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WITCHES'-BROOM OF *PAULOWNIA TOMENTOSA* L.*†

YOZAN TOKUSHIGE

INTRODUCTION

"Witches'-broom" of *Paulownia tomentosa* is not a disease of recent origin. T. Kawakami (1902) suggested that the disease was observed for the first time in a certain part of Kumamoto Prefecture in about 1880 and after that time it has gradually been spreading to various districts in Kyushu. Hazime Yoshii (1931 a) stated that the disease distributed in the southern parts of Japan including all Kyushu districts and southern parts of Korea, and was spreading to other districts. It was also found in North China in 1941. It seems that the disease spread to Kanto district in 1950. In these districts various protecting-measures have been taken without success to protect paulownia from this wide-spread and fatal disease.

The study on the disease had been undertaken by T. Kawakami (1902) in Kumamoto Prefecture. He discovered a kind of parasitic fungus on the petioles and the terminal buds of paulownia, isolated and cultured the fungus and studied its morphology, physiology and its parasitic nature. The results led him to the conclusion that it was the pathogenic fungus of the witches'-broom. The scientific name, *Gloeosporium Kawakamii* Miyabe was given to this parasitic fungus.

Hazime Yoshii attempted to ascertain the relationship of *Gloeosporium Kawakamii* with the witches'-broom of paulownia.

* Contribution from the Laboratory of Plant Pathology, Kyushu University.

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He studied on the fungus in respect to its morphology and nature in culture media, germinative physiology of the conidia, inoculation experiment, symptoms and anatomy of the infected paulownia. He came to the conclusion that *Gloeosporium Kawakamii* was not the pathogenic fungus of the witches'-broom of paulownia, but that the fungus was the causal organism of an anthracnose of paulownia (Yoshii, 1931 a, b, c ; 1933 a).

Subsequently Hazime Yoshii (1933 b), assuming that the witches'-broom was a sort of virus disease, carried out graft inoculation. He succeeded in grafting and ascertained its infectious nature, but unfortunately the results were not observed for the successive years.

In 1946 the author started the experiment to confirm the graft-infectious nature of the witches'-broom of paulownia. In 1947 He succeeded in grafting four trees, —two of which showed the successful infection from diseased scions to healthy stocks.

In 1948 He tried to graft sixty trees and obtained the succesful results of grafting infection. The results of the experiments

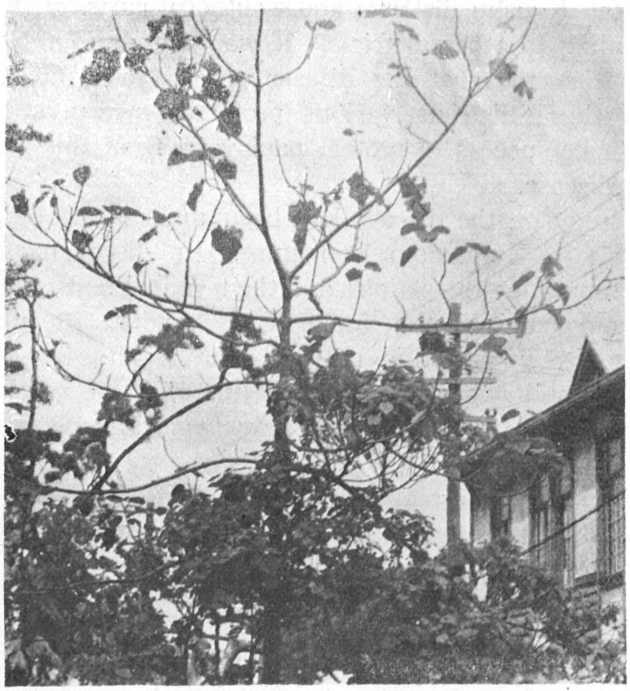

Fig. 1 Paulownia tree affected with "witches'-broom ".

were reported at the Meeting of the Phytopathological Society of Japan (1948) and at the Meeting of the Japanese Forestry Society Kyushu Branch (1949).

Hiromu Yoshii (1950) of the College of Agriculture, Matsuyama, reported on the graft infectivity of the present disease, in which two of ten grafts showed the successful infection from diseased scion to healthy stocks. This report corroborates the authors' conclusion.

The present paper deals with the detailed results of the authors' experiments on graft infection of witches'-broom of paulownia.

Fig. 2. Witches'-broom symptom on the top of a diseased paulownia branch.

SYMPTOMS

Typical symptoms of the disease are given in contrast with the normal trees.

(1) The growth habit

In the case of normal paulownia, a bud sprouts in spring and grows to a new stem or a new branch, which bears about ten

pairs of opposite leaves. The growth of stem ceases before the beginning of September. The axillary buds of the new stem or the branch do not sprout for this season, so that they usually have no lateral shoots for the current season (Fig. 3).

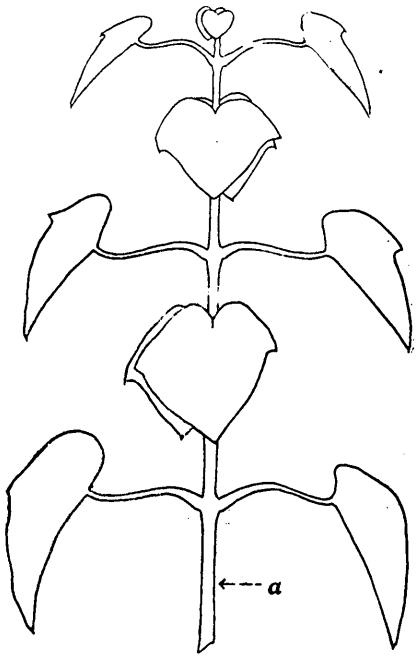

Fig. 3

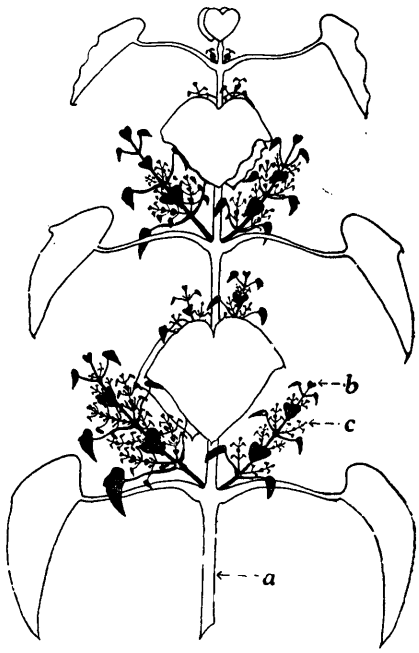

Fig. 4

Fig. 3. The arrangement of leaves on normal paulownia. a: New stem.

Fig. 4. The arrangement of leaves and new shoots from resting buds on diseased paulownia. a: New stem or branch. b: Primary shoot. c: Secondary shoot.

In the case of the diseased paulownia, a bud sprouts in spring and grows to a new stem to a new branch which does not cease its growth until late in autumn. The primary axillary buds on the new stem or the new branch sprout and grow to the secondary shoots, then the secondary axillary buds to the third shoots and thus sprouting is repeated until late in autumn. The restlessness of the sprouting of the axillary buds and the growth of the shoots and branches without any restriction are the causes of the symptom of the witches'-broom.

(2) Branches

The branches and shoots of the diseased tree are slender and brittle and show an extreme negative geotropism. The color of diseased branches and shoots becomes yellowish green.

(3) Leaves and hairs

There are two sorts of leaf-forms in normal paulownia. One is the leaf-form seen in the young tree of one or two years old and the other is that seen in the elder tree. The former shows both large and small incisions on the margin of a leaf while the latter shows only large incisions (Figs. 5, 6). With the growth of the tree, the leaves which have only large incisions increase in number, and within 2 or 3 years the whole tree comes to have leaves with large incisions on the margin.

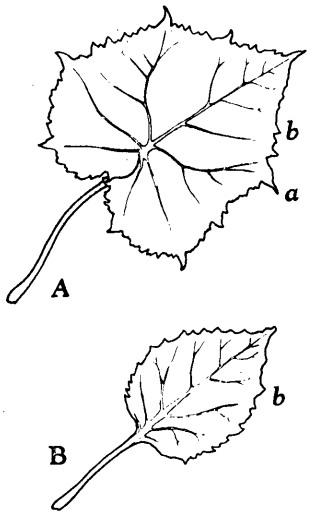

Fig. 5. The leaf-form on one or two years old normal paulownia.
A The leaf on uper parts of branch and stem.
B The leaf on lower parts of branch and stem.
a Large incisions.
b Small incisions.

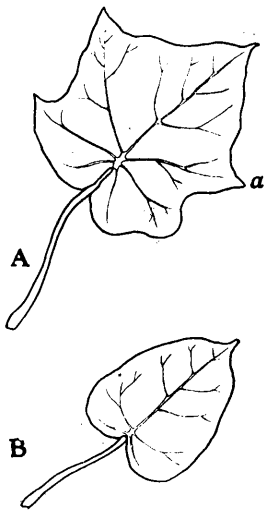

Fig. 6. The leaf-form on more than three years old normal paulownia.
A The leaf on uper parts of branch.
B The leaf on lower parts of branch.
a Large incisions.

In the diseased tree, however, the leaves with both large and small incisions appear even though it becomes more than two

years old (Fig. 7, left). Usually all the leaves on the diseased shoots are abnormally thin and narrow and are uneven on the surface. The color is faded to a yellowish here. Malformed leaves are often observed on the diseased shoots.

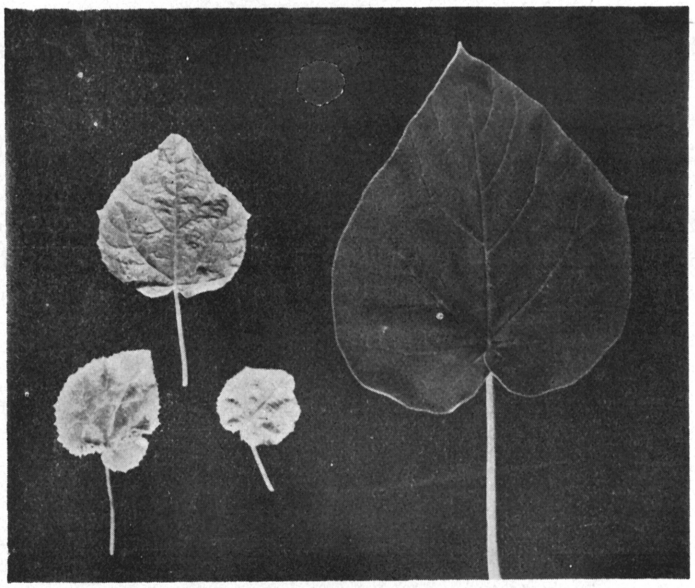

Fig. 7. A leaf from healthy plant (right) and three leaves from diseased plant (left).

There are four sorts of types of hairs on the under side of the leaves of paulownia (Fig. 8). The hairs which grow on the under side of the leaves on the healthy tree of more than two years old are mostly D type, and they grow very thickly. While most of the hairs which grow on the under side of the leaves on the diseased tree of more than two years old are those of A, B, or C type, and they grow sparsely.

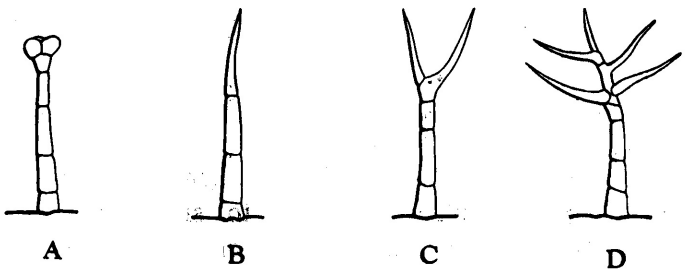

Fig. 8. The type of hairs on the under side of the leaf.

(4) Roots

The roots of the diseased trees are much retarded in growth. They are easy to decay; inner parts are discolored and become brownish. They have little regenerating power.

(5) Anatomical observation

No X-body has been found in any parts of the diseased tree. The cell menbrane is thinner and the nucleus shrinked and small.

A marked contrast is seen between the diseased and healthy trees in the differentiation of the woody cylinder. In the normal young tree, most of the large vessels are situated just out-side of pith and smaller vessels are scattered within the xylem elements (Fig. 9). On the contrary, in the diseased tree, many large vessels are also scattered within the xylem elements (Fig. 10)

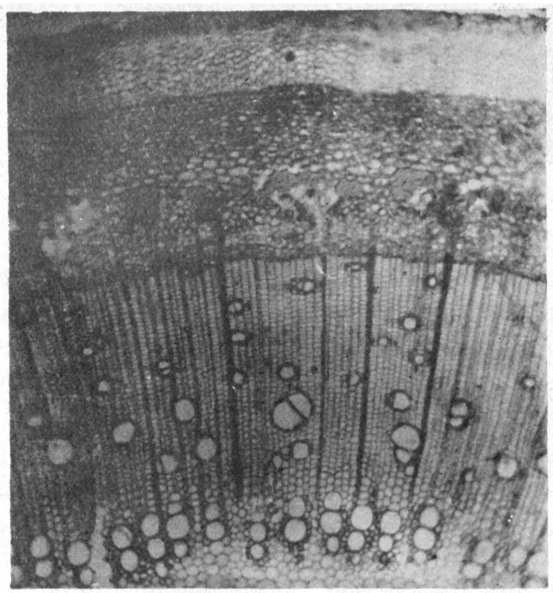

Fig. 9. Cross section of healthy stem. (×50)

The cell arrangement in the woody cylinder is irregular, especially around the vessels, and the rays are bent to and fro in the cross-section of the diseased stem.

(6) The formation of witches'-broom symptom

The diseased paulownia begin to show the characteristic symptoms of witches'-broom in May or June. The symptom is not restricted to the specific parts of a tree. It appears on the

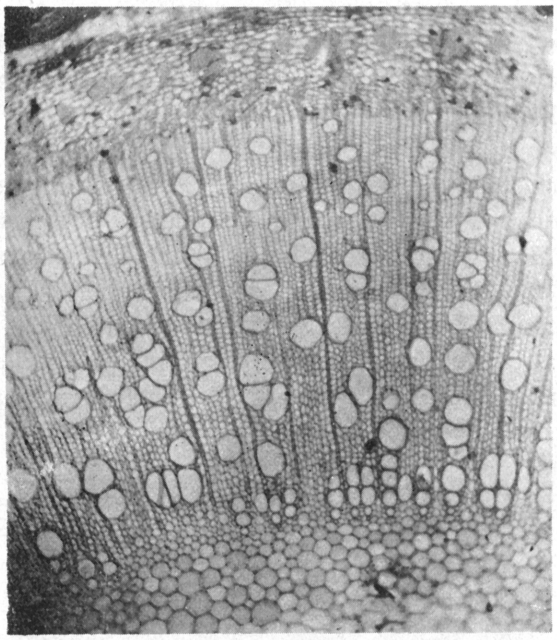

Fig. 10. Cross section of diseased stem. (×50)

lower or middle branch as well as on the top part of a tree and then spreads to the adjacent branches until the entire tree becomes affected. Many of the diseased leaves do not persist until late and begin to absciss in late summer or early in autumn. This abscission begins on the lower leaves of the diseased shoots and progresses upward as the season advances. The small leaves on the upper part of the diseased shoots, however, remain attached and the axillary buds continue to sprout late in autumn or even in winter.

In case the disease attacks the tree of one or two years old it may die within the current season or in the next season. In case the disease attacks the tree of more than three years old the growth power of the tree is strongly depressed. Even though they do not die within the current season, they will be dead within a few years.

Infection Experiments

Infection experiments were carried out by the means of grafting. Two methods of grafting were undertaken as follows: (1)

Grafting the diseased scion on the healthy stock (Fig. 11). (2) Grafting the healthy scion on the diseased stock (Fig. 12). If the symptoms of witches'-broom appear on the healthy stock in the former (1) case, or if the symptoms appear on the healthy scion in the latter (2) case, the witches'-broom of paulownia is an infectious disease. Experiments were carried out on the trees in pots which were placed in the green house.

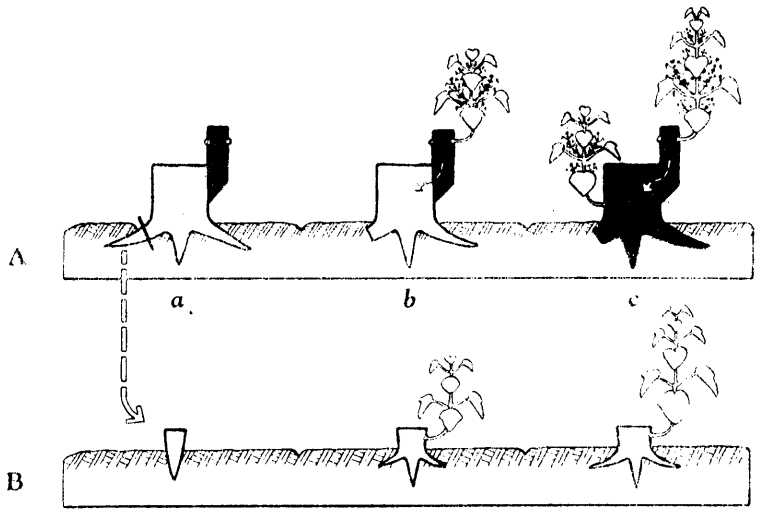

Fig. 11. Infection from the diseased scion to the healthy stock by grafting.

A Grafting the diseased scion on the healthy stock.
- a First state: Before budding.
- b Second state: Diseased symptom appeared on the grafted (diseased) scion.
- c Third state: Diseased symptom appeared both on the diseased scion and the healthy stock.

B Control from healthy root cutting.

1. Grafting the diseased *Paulownia tomentosa* scions on the healthy *Paulownia tomentosa* stocks.

In 1946, apparently healthy trees were selected from among the paulownia trees grown at the Fukuoka Forest Experimental Station. Seeds and root-stocks collected from these healthy trees were sown or planted in pots in the spring of 1947. In the next year, sixty two vigorous plants were selected from among the plants from seeds, and twenty-nine vigorous plants were selected from among the plants from root-shoots. On March 10, 1948,

thirty one healthy plants from seed were grafted with the same number of the scions, and the other thirty one plants were left without treatment for control. On the other hand twenty nine healthy plants from root-shoots were grafted with the same number of the diseased scions, while twenty-nine pieces of roots each of which was cut off from the root of grafted stock were planted in pots for control (Tables 1, 2, and Figs. 11—15).

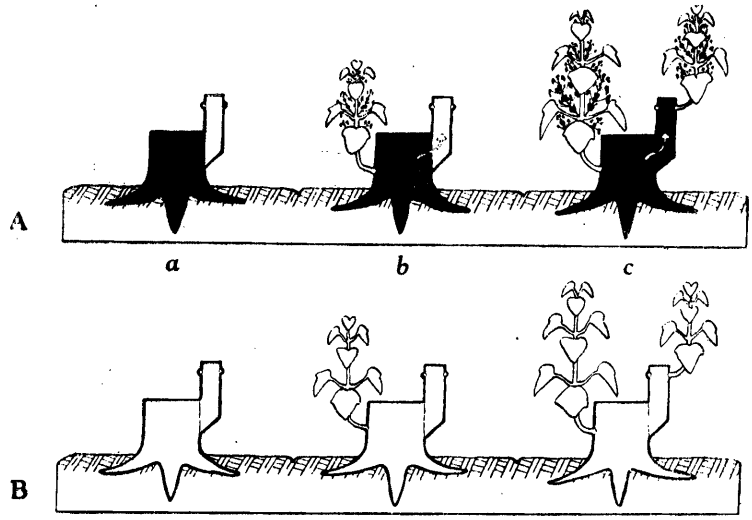

Fig. 12. Infection from the diseased stock to the healthy scion by grafting.

A Grafting the healthy scion on the diseased stock.
a First state: Before budding.
b Second state: Diseased symptom appeared on the diseased stock.
c Third state: Diseased symptom appeared both on the healthy scion and the diseased stock.
B Grafting the healthy scion on the healthy stock (check).

Table 1. Long observations on the graft-plants (grafted on March, 10, 1948): The diseased scions on the healthy stocks.

Plant no. \ Date of exam.		1948							1949						source of stocks
		30 IV	5 V	15 V	26 V	16 VI	26 VI	21 VII	3 VI	13 VI	23 VI	2 VII	12 VII	22 VII	
121	Gr	+	+	+	+	+	+	+							Se
	St	−	−					+							
128	Gr	+	+	+	+	+	+	+							
	St	−	−	−	+	+	+	+							

Plant no.		Date of exam. 1948 30 IV	5 V	15 V	26 V	16 VI	26 VI	21 VII	1949 3 VI	13 VI	23 VI	2 VII	12 VII	22 VII	source of stocks
138	Gr	−	−	+	+	+	+	+	+	+	+	+	+	+	Se
	St					−	−	+	+	+	+	+	+	+	
131	Gr	−	+	+	+	+	+	+							〃
	St					−	−	−							
130	Gr	−	−	+	+	+	+	+	+	+	+	+	+	+	〃
	St	−	−	−	−	−	−	−	+	+	+	+	+	+	
133	Gr	+	+	+	+	+	+	+							〃
	St	−	−	−	+	+	+	+							
115	Gr	−	+	+	+	+	+	+							〃
	St					+	+	+							
6	Gr	−	+	+	+	+	+	+							Ro
	St														
8	Gr	−	−	−	+	+	+	+							〃
	St	−	−	−	−	+	+	+							
4	Gr	+	+	−	−	−	−	−							〃
	St	−	−	−	−	−	−	−	−	−	−	−	−	−	
5	Gr	−	−	−	−	−	−	−	−	−	−	−	−	−	〃
	St			−	−	−	−	−							
3	Gr	−	+	+	+										〃
	St		−												
2	Gr	−	−	+	+	+	+	+	+	+	+	+	+	+	〃
	St				−	+	+	+	+	+	+	+	+	+	
1	Gr	−	+	+	+	+	+	+							〃
	St	−	−	−	−	−	−	−							
168	Gr	−	+	+	+	+	+								〃
	St														
188	U														〃
171	Gr	−	−	+	+	+	+	+	+	+	+	+	+	+	〃
	St														
156	Gr	−	−	−	−	+	+	+	+	+	+	+	+	+	〃
	St	−	−	−	−	+	+	+	+	+	+	+	+	+	
197	Gr	−	+	+	+	+	+	+	+	+	+	+	+	+	〃
	St					−	−	+	+	+	+	+	+	+	

Plant no. \ Date of exam.		1948							1949						source of stocks
		30 IV	5 V	15 V	26 V	16 VI	26 VI	21 VII	3 VI	13 VI	23 VI	2 VII	12 VII	22 VII	
185	Gr	–	–	–	–	–	+	+							Ro
	St	–	–	–											
170	Gr	–	–	–	+	+	+	+	+	+	+	+	+	+	〃
	St	–	–	–											
30	Gr	–	–	–	–	–	–	+	–	–	+	+	+	+	〃
	St	–	–	–	–	–	–	+	–	–	+	+	+	+	
50	Gr	–	+	+	+	+	+	+	+	+	+	+	+	+	〃
	St		–	–	+	+	+	+	+	+	+	+	+	+	
57	Gr	–	–	–	+	+	+	+	+	+	+	+	+	+	〃
	St	–	–	–	–	–	–	+	–	+	+	+	+	+	
96	Gr	–	–	+	+	+	+	+	+	+	+	+	+	+	〃
	St	–	–	–	+	+	+	+	+	+	+	+	+	+	
26	Gr	–	–	–	–	–	–	–	+	+	+	+	+	+	〃
	St								+	+	+	+	+	+	
63	Gr														〃
	St														
19	Gr	–	–	–	+	+	+	+	+	+	+				〃
	St				–	+	+	+	+	+	+	+	+	+	
22	Gr	–	–	–	+	+	+	+							〃
	St	–	–	–	–	–	–								
49	Gr	–	–	+	+	+	+	+							〃
	St	–	–	–	–										
155	U														〃
89	Gr	–	–	–	–	+	+	+	+	+	+				〃
	St					+	+	+	+	+	+	+	+	+	
93	Gr	–	+	+	+	+	+	+							〃
	St					–	–	+							
101	Gr	–	+	+	+	+	+	+							〃
	St		–	–	–	–	–	–	–	–	–	–	–	–	
41	U														〃
31	U														〃

Plant no.		Date of exam.	1948							1949						source of stocks
			30 IV	5 V	15 V	26 V	16 VI	26 VI	21 VII	3 VI	13 VI	23 VI	2 VII	12 VII	22 VII	
107	Gr		+	+	+	+	+	+	+	+	+	+				Se
	St			+	+	+	+	+	+		+	+	+	+	+	
105	Gr		+	+	+	+	+	+	+							//
	St		−	−	+	+	+	+	+							
109	Gr		+	+	+	+	+	+	+	+	+	+	+			//
	St		−	+	+	+	+	+	+	+	+	+	+			
199	Gr		+	+	+	+										//
	St		−	−	−											
114	Gr		+	+	+	+	+	+	+							//
	St		−	−	−	+	+	+	+							
201	Gr		+	+	+	+	+	+	+	+	+	+	+	+	+	//
	St		−	−	−	+	+	+	+	+	+	+	+	+	+	
180	Gr		+	+	+	+	+	+	+							//
	St		−	−												
205	Gr		+	+	+	+	+	+	+							//
	St		−	−	+	+	+	+	+							
75	Gr		+	+	+	+	+	+	+	+	+	+	+	+	+	//
	St						−	−	+	+	+	+	+	+	+	
113	Gr		+	+	+	+	+	+	+							//
	St															
110	Gr		+	+	+	+	+	+	+	+	+	+	+	+	+	//
	St		−	−	−	+	+	+	+	+	+	+	+	+	+	
73	Gr		−	−	−	−	−	−	−	−	−	−	−	−	−	//
	St															
156	Gr		−	−	−	−	−	−	−	−	−	−	−	−	−	//
	St															
16	Gr		−	−	−	−	−	−	−							//
	St									−	−	−	−	−	−	
182	Gr		−	−	−	−	−	−	−							//
	St		−	−	−	−	−	−	−	−	−	−	−	−	−	
125	U															//
122	U															//

Plant no.		Date of exam. 1948 30 IV	5 V	15 V	26 V	16 VI	26 VI	21 VII	1949 3 VI	13 VI	23 VI	2 VII	12 VII	22 VII	source of stocks
17	Gr	−	+	+	+	+	+	+							Se
	St			−	+	+	+	+							
183	Gr	+	+	+	+	+	+	+							〃
	St	−	−	−	+	+	+	+							
140	Gr	+	+	+	+	+	+	+							〃
	St					−	−	+							
123	Gr	+	+	+	+	+	+								〃
	St														
132	Gr	−	−	−	+	−	−								〃
	St														
143	Gr	+	+	+	+	+	+	+	+	+	+	+	+	+	〃
	St	−	−	−	+	+	+	+	+	+	+	+	+	+	
136	Gr	+	+	+	+	+	+	+							〃
	St														

+...Symptom produced, −...Symptom not produced, Gr...Scion,
St...Stock, U...Unsuccessful grafting,
Ro...From root-shoot, Se...From seed.

Following results are obtained from Table 1.

(1) It took about fifty five days after grafting before the first symptom of witches'-broom appeared on the healthy stocks.

(2) The symptoms of witches'-broom appeared on the diseased scions at first and it appeared later on the healthy stocks.

(3) Only twenty seven of the total sixty graft-plants survived the winter.

The results show distinctly the progress of infection from diseased scions to healthy stocks.

The followings are obtained from Table 2.

(1) It is clearly observed that thirty of the sixty young-shoots were infected by grafting the diseased scions. Infection ratio is more than 90 per cent when the number of dead or unsuccessful graft-plants are taken out of consideration.

(2) Eighteen of the thirty one plants from seed were infected by the grafting the diseased scions. The infection ratio is almost 100 per cent when the number of dead or unsuccessful graft-plants are not considered.

(3) Twelve of the twenty-nine plants from root-shoots were infected by grafting the diseased scions. The infection ratio is about 80 per cent when the number of dead- or successful graft-plants are not considered.

(4) All the control plants from seed and root-shoots remained healthy except those root-shoots that died by careless management.

Above results clearly indicate the infectious nature of the disease from diseased scions to healthy stocks, though it has once been said that witches'-broom symptom of paulownia is the consequence of the repeated vegetative propagation.

Table 2. The results of grafting: the diseased scions on the healthy stocks.

Treatment	Seedlings	No. of plants used	No. of plants dead or unsuccessful grafting	No. of plants with symptom	No. of plants without symptom
Diseased scions grafted with healthy stocks	from seed	31	13	18	0
	from root-shoots	29	14	12	3
	total	60	27	30	3
Not treated (check)	from seed	31	0	0	31
	from root-shoots	29	6	0	23
	total	60	6	0	54

2. Grafting the healthy scions on the diseased stocks.

Diseased materials were selected from among the paulownia trees that showed the witches'-broom symptom on the scions and stocks in the infection experiment in 1948. The healthy scions were grafted on five diseased plants from seed and on six diseased plants from roots on March 22, 1949. For the control, the healthy scions originated from above the same were grafted on five healthy plants from seed and on six healthy plants from root-shoots, which were selected from among the paulownia tree that were used for the checks in 1948 (Tables 3, 4, 5, and Fig. 12).

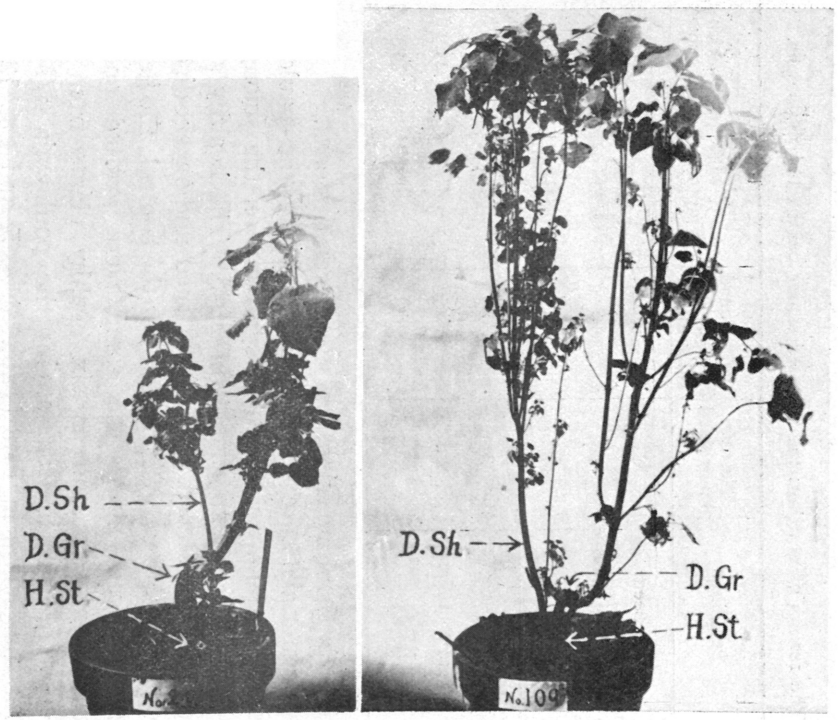

Fig. 13. Graft-plant (diseased scion on healthy stock.).
In the case of spring graft, the diseased scion on the healthy stock, the typical symptom appeared both on stock and scion in current summer.
D. Gr....Diseased scion, H. St...Stock which was healthy,
D. Sh...Diseased shoot from the stock.

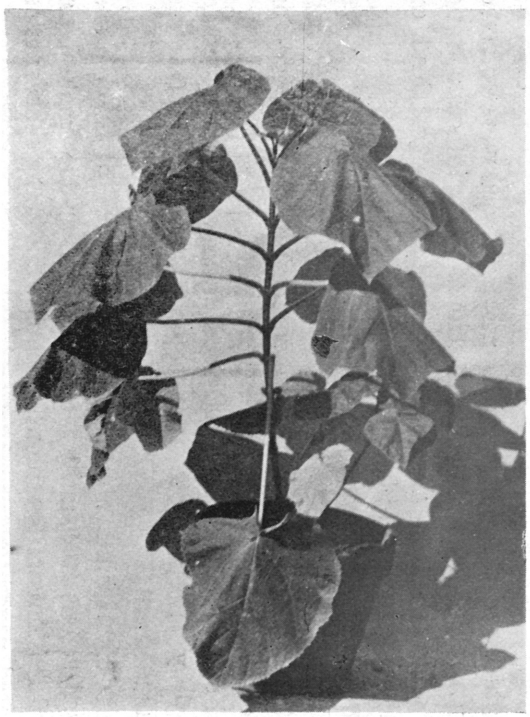

Fig. 14. Control seedling.

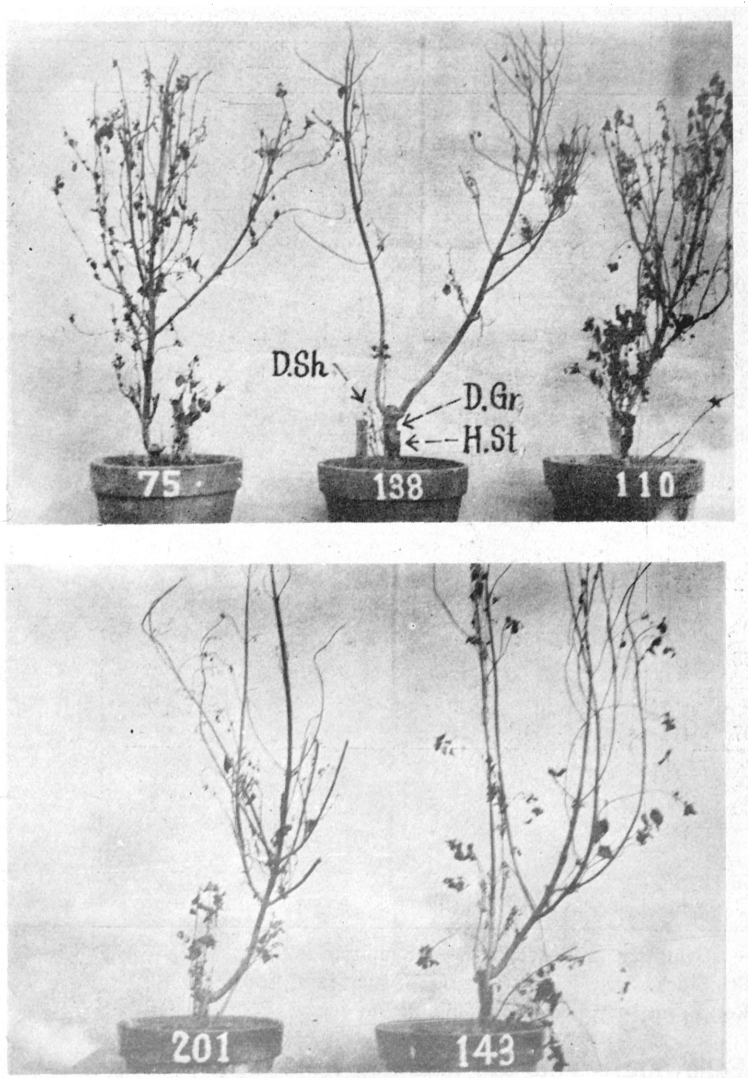

Fig. 15. Graft-plants (diseased scion on healthy stock). In current winter.

Fig. 3. Long observations on the graft-plants (grafted on March 22, 1949): The healthy scions on the diseased stocks.

Plant no. \ Date of exam.		1949 12 V	22 V	3 VI	13 VI	23 VI	2 VII	12 VII	22 VII
201	Gr	−	+	+	+	+	+	+	+
	St	+	+	+	+	+	+	+	+
75	Gr	−	−	+	+	+	+	+	+
	St	+	+	+	+	+	+	+	+
110	Gr	+	+	+	+	+	+	+	+
	St	+	+	+	+	+	+	+	+
143	Gr	−	−	+	+	+	+	+	+
	St	+	+	+	+	+	+	+	+
138	U								
6	U								
2	U								
156	U								
197	U								
30	Gr	−	−	−	−	−	−	−	−
	St	+	+	+	+	+	+	+	+
96	Gr	−	−	−	−	−	−	+	+
	St	+	+	+	+	+	+	+	+

+...Symptom produced, −...Symptom not produced, Gr...Scion,
St...Stock, U...Unsuccessful grafting,
Ro...From root-shoot, Se...From seed.

Following results are obtained from Tables 3 and 4.

(1) It took about fifty-one days after grafting before the symptom appears on the healthy scions.

(2) It was observed that the symptom appeared at first on the stocks and later on the scions.

The results show distinctly the progress of infection from diseased stocks to healthy scions.

Fig. 4. Long observations on the graft-plants (grafted on March 22, 1949): The healthy scions on the healthy stocks.

Plant no. \ Date of exam.		1949							
		12 V	22 V	3 VI	13 VI	23 VI	2 VII	12 VII	22 VII
201′	Gr	–	–	–	–	–	–	–	–
	St								
75′	Gr	–	–	–	–	–	–	–	–
	St								
110′	Gr	–	–	–	–	–	–	–	–
	St								
143′	U								
138′	Gr	–	–	–	–	–	–	–	–
	St								
6′	Gr	–	–	–	–	–	–	–	–
	St								
2′	U								
156′	U								
197′	U								
30′	U								
96′	Gr	–	–	–	–	–	–	–	–
	St								

Abbreviations are the same that of Table 3. The scions used in this experiment are of the same origin as that in Table 3.

Table 5. The results of grafting: The healthy scions on the diseased stocks.

Treatment	No. of plants used	No. of plants or dead unsuccesful grafting	No. of plants with symptom	No. of plants without symptom
Healthy scions grafted with diseased stocks	11	5	5	1
Healthy scions grafted with diseased stocks	11	5	0	6

Following results are obtained from Table 5.

(1) It is clear that five of the six healthy young-shoots were infected by grafting the diseased stocks, when five unsuccessful graftings were taken out of consideration.

(2) In the case of the control experiment, all six young shoots remained healthy through grafting on healthy stocks, when five unsuccessful graftings were taken out of consideration.

From the above results, it is obvious that the witches'-broom of paulownia is infectious from diseased stocks to healthy scions.

3. Grafting the diseased *Paulownia tomentosa* scions on the healthy *Paulownia Fortunei* stocks.

Ten root-shoots were taken in the spring of 1948 from the roots of the *P. Fortunei* which had been grown in the Faculty of Agriculture.

Four diseased scions of *P. tomentosa* were grafted on four healthy stocks of *P. Fortunei* on March 23, 1949. For the control, three healthy scions of *P. tomentosa* were grafted on three healthy stocks of *P. Fortunei* and three healthy root-shoots of *P. Fortunei* were left untreated (Tables 6, 7 and 8).

Table 6. Long observations on the graft-plants (grafted on Match 23, 1949): Diseased *P. tomentosa* on healthy *P. Fortunei*.

Plant no. \ Date of exam.		1949							
		12 V	22 V	1 VI	11 VI	21 VI	1 VII	11 VII	21 VII
12	Gr	−	+	+	+	+	+	+	+
	St							−	+
11	Gr	+	+	+	+	+	+	+	+
	St		−	−	−	+	+	+	+
10	Gr	+	+	+	+	+	+	+	+
	St		−	−	−	+	+	+	+
18	U								

+...Symptom produced, −...Symptom not produced, Gr...Scion, St...Stock, U...Unsuccessful grafting.

Following results are obtained from Tables 6 and 7.

(1) It took more than ninety days after grafting before the witches'-broom symptom appeared on the healthy stocks of

P. Fortunei.

(2) The symptom appeared at first on the diseased scions of *P. tomentosa* and late on the stocks of *P. Fortunei* in the whole plants.

The data show distinctly the progress of witches'-broom infection from the diseased scions *P. tomentosa* to the healthy stocks *P. Fortunei.*

Table 7. Long observations on the graft-plants (grafted on March 23, 1949): Healthy *P. tomentosa* on healthy *P. Fortunei.*

Plant no. \ Date of exam.		1949							
		12 V	22 V	1 VI	11 VI	21 VI	1 VII	11 VII	21 VII
14	Gr	−	−	−	−	−	−	−	−
	St								
15	Gr	−	−	−	−	−	−	−	−
	St								
17	Gr	−	−	−	−	−	−	−	−
	St								

Abbreviations are the same as that of Table 6.

Table 8. The results of grafting: Diseased *P. tomentosa* scion on healthy *P. Fortunei.*

Treatment	No. of plants used	No. of plants unsuccessful grafting	No. of plants with symptom	No. of plants without symptom
P. Fortunei grafted with diseased scions.	4	1	3	0
P. Fortunei grafted with healthy scions (check I)	3	0	0	3
P. Fortunei not grafted (check II)	3	0	0	3

From Table 8 the followings are observed.

(1) All of the three healthy stocks of *P. Fortunei* were infected by grafting the diseased scions of *P. tomentosa,* when unsuccessful grafting was taken out of consideration.

(2) In the case of control graftings it is known that the symptoms did not appear on the healthy scions of *P. tomentosa* which were grafted on the healthy stocks of *P. Fortunei.*

Accordingly, it may be concluded that the witches'-broom of *P. tomentosa* is able to transmit to *P. Fortunei*, and that witches'-broom of *P. Fortunei* is not the results due to the stimulating action by the grafting with *P. tomentosa*.

4. Impossibility of the transmission of the disease through seed.

The seeds were collected from both healthy and diseased trees grown at the Fukuoka Forestry Experimental Station in 1949 and were sown in disinfected soil in pots in 1950. Twenty five pots were used to sow the seeds from the healthy *Paulownia tomentosa* and the same number of pots for the seeds from the diseased paulownia. About one hundred seeds were sown in each pot. No symptoms of the disease were observed on any of the seedlings obtained. Therefore, it seems that the witches'-broom disease of paulownia is not transmitted through seed so far as is shown in this experiment.

Discussion

It is shown that the symptoms of witches'-broom did not appear on any of the young-shoots of paulownia which had not been treated and on any of the graft-plants, healthy scions to healthy stocks. While, it is shown that the symptoms appeared on the healthy stocks as the result of grafting the diseased scions and that the symptom appeared on the healthy scions as the result of grafting the diseased stocks. Through these experimental data it is concluded that the witches'-broom of paulownia is an infectious disease. It is suggested from the following facts that it is a virus disease. (1) No visible parasitic organism has been found on the diseased materials. (2) The witches'-broom is a systemic disease. (3) Possibilities of infection were ascertained by grafting.

Paulownia Fortunei has bean considered as a possible resistant species, but it is found that it is also susceptible to the disease.

Summary

The witches'-broom of *Paulownia tomentosa* is a very severe disease and has long been known for its characteristic symptoms. The geographical distribution of the disease covers the southern parts of Japan and Korea. It is gradually spreading to other

districts at present. T. Kawakami stated in 1902 that *Gloeosporium Kawakamii* Miyabe was the pathogenic fungus of this disease. Hazime Yoshii proved experimentally in 1933 that the disease was not caused by *Gloeosporium Kawakamii.*

The experimental results of the present author are as follows.

(1) All eighteen plants from seed were infected by grafting the diseased scions.

(2) Twelve of fifteen plants from root-shoots were infected by grafting the diseased scions.

(3) Five of six plants from root-shoots were infected by grafting on diseased stocks.

(4) All of three *Paulownia Fortunei* were infected by grafting the diseased scions of *Paulownia tomentosa.*

From these experiments, it is concluded that the witches'-broom of paulownia is a virus disease, graft infectious, and that *Paulownia tomentosa* and *Paulownia Fortunei* are susceptible to the disease.

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