60	A
N-12	50	50	65	55	A
N-17	50	50	35	45	A

/a : Bacterial populations were calculated at each stationary stages using spectrophotometer.
/b - There were no significant between isolates.

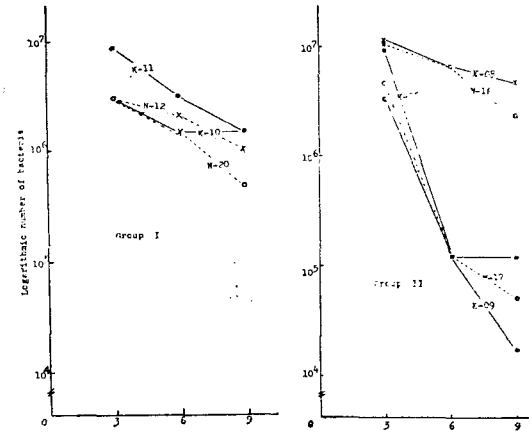
Furthermore, the death phase of K isolates were started after 9 days of incubation but N isolates were started after 2 or 4 days in the extract of Milyang 23. (Fig 3).



Days after inoculation

Fig. 3. Bacterial growth curves in fresh leaf extract of Milyang 23 when 2×10^4 cells/ml were inoculated and cultured at 28±1°C under stand condition (left:Group I, right: Group II)

In the extracts of Tongil, all the isolates started the death phase after 4 days of incubation. (Fig 4). The data suggested that the extract of "Kresek" inducing variety milyang 23, contained some factors that tende to influence the growth of the bacteria.



Days after inoculation

Fig. 4. Bacterial growth curves in fresh leaf extrac of Tongil when 2×10^4 cells/ml were inoculat ed and cultured at 28±1C under stand condit ion (left:Group I, right:Group II)

To determine the difference of the nutritive comp osition between two extracts, electric iso-point of a certain substance in the extracts was observed. In the extract of Milyang 23, heavy precipitation was formed at pH3.0~4.0 within 24 hours at room temperature, while traceable precipitation was formed in the other extract at the same pH range. (Table 7).

Table 7. Formation of precipitation at different pH range of fresh leaf extract of 2 rice varieties after 1 day.

varieties	pH of fresh leaf extract/a			
	7.0~6.0	6.0~0.5	5.0~4.0	4.0~3.0
Milyang 23	—	—	—	+++/b
Tongil	—	—	—	+

/a:measured by pH test paper
/b:+ traceable precipitation
+++ heavy precipitation

DISCUSSION

Although there are many reports on induction of "Kresek" symptom in many countries, relatively little has been known about nature of "Kresek". The relation between "Kresek" and blight symptom, however, is not fully understood.

Watanabe [20] indicated that all isolates were capable

of inducing "Kresek" but there was a wide range of variation among the isolates tested in his studies. However, Devadath and Premalatha[3] reported that virulent strain of *X·oryzae* induced "Kresek" while a less virulent strain induced leaf blight. But Shigemura and Tabei[29] indicated that bacterial isolates virulent than others. Yoshimura et. al.[21] came to a similar conclusion in Japan.

The experiment indicated that isolate-K could always induce "Kresek" symptom on three out of ten varieties when the pathogenic bacteria were introduced either way through the leaves or roots, while the other seven varieties showed typical blight symptom with the same pathogens. Also there were no "Kresek" on all the varieties tested when leaves or roots were inoculated with isolate N. Result of the present study, then, can be interpreted that "Kresek" induction may be related with host-parasite interaction. The study, however, must be continued with the more of isolates for their correct ecology on "Kresek" induction.

Some workers[19,22] agreed that "Kresek" was caused by plugging vessel elements by bacterial mass, and disturbed the movement of water in the plants. Park and Cho[15] demonstrated that susceptible varieties have larger and longer vessel elements than resistant varieties. The results of the study indicated that Milyang 23, suscepitible to "Kresek", had a smaller vessel diameter than Yushin and Tongil which were not showing "Kresek" but leaf blight. Such a disagreement may be due to the different concepts of blight and "Kresek" symptom. If we confined to "Kresek" large diameter may extend the time to plug with bacierial mass.

The nutrients necessry for the pathogen may be absent from resistant host tissue or if they are present, they may be very small quantity.[1,6,7,9] With bacterial leaf blight of rice, limited reports indicated a factors in plant extracts that might be related to resistance.[5,9,12,15] As shown in Table 5, the bacterial number of K-isolates but there was no difference of bacterial number between K-isolate and N-isolates in the extract of Tongil. And in this study, there were no difference of bacterial growth among the pathotypes except the isolate K-08 which showed two times of bacterial number than those of N-12, N-17 and N-20 in Tongil extract, despite that the isolates belong to Group I or II could not produce any symptoms on Tongil. It may be due to the fact that living cells can produce antibacterial substance but it was not produced in the extract of tissues after the pathogenic bacteria were inoculated with incompatible varieties. In support of such possibility, Nishinaka and Watanabe [14] demonstrated that in leaves inoculated with incompatible strains antibacterial substance were detected after 24 hours of inoculation, and increased rapidly to the maximum level within 3-5 days. Bacterial multiplication in the leaves was depressed with the accumulation of these substances.

Isolates-N reached to death phase in growth curve much earlier than isolates-K when they were grown in the extract of milyang 23. Both isolates reached, however, at the same time after 3 days of incubation in the extract from Tongil. The results indicated that the extract of Milyang 23 contained some factors to facilitate bacterial multiplication.

Further studies are needed to obtain informations on biochemical properties of plant extracts that may influence the bacterial multiplication.

적 요

1. "Kresek" 유발균주(K균주)는 품종에 따라서 발현에 차이가 있었으며 지상부 또는 지하부에 접종하여도 "Kresek"을 유발시킬 수 있었으나 대조균주(N균주)는 전연 유발되지 않았다.
2. 엽맥의 도관직경은 밀양 23이 유신이나 통일보다 현저히 작았으며 이들간에 고도의 통계적인 유의차가 인정되었다.
3. 밀양 23의 즙액에서 K균주들은 N균주들보다 세균의 증식이 왕성하였으며 통일에서는 균주들간에 증식의 차이가 없었다.
4. 밀양 23의 즙액에서는 K균주의 Dead phase가 접종 9일째부터 N균주는 4일째부터 시작되었으며 통일에서는 모두 3일째부터 시작되었다.
5. 밀양 23즙액의 경우 pH 3.0-4.0 범위에서 다량의 침전물이 형성되었으나 통일의 즙액에서는 극히 소량의 침전물을 관찰할 수가 있었다.

LITERATURE CITED

1. Cho, Y.S., 1970. Studies on the nature of resistance in alfalfa plants to bacterial wilt. Ph. D. Thesis, Univ. of Minesota.

2. Choi, Y.C., U.H. Cho, B. J. Chung, Y.S. Cho and Y.H. Yu. 1977. "kresek" Disease in Korea I. Korean J. Pl. Prot.:16 (1) 1-6.
3. Devadath, S. and Premalathe Dath. 1970. Mechanism of wilt ("kresek" phase) in bacterial blight of rice. Oryza 7 : 5-12.
4. Ezuka, A. and O. Horino. 1964. Classification of rice varieties and *Xanthomonas oryzae* strains on the basis of their differential interactions. Tokaikink: Nat. Agr. Expt. Stn. 27 : 1-19.
5. Fang, C. T., C.F., Lin, C.L. Chu and T.K. Shu. 1963. II Varietal resistance of rice to bacterial leaf blight and a preliminary analysis of its mechanism. Acta. Phytopath. Sin. 6 : 107-112.
6. Gaber, F.D. and H.F. Heggested. 1958. Obserbations on the pathogenicity of biochemical mutants of *Pseudomonas tobaci.* Phytopathology 48 : 535-537.
7. Gaber, E. D., 1961. Wild fire disease of tobacco. J. Bacteriol. 81 : 974-978.
8. Goto, M. 1964. "kresek" and pale yellow leaf, systemic symptom of bacterial blight of rice caused by *Xanthomonas oryzae.* Pl. Dis. Peptr. 48 : 858-861.
9. Hildebrand, E.F. and D.E. Scands. 1966. Synthesis of glucosidase by *Pseudomonas syrinagae* in tobacco leaves. Phytophology 56 : 881.
10. International Rice Research Institute Annual Report 1967.
11. Kelman, A. 1953. The bacterial wilt caused by *Pseudomonas solanacearum.* North carolina Agr. Expt. Stn. Tech. Bull. No. 99. 194p.
12. Mizukami, T. and Y. Murayama. 1960. Studies on the bacterial leaf blight disease of rice plant. I. On the relationships between the growth of *X. oryzae* in rice plant leaf and the free amino acids in it. Sci. Bull. Fac. Agr. Saga University 11 : 75-82.
13. Mizukami, T. 1961. Studies on the ecological properties of *Xanthomonas oryzae* (Uyeda et. Ishiyama) Dowson, the causal organism of bacterial leaf blight of rice plant. Sci. Bull. Fac. Agr. Saga. University 13 : 1-85.
14. Nakanish Kyoto and Minoru Watanabe. 1977. Studies on the mechanisms of resistance of rice plants against *Xanthomonas oryzae.* III. Relationship between the rate of production of antibacterial substances and multiplication of pathogenic bacterial in infected leaves of resistant and susceptible varieties. Ann. Phytopath. Soc. Japan. 43 : 256-269.
15. Park. C.S. and Y.S. Cho. 1971. Studies on the nature of resistance of rice plant to bacterial leaf blight caused by *Xanthomonas oryzae* (Uyeda et. Ishiyama) Dowson (in Korean). Korean J. Pl Prot.: 11(2) 55-60
16. Reitsma, J. and P.S. J. Schure. 1950 "kresek", a bacterial disease of rice. Contrib. Gen. Agr. Res. Sta. Indonesia. 117 : 1-17.
17. Ou S·H 1972. Rice disease. Common-wealth mycological institute, Kew, Sirrey, England p51-84.
18. Suwa, T. 1962. Studies on the cultural media of *Xanthomonas oryzae*(Uyeda et. Ishiyama) Dowson. Ann. Phytopathol. Soc. Japan 27 : 165-71.
19. Tabei, H. 1977. Anatomical studies of rice plant affected with bacterial leaf blight, *Xanthomonas oryzae*(Uyeda et. Ishiyama) Dowson. Bull. Kyushu Agr. Exp. Stn. 14(2) : 193-257.
20. Watanabe, Y. 1975. Ecological studies on "Kresek" phase of bacterial leaf of rice. Bull. Tokai-kinki Natl. Agr. Expt. Stn. No28 123p.
21. Yoshimura, S. and K. Twata, S. and K. Twata. 1965. On the abnormal growth of rice plant caused by bacterial leaf blight (2). Proc. Assoc. Pl. Prot. Hokuriku 13 : 40-42.
22. Yoshimura, S. and K. Twata. 1965. On the abnormal growth of rice plant caused by bacterial leaf blight (3). Proc. Assoc. Pl. Prot. Hokuriku 13 : 42-47.