Trichome Infection of the Tea Anthracnose Fungus *Gloeosporium theae-sinensis*

By ETSUJI HAMAYA

Tea Agronomy Division, National Research Institute of Tea
(Kanaya, Shizuoka, 428 Japan)

Gloeosporium theae-sinensis Miyake is the fungus which causes anthracnose on tea plants. Tea anthracnose breaks out from May to September, forming large lesions on the leaves. The characteristic lesion is irregularly oval from about 2 cm in diameter to more than one half of the leaf area in size and reddish brown in color (Plate 1). Only the young leaves are attacked and most of them fall off. Usually, severe occurrence of the disease affects the shoots of the second and third flush. In case when the third plucking is not practiced, extensive damage to tea gardens, due to remaining infected shoots, is often observed in late summer or early autumn, with almost all the leaves having large red-brown lesions. In those gardens, new shoots for the first crop of the next year do not develop well due to heavy defoliation. Although anthracnose is one of the most important tea diseases in Japan, it was very recently found by Hamaya (1980) that the fungus invaded the plant only through the trichomes of leaves. In the present paper, the trichome infection of this causal fungus and varietal resistance in it will be described.

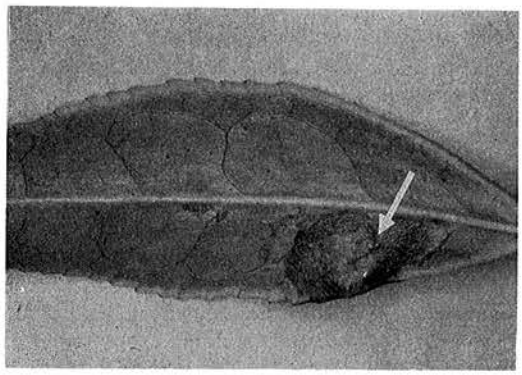

Plate 1. Lesion of tea anthracnose. Arrow indicates the spot infected initially.

Trichomes of tea plant

Trichomes of plants may be classified into some different morphological categories, but those occurring on the under surface of tea leaves are referred to as hairs of common type. They are highly characteristic of tea. Each of the hairs is silky, soft and made up of one long cell, and is bent at right angle near the base, so that it lies almost flat on the surface of the leaf, and it is surrounded at the point of insertion by radially arranged epidermal cells. The hairs vary in length, thickness of the lateral cell wall and density on the leaves in accordance with the varieties or the ages of the leaves. Their length attains frequently 400 to 800 mμ, in general, the hairs on the very young leaves are thinly walled with much protoplasmic contents in a tubular structure, and are more abundant than on the old leaves, often forming a dense pubescence. As the leaf grows older, the hair lateral cell wall becomes thickened, impregnating the lumen from the distal portion, the cavity is largely obliterated except only the part of the base, and finally almost all the hairs get dry and fall.

Trichome infection of the fungus

Tea anthracnose spreads by conidia produced in the lesion of the live leaf on the plant. When it rains, the water droplets in which the spores are suspended are splashed to new

leaves of the host plant. The spores adhering to the trichome germinate and form appressoria and then the infection hyphae penetrate into the cell wall of the hair. Presence of free water on the surface of the leaf is the most important factor for the infection. The infection occurs only when the plant is kept wet after inoculation for at least 12 hr. Germination of the conidia hardly occurs in distilled water, but it is markedly stimulated by the presence of juice or decoction of tea leaf and the formation of appressoria shows a high incidence in a solution containing suitable concentration of tea leaf extract, while at higher concentration, only hyphal growth would be promoted. These phenomena suggest that the leachates derived from the tea plant and present on the surface of the leaf play an important role in the infection. The fungus which penetrates into the cell wall grows downwards in the lumen of the trichome and invades the leaf tissues. Subsequently, a small, slightly elevated round shape spot 0.2–0.5 mm in diameter, light green in color is formed surrounding the hair. The incubation period is from 10 to 30, mostly about 20 days. Following the formation of the small spot, enlargement of the lesion is comparatively rapid; at first expanding of the spot appears as a watery, yellowish green or yellow discoloration, and then the color turns to reddish brown or brown.

As a rule, only one lesion takes place on one leaf, and even after the lesion has matured the small initially formed spot can be easily distinguished from the rest area of the patch owing to its whitish color and particularly by a hair remaining at the center (Plate 1, 2). In microscopical examination, it is observed that the lumen of the hair present at the center of the small spot is open and some fungal hyphae have grown in it (Plate 3), on the contrary, the cavities of the other hairs occurring on the rest area of the lesion are mostly closed and no fungus is found in them (Plate 5). The fungus detected in the hair of the small spot can be proved to be the

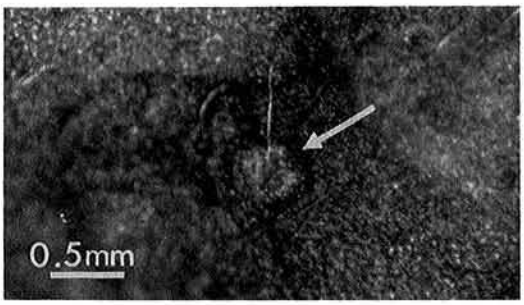

Plate 2. Initially infected spot, with a hair at the center

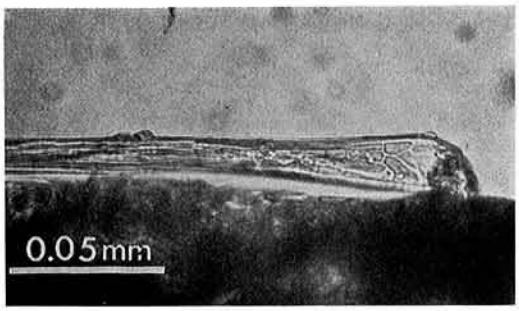

Plate 3. Infected hair, with fungal hyphae in the lumen

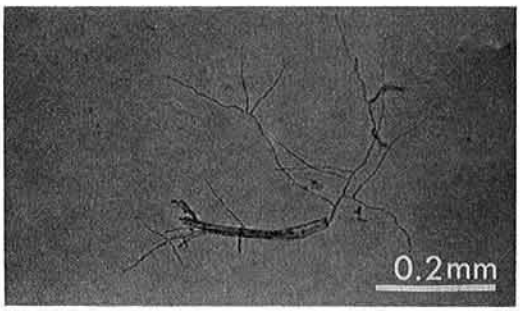

Plate 4. Growth of the causal fungus from the infected hair on a PSA medium

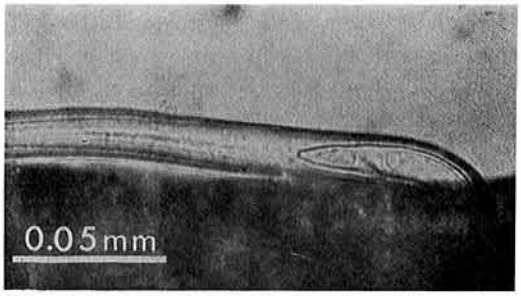

Plate 5. Uninfected hair, with mostly closed cavity

anthracnose fungus by cultural tests. The fungus grows from the hair which has been surface-disinfected by dipping in alcohol for an instant and placed on a potato sucrose agar medium (Plate 4).

Varietal difference of trichomes

By wound-infection, the leaves whatever ages of all tea varieties are susceptible to the fungus, although the size of formed lesions is different by variety. However, in the field, anthracnose invades only young three leaves from the top of the growing shoot, and certain varieties are very susceptive but other some varieties are highly resistant to the disease. It is assumed that the inability of the fungus to attack mature leaves is due to the progressive thickening of the cell wall of trichomes and its falling off with maturity. On the other hand, generally, the lateral cell wall of trichomes occurring on the leaves of the resistant varieties tends to be thicker or thicken faster than those of the susceptive varieties. The cell walls of trichomes are thickened by development of secondary walls, which may be lignified. Safranin has an affinity with lignified cell wall. Table 1 shows variation of staining trichomes by safranin which was observed among several varieties different in susceptibility to anthracnose. The trichomes of resistant varieties were stained in higher incidence than those of susceptive varieties were. The shoots of the varieties were soaked in 1% safranin solution for three min and washed with tap water for fifteen min, then the stained and unstained trichomes occurring on an area of 1.8 mm × 18 mm at the middle position between the mid-rib and margin of the leaves were counted.

As the tea plant is infected with the fungus only through the hairs of the under surface of the young leaves, it is inferred that varieties lacking trichomes on their leaves would be insusceptible to the disease. An inoculation test with spore suspension spray was done on

Table 1. Varietal difference in safranin stainability of leaf trichomes and susceptibility to tea anthracnose

Variety	Susceptibility[a] to anthracnose	Leaf position from top	Trichomes[b] Number of observed	Ratio of stained
				%
Sayamakaori	5	3	164	32.3
		4	129	40.3
		5	159	55.7
Yabukita	4	3	68	13.2
		4	72	16.1
		5	41	49.4
Izumi	3	3	110	36.5
		4	114	58.6
		5	131	91.2
Yamatomidori	0	3	172	82.5
		4	219	97.7
		5	161	95.3
Yutakamidori	0	3	192	76.3
		4	243	94.8
		5	313	99.8
Benihomare	0	3	154	82.8
		4	208	85.9
		5	187	99.7

(a) Varieties are scored for severity of natural infection based on a scale of 0 to 5, with 5 indicating the severest infection

(b) Mean of trichomes number on an area 1.8 mm × 18 mm of two leaves

Table 2. Varietal morphology of leaf trichomes and susceptibility to tea anthracnose

Variety or strain	Trichomes		Plants	
	Length	Density	Number of tested	Ratio of affected
				%
Z 1	ordinary	ordinary	63	63.5
V 9	very short	rare	29	0
V 12	ordinary	ordinary	64	42.2
V 31	slightly short	ordinary	29	24.1
V 36	ordinary	ordinary	77	39.0
V 38	slightly short	slightly rare	52	30.8
V 40	short	slightly rare	64	0
V 43	very short	rare	31	9.7
V 44	ordinary	ordinary	14	28.6
V 52	very short	rare	61	1.6

Plants growing on the same nursery bed were inoculated on June 20, and observed on July 20, 1980.

young plants of several clones including so-called hairless strains all of which were bud mutants of Z 1 induced by gamma-ray irradiation. Although the original variety Z 1 and the strains keeping ordinary hairs showed moderate susceptibility, the strains bearing only rare, short or very short trichomes were highly resistant to the disease. These results are demonstrated in Table 2.

Conclusion

There are few reports on the direct influence of trichomes on infection. Kitajima (1951) found that primary infection of the peach anthracnose fungus *Gloeosporium laeticolor* occurred on the trichomes of young fruit and invaded into the fruit tissues through the affected trichomes. In that case, however, the fungus could also invade directly both the young peach leaf and the nectarine fruit without forming appressoria at the entry points, although the tea anthracnose fungus can invade the plant only through the trichome of young leaves.

The reason for trichomes being favored as an infection site is not clear, they may have provided less of a physical barrier to entry, leakage of nutrients may have been greater around trichomes or there may have been increased availability of water. In any case, as the trichome of the young leaf is the sole entry port of the tea anthracnose, it is reliable that the important factor of resistibility to the disease in tea plant is governed by the properties of leaf trichomes. Therefore, observation of the leaf trichomes will become one of the practical methods for screening resistance to anthracnose in tea breeding.

References

1) Abe, T., Kono, M. & Takaya, S.: Studies on the anthracnose of tea bush. III. Sporulation and germination of conidia of the anthracnose fungi. *Sci. Rept. Saikyo Univ. Agr.*, **10**, 68–76 (1958) [In Japanese with English summary].
2) Abe, T. & Kono, M.: Studies on the anthracnose of tea bush. IV. Sporulation, germination and infection of conidia of the anthracnose fungi. *Sci. Rept. Kyoto Pref. Univ. Agr.*, 11, 38–43 (1959) [In Japanese with English summary].
3) Hamaya, E.: Infection route of the tea anthracnose fungus *Gloeosporium theae-sinensis* (abstr.). *Ann. Phytopath. Soc. Jap.* 4F, 110 (1980) [In Japanese].
4) Hamaya, E.: Varietal resistance in trichome infection of tea anthracnose (abstr.). *Ann. Phytopath. Soc. Jap.*, 47, 96 (1981) [In Japanese].
5) Kitajima, H.: Studies on the dissemination of peach anthracnose I. Overwintering of the causal fungus. *Ann. Phytopath. Soc. Jap.*, 13, 57–59 (1949) [In Japanese with English

summary].
6) Kitajima, H.: Studies on the dissemination of peach anthracnose II. *Ann Phytopath. Soc. Jap.*, **15**, 67–71 (1951) [In Japanese with English summary].
7) Kitajima, H.: Studies on the dissemination of peach anthracnose III. Histopathological observation. *Ann. Phytopath. Soc. Jap.*, **16**, 109–112 (1952) [In Japanese with English summary].
8) Nakayama, A.: Characteristics of the mutations induced from gamma-rayed tea plant under heavy prunning treatment. *Study of Tea*, 47, 29–35 (1974) [In Japanese with English summary].
9 Takaya, S.: Results of re-examination and some findings on the conidium germination of tea anthracnose fungus. *Study of Tea*, 48, 49-60 (1975) [In Japanese with English summary].

(Received for publication, January 5, 1982)