19. IMPORTANT DISEASES OF MAIZE IN JAPAN

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Twenty-two kinds of maize diseases have been known to occur in Japan (Table 1).

Table 1. List of the maize diseases in Japan.

Common name	Pathogen or causal virus
Virus diseases	
Mosaic	Cucumber mosaic virus
Mosaic	Sugar-cane mosaic virus
*Streaked dwarf	Rice black-streaked dwarf virus
Stripe	Rice stripe virus
Bacterial diseases	
Bacterial leaf blight	*Pseudomonas alboprecipitans*
Bacterial stripe	*Pseudomonas andropogonis*
Fungal diseases	
Anthracnose	*Colletotrichum graminicolum*
Blue mold	*Penicillium* sp.
Brown spot	*Physoderma zeae-maydis*
Curvuraria leaf blight	*Curvularia geniculata*
Downy mildew (Crazy top)	*Sclerophthora macrospora* (*Sclerospora macrospora*)
*Gibberella ear rot and seedling blight	*Gibberella zeae, Gibberella fujikuroi* (*Fusarium moniliforme*)
Head smut	*Sorosporium reilianum*
*Kabatiella leaf spot	*Kabatiella zeae*
*Nothern leaf blight	*Trichometasphaeria turcica* (*Helminthosporium turcicum*)
*Rust	*Puccinia sorghi*
Seedling blight	*Fusarium* sp.
Sheath blight	*Pellicularia sasaki*
*Smut	*Ustilago maydis*
Southern blight	*Corticium rolfsii*
Southern leaf spot	*Cochliobolus heterostrophus* (*Helminthosporium maydis*)
Summer blight	*Pellicularia filamentosa* (*Rhizoctonia solani*)

* shows the important diseases.

The important diseases among these may be treaked dwarf, Helminthosporium leaf blight and leaf spot, Kabatiella leaf spot, rust, smut and Gibberella ear rot.

Streaked Dwarf

As virus diseases of maize, mosaic caused by cucumber mosaic virus and sugarcane mosaic virus, stripe and streaked dwarf are known. Maize streaked dwarf was first found in 1955 in Yamanashi Prefecture. Of the virus diseases, streaked dwarf has caused the most destructive damage to the maize cultivation in the south-western parts of Japan, including Kanto-Tosan district.

Symptoms—Infected maize plants are dwarfed conspicuously decreasing the number of nodes and especially shortening of the upper internodes above the node where the first ear is attached. The leaf blades become also short and dark green in its color, often together with continuous, light yellowish green spots along the veins. The symptom of the disease is characteristic in the development of streaks. The streaks are short and pearl-white to pale brown in color, and appear in the lower surface of leaf blade, and on the surface of leaf sheath and husk.

The severity of symptom seems to depend on the time of infection. Plants infected in the early stage die early or produce no ear shoot. Even if a few of ear cobs develop, these are very small in size and the kernels are often produced only on the half side of them. In the field the first symptom sometimes appears in the 5–6 leaf stage,

Table 2. Comparison of healthy and of infected maizes with streaked dwarf virus.
(Variety: Nagano No. 1)

Character	Healthy	Diseased		
		Slight	Moderate	Heavy
Length of stalk (cm)	244.0	169.5	116.6	114.3
Number of Nodes	16.2	13.3	13.1	12.1
Length of blade (cm)	71.0	65.5	54.5	46.2
Width of blade (cm)	9.6	9.4	8.7	7.7
Length of ear (cm)	22.8	16.3	7.3	No ear produced
Diameter of ear (cm)	5.1	4.2	2.8	
Seed weight per one ear (g)	124.5	72.4	10.0	

After Kosuge (1966)

but usually in the 10. Few infections occur on the plants after the 10 leaf stage. The incubation period of the virus in the plant is 6–29 days.

The virus—The causal virus is the same to black-streaked dwarf virus of rice. The virus particle is spherical in form and 75 mμ in diameter. The viruses are transmitted mainly by a leaf hopper, *Laodelphax striatellus*. It has been recently confirmed that other two species of the leaf hoppers, *Delphacodes albifascia* and *Unkanodes sapporonus*, can also transmit this virus. The leaf hoppers begin to transmit in 7–21 days after acquisition feeding and retain their infectivity almost as long as they live. In this disease the viruses are not transmitted through eggs of the leaf hoppers. As host plants 25 kinds of cereals and grasses, including maize, rice, barley and wheat, are known.

Resistance of varieties—Soejima, Nozaki and Matsunaga (1967) reported on the resistance of maize varieties of streaked dwarf virus. Not a few varieties are susceptible, but some local varieties cultivated at the foot of Mt. Fuji, and many varieties

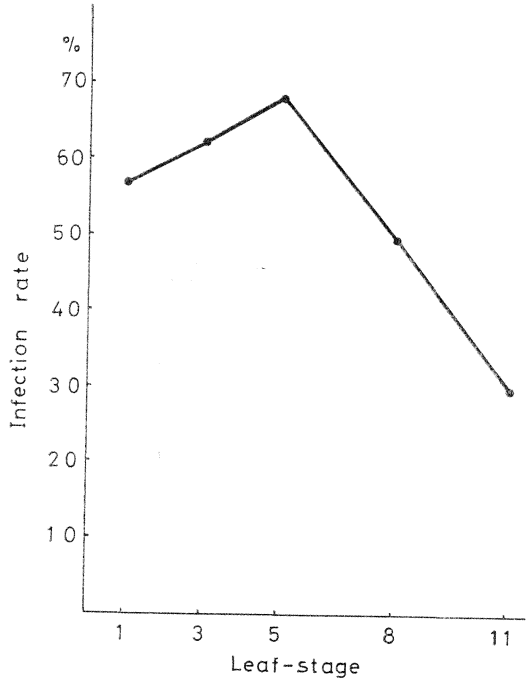

Fig. 1. Influence of the leaf-stage of maize plant to infection rate due to the streaked dwarf. (Variety: Odecchi, Soejima *et al.* 1967)

which are originally introduced from Thailand are highly resistant. The 2 varieties, Kamigane-1 and Guatemala-Prabudhabat, are suitable as parent plants in breeding for

Table 3. Resistant varieties of maize to streaked dwarf.

Variety	Grade of resistance	Time of maturity
Kamigane 1	HR*	late
Narusawa-Saiko 1	R	early
Guatemala Prabudhabat	R	late
Hirano	R	early
Suyama-Inno 1	R	moderate
Tsukui-Yoshino	R	moderate
Guatemala No. 4	R	late
Guatemala Intermediate 1	R	late
Congo Konkhaen	MR	very late
Kamigane-Kamihagiwara 1	MR	early
Kamigane-Kamihagiwara 3	MR	moderate
Golden	MR	mederate
Wisconsin 531	MR	early
Hawaiian Sweet	MR	late
Iwama-zairai	M	late
Wis. 531 (455×466)	M	early

* HR : Highly resistant, R : Resistant, MR : Moderately resistant, M : Moderate.
After Soejima *et al.* (1967)

Table 4. Susceptibility of F_1 hybrids to streaked dwarf.

Mother variety	Father variety			Mean
	White Dent Corn	Long Ear Synthetic	Yachimatazairai	
Kamigane 1	21.9*	40.6	40.6	34.4
Suyama-Inno 1	45.2	35.5	45.2	42.0
Koga 1	28.1	40.6	58.1	42.3
Kamikadohara 1	46.9	65.6	48.5	53.6
Guatemala Sarabri	32.3	48.4	41.9	40.9
〃 Prabudhabat	28.1	25.8	31.3	28.3
〃 Intermediate 1	74.2	46.7	43.3	54.7

* Infection rate (Soejima *et al.* 1967)

resistance in the green fodder or silage corn.

Control—The control measures are recommended as follows: (1) Control leaf hoppers in the early stage of the maize (until about 8 leaf stage) by the application of systemic insecticides. (2) Use the resistant maize hybrids.

Northern Leaf Blight

The northern leaf blight caused by *Helminthosporium turcicum* is common on maize. Under favorable conditions, cool and rainy climate in the growing season, it may occasionally become locally severe in Hokkaido, Tohoku and Kanto-Tosan district.

Symptoms—The disease occurs mainly on the leaf blades, on the leaf sheaths and sometimes on the tassels. The lesions appear first on the lower leaves. They are first water-soaked, and then develop into characteristic symptoms which are large linear to irregular, somewhat elliptical lesions, with grayish green to tan in color. When fully expanded the lesions may be 9 by 110 mm. Under favorable conditions, the lesions coalesce and the plants appear dead and gray, as though injured by frost.

The causal organism—*Helminthosporium turcicum* Pass. (The perfect stage: *Trichometasphaeria turcica* Luttrell). Conidia are abundantly produced on the leaf lesions. Conidiophores arise in fascicles from the stomata. They are dark brown, 2- to 8-septate, 7–12 by 66–263 μ. Conidia are straight or slightly curved, light brown, tapering toward both ends, usually 3- to 8-septate with protruding hilum, varying greatly in size, 12–28 by 28–153 μ.

Etiology and resistance of variety—The fungus subsists between crop seasons by mycelia or conidia in or on infected maize leaves. The spore formation is best at about 23°C. The newly formed spores are carried by the wind to growing maize leaves. When moisture is present and temperature is within 20 to 30°C, they germinate and penertate within 6 to 18 hours. The optimum temperature for mycelial growth is 27–30°C. The fungus attacks also sorphum, Sudangrass, Johnsongrass and teosinte.

Yamashita, Muramatsu, and Okochi (1961) investigated on the influence of environmental conditions on the development of the disease. The disease is increased by sowing early in season in a susceptible variety. Low levels of the applications of nitrogen and potassium also increase the disease conspicuously. The different resistance of maize varieties or strains are recognized from the results of field observations from 1951 to 1961 in the Gotenba branch station of Shizuoka Pref. Agr. Exp. Sta. as shown in Table 5.

Control—The disease is controlled very effectively by use of resistant hybrids. The

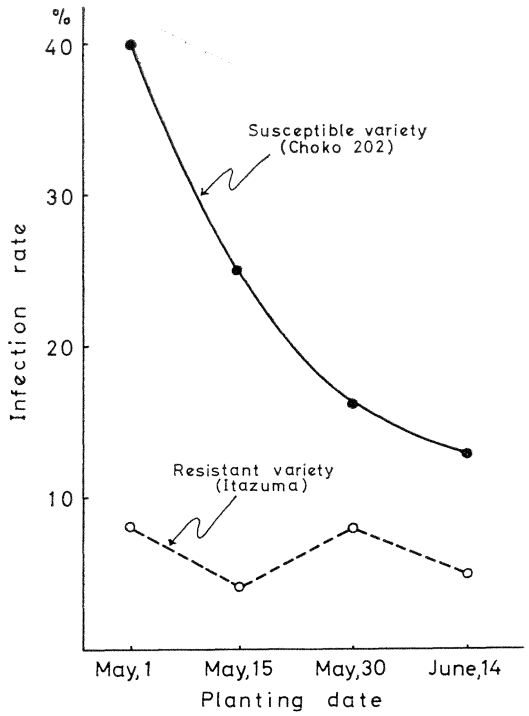

Fig. 2. Influence of the planting date of maize on the northern leaf blight. (Yamashita *et al.* 1961)

Table 5. Resistance of varieties or strains of maize to northern leaf blight.

Highly resistant:

MS 29, J 189, J 429, J 437, J 438

Resistant:

Jaries Golden Prolific, Ehime-otomorokoshi 3, Itazuma, Suyama, TC 5, TC 6, TC 12, MS 6, MS 19, J 55, J 153, J 219, J 262, J 372, J 466

Moderately resistant:

Koshu, Nakadama, Jurigi, Hakushoku-zairai, C 164, C 1317, KY.S, Choko 242, TC 3, TC 74, MS 25, J 168, J 422, J 344, J 112

Moderate:

Leaming Early Dent, Irareko, Naka-aka-tomorokoshi, Okuzuru-wase, Hachiretsu-wase, White Dent Corn, Choko 245, TC 45, TC 55, TC 53, TC 77, TC 78, TC 96, MS 10, MS 33, MS 43, Jms SC, J 207, J 290, J 83, J 218, J 180, J 436, J 440, J 470, J 435.

Moderately susceptible:

Nagano 1, Nagano 25, Ehime-otomorokoshi 1, Reid's Early Yellow, Sakashita, Choko 161, TC 73, J 213, J 232, J 386, J 378, J 183

Susceptible:

Wisconsin 690, Golden, Wood's Improved Golden, Purdue Bantam, Choko 202, Choko 221, Choko 227, Choko 237, TC 1, TC 7, MS 7, MS 24, J 185, J 472, J 131, J 186, J 376

Highly susceptible:

Wisconsin, Wisconsin 531, Sweet, MS 42

other measures such as, removing crop residues, planting as late as ripening of the crop permits, and using enough nitrogen and potassium manures, are also recommended.

Southern Leaf Spot

The southern leaf spot caused by *Helminthosporium maydis* is distributed widely in Japan. The disease occurs more severely in the warmer climatic zones such as, Kyushu, Shikoku, and Chugoku districts, than the northern leaf blight does and also on the green fodder maize.

Symptoms—The lesions on the leaves are first small, brownish spots. The numerous spots are elongated gradually between the veins and finally become spindle or elliptical, 2 by 10 mm, grayish tan with purple or reddish brown margins. The heavily infected leaves get killed from the top of the leaf without the further enlargement in size of spots. The lesions on the leaves are distinct from those of northern leaf blight, as they are smaller, more definite, and different in pattern and color. Another difference between these two Helminthosporioses is that *H. maydis* attaches the seedlings and young plants.

The causal organism—*Helminthosporium maydis* Nisikado et Miyake (The prefect stage: *Cochliobolus heterostrophus* Drechsler). Conidiophores emerge 1 to 3 from the stoma on the older portion of the lesion. They are greenish brown, 4- to 11-septate, 5–9 by 43–487 μ. Conidia are light greenish brown, often curved, tapering toward both ends, usually 4- to 10-septate, and 10–22 by 30–140 μ in size. The perfect stage is rarely found in nature.

Etiology and resistance of variety—The etiology of the disease is similar to that of northern leaf blight disease. The minimum and maximum temperatures for the formation of conidia and for mycelial growth of the fungus are slightly higher (by about 3–4°C) than those of *H. turcicum*.

Nishihara (1966) reported that the resistance of the varieties could be adequately determined in counting the number of lesions or estimating lesion areas. Using this method White Dent Corn 491, Nagano No. 1, Nagano No. 25, J 219, and Yellow Dent Corn are determined to be resistant to the disease.

Kabatiella Leaf Spot

A new leaf spot disease, Kabatiella leaf spot caused by *Kabatiella zeae* was first found in Hokkaido in 1956. The disease is now distributed in Hokkaido and Tosan district.

Symptoms—The disease occurs mainly on leaf blades, on leaf sheaths and husks, and rarely on stems of maize plants. The symptoms are small circular, elliptical or spindle-shaped spots with 1–3 mm in diameter and often very abundant in the number. The lesions are water-soaked at first and turn light gray or brownish gray with definite brown or brownish purple margins and light yellow haloes. When the spots are numerous, the whole leaf becomes brownish gray and dies prematurely.

The causal organism—*Kabatiella zeae* Narita et Y. Hiratsuka. The acervuli are indistinctive without setae. The conidiophores emerge from the stomata or through the epidermis. They are hyaline, clavate, and 4–6 by 10–15 μ in size. One to eight conidia are borne in a cluster at the tip of the conidiophore. The conidia are hyaline, falcate, nonseptate, and 2.0–3.5 by 16.3–47.5 μ.

Etiology and resistance of variety—Although the disease cycle has not been clarified, the fungus appears to overwinter on or in infected plant refuse. The fungus attacks only maize plant. Narita and Hiratsuka (1959) stated from their observations in

the field that flint corn is damaged most conspicuously among the maizes. In their inoculation tests the disease occurs, however, on sweet corn, on dent corn, on waxy corn as well as on flint corn. On the other hand, pop corn is moderately resistant to the disease.

Other Diseases

Rust—Although three rusts are known on maize plants in the world, only common rust is found in Japan. This rust, caused by *Puccinia sorghi*, is distributed in the southwestern parts of Japan and as far north as Kanto-Tosan district since 1938. In general, the damages from the disease are less heavy. Soejima, however, in 1967 observed the outbreak of the disease soon after 5 to 6 leaf stage of young maize plant in Miyazaki Pref.. Then, it was found that the varieties, Puebla Crupo 1 from Mexico and Bolito Amarillo from India are highly resistant and three varieties from Mexico, Colaya, La Pasta, and Tuxpantigua are resistant, but almost all native varieties and their hybrids are susceptible to this disease.

Smut—Common smut caused by *Ustilago maydis* is common in Japan without causing heavy losses. As well known the galls, which are full of the black chlamydospores of the causal organism, appear on all aboveground parts of maize plants, commonly on axillary buds and flowers of ear and tassel.

Gibberella ear rot—The Gibberella ear rot caused by two species of *Gibberella, G. zeae* and *G. fujikuroi*, is distributed widely in Japan. They attack the ears of maize plants in autumn and the seedlings in spring and cause ear rot and seedling blight.

Downy mildew—Several downy mildew diseases are known to attack maize plants. Only crazy top caused by *Sclerophthora macrospora* occurs very rarely in Japan.

Conclusion

The researches on the maize diseases have not been carried out seriously in Japan, because the maize is not so economical as rice. However, some studies on the important diseases have been made, concerning the etiology and the control.

The streaked dwarf, one of the most important virus diseases, is controlled by the application of insecticides to kill the leaf hoppers, the vector of the virus, and by use of the resistant hybrids.

The cultivation of the risistant varieties is also effective to control two Helminthosporioses, i.e., northern leaf blight and southern leaf spot.

As far the control of the maize diseases, it seems the most effective to use the resistant varieties or hybrids, although it is needed to know the etiology.

I propose that our plant pathologists should be more concerned with this aspect in cooperation with the breeders.

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