下位葉鞘剥離によるトウモロコシの紋枯病抵抗性

誌名	草地試験場研究報告 : s ō chi shikenj ō kenky ū h ō koku = Bulletin of the National Grassland Research Institute
ISSN	03850196
著者名	加藤,章夫 井上,康昭
発行元	農林省草地試験場
巻/号	51号
巻号補足	
掲載ページ	p. 1-5
発行年月	1995年3月

Resistance to Banded Leaf and Sheath Blight (*Rhizoctonia solani* Kühn) after Fall of Lower Sheaths in Maize.

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(Received January 6, 1995)

ABSTRACT

The mechanism of the resistance to banded leaf and sheath blight in maize is analyzed. Maize plants which lower sheath fall along with brace root development were not affected by the disease. Field observation showed that the height of the uppermost lesions among the plants in which lower sheaths fell during the growth period was 7-20 cm lower than that of the plants in which sheaths did not fall. Hand-stripping treatment of lower sheath of maize plants revealed that sheath fall at 8 to 15 days before silking enabled maize plants to avoid the disease. In addition, the sheath fall character was assumed to be a genetical character transmitted in a recessive manner based on experiments involving 69 F_1 lines and their parental 20 inbred lines.

Kato, A., and Y. Inoue (1995) : Resistance to banded leaf and sheath blight (*Rhizoctonia solani* Kühn) after fall of lower sheaths in maize. Bull. Natl. Grassl. Res. Inst. 51 : 1-5.
Key words : maize, resistance, banded leaf and sheath blight, *Rhizoctonia solani*

INTRODUCTION

Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani* Kühn is not always a serious disease under normal climatic conditions in Japan, although maize is heavily infected under rainy and humid conditions. In many Asian countries, epidemics of the disease have been recorded (Sharma and Hembram, 1990 ; Vimla *et al.*, 1988).

Evaluation and screening methods for the disease have been reported (Ahuja and Payak, 1978, 1981, 1983 ; Koinuma and Mochizuki, 1989) and some resistant lines were identified (Ahuja and Payak, 1984). However genetic variability of the resistance to the disease is considered to be limited (Sharma and Hembram, 1990) and no line has been found to be completely resistant to BLSB. The occurrence of this disease is highly variable among plants within a line. Severely infected plants coexist with uninfected plants in the same line at the same time. The symptoms of BLSB consist first of the appearance of grayish lesions on the lowest sheath, which there after spread to the younger leaf sheaths. Sharma and Hembram (1990) reported that the progression of the disease could be prevented by removing the leaf sheaths with a scalpel just above the inoculated in-

Fig. 1. Brace root emergence and fall of lower sheaths in a line with early sheath fall, 288212/288205.

ternode. The authers assume that some maize plants may avoid the disease by the fall of lower sheaths caused by the growth of brace roots (Fig. 1).

In this paper we evaluated the control of natural infection with BLSB by spontaneous fall of lower sheaths as well as by hand-stripping of the lower sheaths.

MATERIALS AND METHODS

Experiment 1.

In 1989, the relationship between the sheath fall date and BLSB infection was observed in 3,731 plants including S0 to S5 lines and inbred lines in the breeding nursery. Evaluation of sheath fall was conducted by counting the number of visible internodes at which sheaths fell. The evaluation was made four times (July 21st, 28th, and August 4th and 11th). Infection degree with BLSB was evaluated based on the height of the uppermost lesion of BLSB, as the causal organism of the disease infects bottom sheaths to upper sheaths, successively. The BLSB evaluation was conducted 25 days after silking.

Experiment 2.

In 1990, we examined the effect of hand-stripping of sheaths on the occurrence of the disease using three commercial cultivars (P3358, TX330 and Garst 8344). Hand-stripping was conducted on four different dates (15 and 8 days before silking, and 1 and 6 days after silking). The bottom 1-2 sheaths were stripped until the interode became naked over a distance of more than 3 cm. A split-plot design was adopted for the examination (main block for cultivars and sub block for hand-stripping treatments with three replications, each plot consisted of 38 plants, the plant density was 62,500 plants/ha). The height of the uppermost BLSB lesion was recorded at 27 days after silking.

Experiment 3.

In 1991 the inheritance of earliness of natural sheath fall was examined in the 69 F_1s with their parental 20 inbred lines in two sets of cross combination. The performance of F_1 derived from the inbred lines with different sheath fall dates was analyzed. The first set consisted of twelve inbred lines classified into the three following categories :

early fall - 288212, 189345-7, Na21, Na38
falling at 8-18 days before silking

intermediate - 288205, 289182-8, Na35, Na40, B73, N196
falling 1-7 days before silking

no fall - A680, H119
not falling before silking

Another set, on the other hand, consisted of eight inbred lines (A664, Mo17Ht, Na8, Na28, Na30, Na37, Oh43Ht and Pa91) in which fall of sheaths did not occur. The former set consisted of 46 F_1 combinations and the latter of 23 F_1.

Dates when fall of the sheath occurred over a distance of 3 cm (1-2 internodes) were recorded. The experimental design consisted of a completely randomized block with two replications for F_1s and without replication for the inbred lines. Each plot consisted of 9 plants (planting density was 62,500 plants/ha)

RESULTS

Experiment 1.

The results are shown in Table 1. The average silking date of the maize lines in 1989 was August 4th and sheath fall occurred around the silking date.

Table 1. Relationship between the height of the BLSB lesions and the number of internodes in which sheaths fell.

Date of observation	Number of internodes in which sheaths fell			
	0	1	2	above 3
July 21	27.6 (3662)	19.5 (69)	— (0)	— (0)
July 28	28.3 (3382)	20.0 (308)	15.8 (41)	— (0)
August 4	29.5 (2818)	21.4 (653)	20.5 (252)	19.8 (8)
August 11	30.2 (2418)	22.8 (795)	23.0 (477)	9.7 (41)

Note : Figures refer to the height of the BLSB lesions in *cm*. Figures in parenthesis indicate the number of plants observed (S0 to S5 lines and inbred lines).

Sheath fall considerably reduced the height of BLSB lesios. The height of the BLSB lesions of the plants in which bottom internodes were covered with sheaths on July 21 was 27.6 cm, whereas the height of BLSB lesions of the plants in which one bottom internode had lost sheaths at that time was 19.5 cm. The plants in which three bottom internodes had lost sheaths on August 11 the BLSB lesion height was only 9.7 cm. In the plants in which the lower sheath fell earlier, or the plants in which the lower sheath fell more frequently the height of the BLSB lesions was lower.

Experiment 2.

Because of the relatively dry weather in 1990, natural infection with BLSB was moderate for the three commercial cultivars. The differences among the cultivars were not significant. However the differences in the height of the lesions among the plots differing in the dates for hand stripping were large and significant, as indicated in Fig. 2. In the plants in which the lower sheath was stripped earlier the height of the BLSB lesions was lower. The stripping of the sheaths 15 days before silking (average silking date was July 21st) resulted in the lowest height of the lesions. Most of the plants infected with BLSB in the plots of the -15 day treatment had already been infected with BLSB by the time when hand stripping of the lower sheaths was carried out. Treatment during eight days before silking resulted in a lower value of the height of the BLSB lesions with a significant difference, compared with the control.

Experiment 3.

We classified the F_1 lines into three groups, early

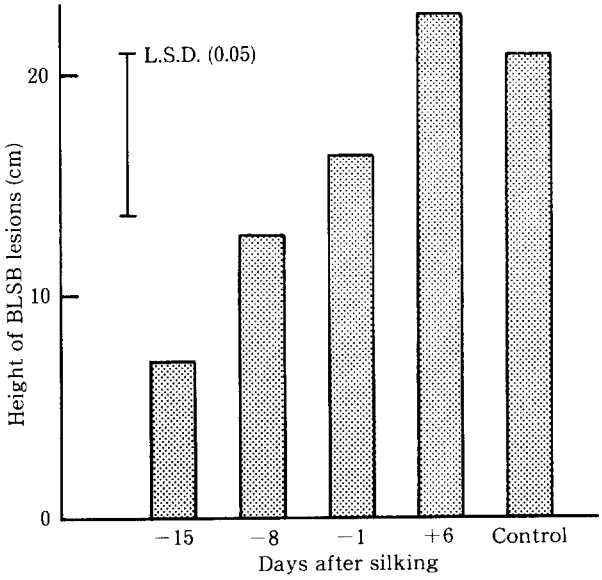

Fig. 2. Effect of hand-stripping of sheaths at different dates on height of BLSB lesions.

fall, intermediate, and no fall before silking, based on the date of sheath fall as in the case of the inbred lines (Fig. 3). In the cross of two inbred lines, 288212 and 189345-7, which belonged to the early sheath fall group, the F_1s exhibited the early and intermediate sheath fall character. The F_1s derived from Na38 and Na21 which also belonged to the early sheath fall group exhibited early, intermediate, as well as no sheath fall character respectively. On the other hand, in the majority of the F_1s between the inbred lines where the sheath fall character was intermediate or absent the sheaths did not fall before silking. None of the 23 F_1s derived from the eight inbred lines without sheath fall exhibited sheath fall (data not shown).

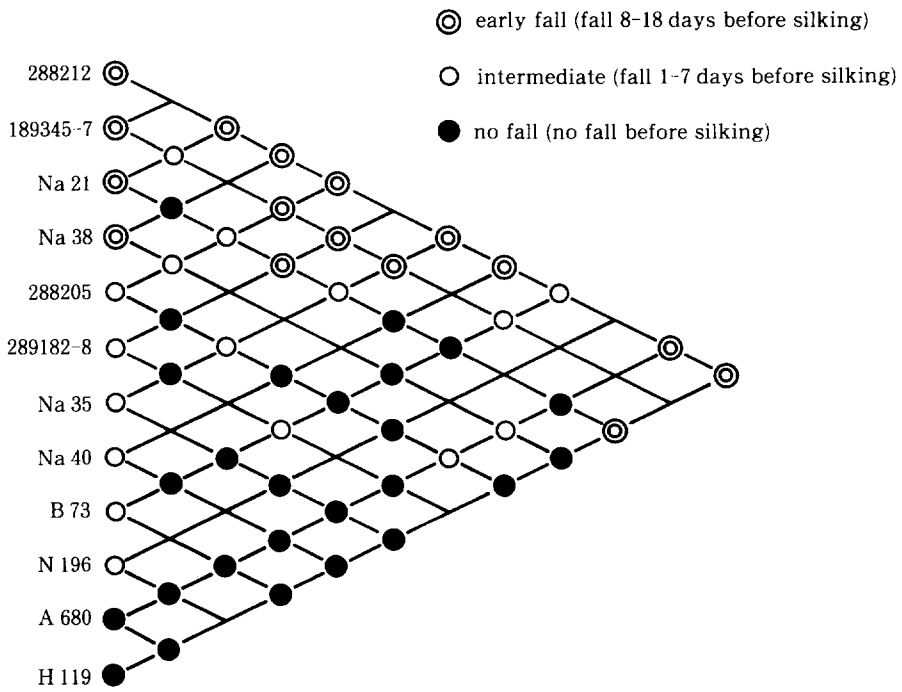

Fig. 3. Earliness of sheath fall in 12 inbred lines with their 46 F_1s. The intersection point indicates the F_1 derived from the parents at the end of the left line.

DISCUSSION

The fall of the lower sheaths under natural conditions, in particular at the early stage before silking, enables maize plants to avoid BLSB infection. The infection of the lower sheaths seems to be necessary for the fungus to infect the upper part of maize plants, due to the soil-borne transmission of the fungus. We assume that the fall of lower sheaths interrupts the infection route of the disease, and induce the resistance of maize to BLSB. The infection was also affected by the number of sheaths that fell. When sheath fall was incomplete (part of the sheath remain attached to the internode) or the length of the naked internodes was shorter than 2 cm, such maize plants became easily infected with BLSB in our field observations (data not shown).

Hand-stripping of the lower sheaths was effective in preventing BLSB infection, as indicated by Sharma and Hembram (1990). They also suggested that the stripping of the sheaths at 40 days after planting may enable to prevent the infection with BLSB in India. We assume that hand-stripping of the sheaths 70 days after planting (15 days before silking) could be effective in preventing the infection with BLSB in the Kanto area in Japan.

The genetic transmission of the earliness of sheath fall remains to be elucidated. In eight out of the ten F_1s derived from the six inbred lines with intermediate sheath fall character sheath fall was not observed (Fig. 3). This finding suggests that the character is transmitted in a recessive manner. However two inbred lines, 288212 and 189345-7, seemed to have a dominant gene or genes which caused early sheath fall, because the crosses between the two lines and two lines (A680 and H119) in which sheath fall did not occur exhibited early sheath fall.

The date and the number of sheaths that fell varied considerably among the plants and lines. In some maize lines, sheath fell started at two weeks before silking, and within three weeks from the beginning of fall four bottom internodes lost sheaths. However, in some lines sheath fall did not occur at all. Since the observation of sheath fall is easy, breeding selection for early sheath fall could be accomplished without much labor. The lines in which

sheaths completely fell at an earlier stage before silking are suitable for breeding BLSB-resistant F_1 lines. On the basis of our F_1 trials, both or one of the parental lines should display the early fall character to develop F_1s with early sheath fall.

The identification of the sheath fall trait, therefore, is useful as a preliminary selection for the detection of resistance of infection with BLSB.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Minoru Yamada and Dr. Eihide Monma for their helpful suggestions.

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下位葉鞘剝離によるトウモロコシの紋枯病抵抗性

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(平成7年1月6日　受理)

要　　旨

感染回避によるトウモロコシの紋枯病抵抗性について論じた。支根の発生に伴い下位葉鞘が自然剝離したトウモロコシは紋枯病の感染を回避する。圃場での観察により生育期間中に下位葉鞘が剝離したトウモロコシは下位葉鞘が剝離しなかった個体よりも紋枯病病斑高が7-20 cm 低くなる。人工的に下位葉鞘を剝離した実験から，絹糸抽出8-15日前に下位葉鞘が剝離するとトウモロコシは紋枯病を回避し抵抗性になると考えられた。自殖系統20とその F_1 系統69を用いて葉鞘剝離時期を調査した結果，早期に葉鞘が剝離する形質は劣性であることが示唆された。

加藤章夫・井上康昭（1995）：下位葉鞘剝離によるトウモロコシの紋枯病抵抗性．草地試研報 51：1～5.

キーワード：トウモロコシ，紋枯病，抵抗性