Breeding of Mulberry Tree

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Transmission of varieties in mulberry tree cultivated in Japan.

Varieties of mulberry tree cultivated in Japan are recently restricted to several leading varieties. Fig. 1. shows percentages of field cultivated with four leading varieties from 1917 to 1963, and as seen in this figure, since 1948, Ichinose has got rapidly a large area and was cultivated in about half of the total mulberry field in 1963.

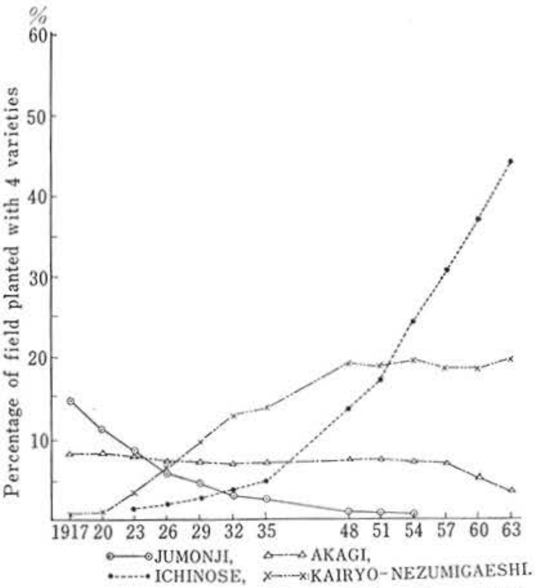


Fig. 1. Transmission of 4 varieties from 1917 to 1963.

Kairyo-nezumigaeshi is another leading variety which was cultivated in about 20% of the total field. Once, around 1930, this variety was at the top of varieties, but its distribution decreased with the increasing of Ichinose. Whereas, recently, Kairyo-nezumigaeshi is gradually increasing because this variety is suited to the shoot rearing spreading in all rearing seasons.

On the other hand, as this variety has a weakness of susceptibility to dwarf disease, the percentage of this variety is relatively low in southern districts where dwarf disease is spreading. Jumonji being at the top in 1917 suddenly decreased to substitute with Kairyo-nezumigaeshi after spreading of spring and autumn rearing in the southern districts, because this variety was not suited to spring rearing owing to late sprouting.

As mentioned above, the mulberry variety seems to be restricted to two leading varieties, Ichinose and Kairyo-nezumigaeshi, and the field cultivated by both varieties reached about 70% of the total field. The reason why the restriction of variety is conspicuous in Japan seemed to be due to the fact that the method of silkworm rearing was improved to be not able to see regional traits, because the shoot rearing was extended over all rearing seasons and the cooperative rearing of young silkworm was commonly used everywhere. Whereas, it is unnatural that only two varieties were cultivated over 70% of the total mulberry field in Japan extending from near the subtropical climate in the southern districts to the frigid climate in northern districts. Therefore, we are exerting our efforts to breed new varieties which have the adaptability for different climate and are suited to improved cultivating technique.

Method for breeding of mulberry tree.

1) Crossing.

The aim of breeding mulberry tree is to increase leaf yield, improve leaf quality and bolster the resistance against disease or climatic hazard. Since the Sericultural Experiment Station belonging to the Ministry of Agriculture and Forestry was established in 1908, the breeding of mulberry tree has been conducted mainly by using the crossing method. A single plant having improved characters will be selected from among F_1 seedlings, and then selected plants will be multiplied with grafting or cutting for raising strains including 15 saplings in each strain.

Such traits as leaf yield, branch height, number of branchches, date of sprouting and susceptibility of diseases or climatic hazard will be compared among strains in the fields of the Sericultural Experiment Station not only in the main station but also in five branch ones. After that, strains selected will be sent to 15 prefectures and planted in the fields of the Sericultural Experiment Station for the adaptability test, including leaf yield and silkworm rearing.

In the process of improvement by the crossing method there are several problems that should be solved. One of them is that the genetical relationship of character was not clarified, and this fact causes the difficulties when we want to improve a definite character. For example, as Ichinose has a weakness that its branches are often lodged by wind, if we improve this weakness, it does not make clear which variety should be used in crossing or which scope of variation would be expected in F_1 seedlings.

Whereas, it has been known that varieties of mulberry tree were highly heterogenous and it is necessary to deal with a large group of seedling for selection of desirable ones. Of course, the genetical relationship of character is gradually clarified by the recent works. For example, the leaf shape is controlled by one gene, that is, lobed leaf dominates the entire one.

Ichinose and Kairyo-nezumigaeshi having lobed leaves are considered to be heterogenous for lobed gene. Also, when a susceptible variety for dwarf disease was used in crossing, the segregation ratio of susceptible plants among F_1 seedlings is relatively high, and the same segregation would be seen in the case of die back disease. Therefore, it is necessary to cross with a resistant variety for improvment of susceptibility.

Another problem is that the mulberry tree is a perenial plant, that is, its performance should be observed over a prolonged period and also the wide behavioral variation will meet with during its growth, that is, plants showing good growth in the initial stages need not necessarily maintain the same order of growth in subsequent stages. So, in the process of selection, strains tested are necessary to plant more than five years in the same field.

2) Raising of polyploid.

There are many triploid varieties cultivated in Japan, especially in the northern districts because triploid varieties have the resistance to cold hazard during winter or the resistance to die back disease spreading in the snowy districts. The first finding of the triploid varieties in the mulberry species was observed by Osawa[1] in 1916, who noticed sterility in some varieties having 42 chromosomes while most varieties had 28. After that, Osawa[1], Tojo[5] and Seki[3] conducted studies on chromosomes covering several hundred varieties, and it is clarified that 125 varieties were triploid. 84 varieties belonged to *Morus bombysis*, and others belonged to *M. alba* and *M. latifolia*.

As colchicine was effective to raise polyploid plants in different species, Seki[2], Sugiyama[4] and Tojo[5] have attempted to raise polyploid plants by using this chemical in the mulberry tree. Usually, tetraploid plants have been obtained successfully by the method of seed soaking or dropping with colchicine solution and triploid plants will be obtained by crossing between diploid and tetraploid plants.

Autotetraploid generally seems to be stronger than the original diploid and shows the so called gigas type, that is, leaf, bud and flower clusters are bigger than that of diploid. Whereas, the shoot growth of tetraploid is slow compared to diploid and as the result, leaf yield of tetraploid is less than that of diploid irrespective of the good leaf quality in the tetraploid.

On the other hand, triploid is excellent in the shoot growth, and its leaf yield is at the same level of diploid. Several triploid strains raised by the colchicine treatment are testing now the adaptability in the different districts, and it is hoped that varieties having a practical value will be selected in the future.

3) Induction of bud mutation.

It was known that in mulberry tree bud mutation was induced spontaneously, but most of them were malformations which had no practical values. Whereas, if mutations can be induced in some characters concerned with leaf yield or disease resistance, they will play an important role in the progress of our breeding programs because mutated characters will be preserved constantly through clonal prapagation.

Also, it has another advantage that the term necessitated to raise new variety will be shorten because mutations would be able to improve aiming characters without any change of genetic balance in the original variety. The problem rising when we wont to use induced mutations in our breeding program is how to increase the mutation rate because the rate of spontaneous mutation is generally very low.

Therefore, in order to increase the mutation rate, radiation and chemicals are generally used in plants, but for the induction of bud mutation in woody plants, radiation seems to be more effective than chemicals. Radiation breeding of mulberry tree, in Japan, started after the establishment of the γ-irradiation room in the Sericultural Experiment Station in 1957, which has now a source of Co^{60} with about 300 curie, and also, several varieties are planted in γ-field attached with the Institute of Radiation Breeding for chronic irradiation during the full growing period.

Many types of mutation are found in irradiated plants, but they are mostly chlorophyll and morphologichl mutations which have no practical values, that is, chlorophyll mutations are variegations of yellow or white color, and morphological ones are small leaf, marginal crinkled leaf and deformed leaf.

Among these mutations, one type which has its leaf induced in Kairyo-nezumigashi is considered to have a practical value, because the leaf of this mutant was 7% thicker than that of the original, and also, the internode length was short compared with the original (Table 1). Moreover, results of the field trials showed that the leaf yield of this mutant was 15 per cent higher than that of the original (Table 2).

Table 1. Comparison of leaf characters and internode length between original and mutant in Kairyo-nezumigaeshi.

	Leaf length (cm)	Leaf width (cm)	Leaf shape index	Leaf weight (g per 100cm²)	Leaf thickness (μ)	Internode length (cm)
Original	18.3	14.6	1.25	1.60	160	2.7
Mutant	18.5	14.5	1.28	1.70	171	2.1

Table 2. Comparison of leaf yield and number of plants infected with dwarf disease between original and mutant in Kairyo-nezumigaeshi.

	Leaf yield (kg per plant)	Branch length (cm)	Number of branches	Number of plants infected with dwarf disease
Original	1.19	174.4	7.8	2
Mutant	1.33	170.9	8.2	0

Results are of 2 years after plantation.

New varieties in mulberry tree.[6]

Names and characters of five new varieties which were carried to practical use after the completion of adaptability test in 1966 are summarized as follows.

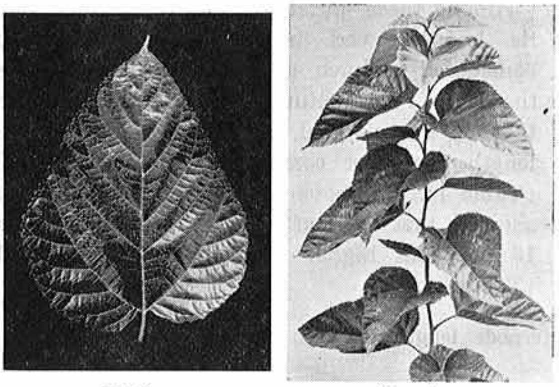
1) Kanmasari (Fig. 2): The name this variety came from the fact that this variety has the resistance to cold hazard in winter. The leaf shape is lobed with two or three lobeletts, but the entire leaves are often observed during the shoot growth. The shoot growth is excellent in the fertile field and a high yield will be expected in the northern districts.

2) Asayuki (Fig. 3): This variety is adaptable to the snowy districts, snow fall being below 100 cm, owing to the resistant to die back disease and dwarf disease. The leaf shape is lobed with four lobeletts. The shoot growth and leaf yield are the same as Kenmochi, a leading variety in these districts.

3) Fukayuki (Fig. 4): As this variety is highly resistant to die back disease, it is adaptable to districts where snowfall is above 150 cm. It has big lobed leaves with four lobeletts and its leaf color is dark green. The shoot length in spring is excellent and a high yield is expected in the spring rearing season.

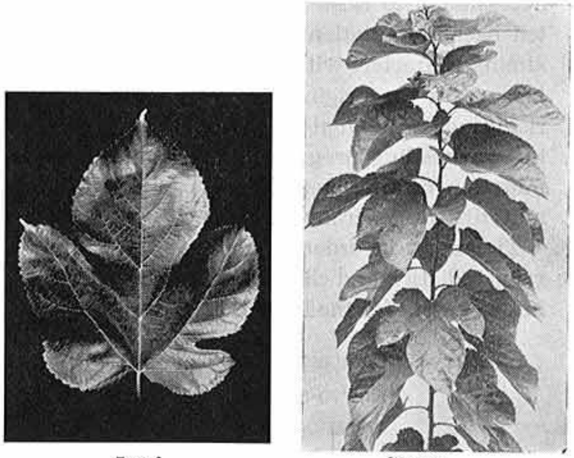
4) Wasemidori (Fig. 5): The characteristics of this variety are that the sprouting of bud in the spring occurs quite early and the hardening of leaf is slow even in late autumn. So, it is adaptable to young and old silkworm rearing in districts with mild climate.

5) Atsubamidori (Fig. 6): The characteristics of this variety are that the leaf is about 15 per cent thicker than that of Ichinose and branch is resistant for lodging by wind. A high leaf yield is expected in the fertile field in districts with mild climate.



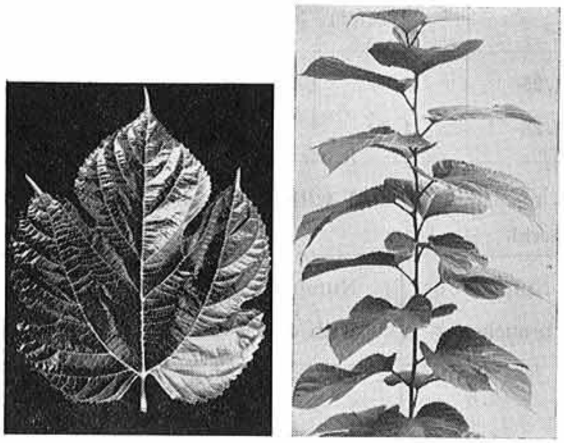
Leaf Shoot

Fig. 2. Leaf and shoot of Kanmasari.



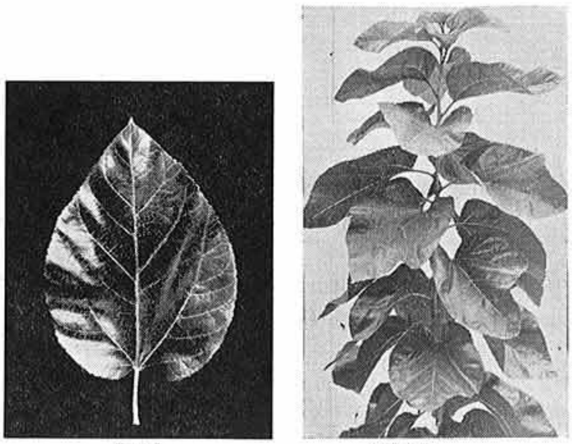
Leaf Shoot

Fig. 3. Leaf and shoot of Asayuki.



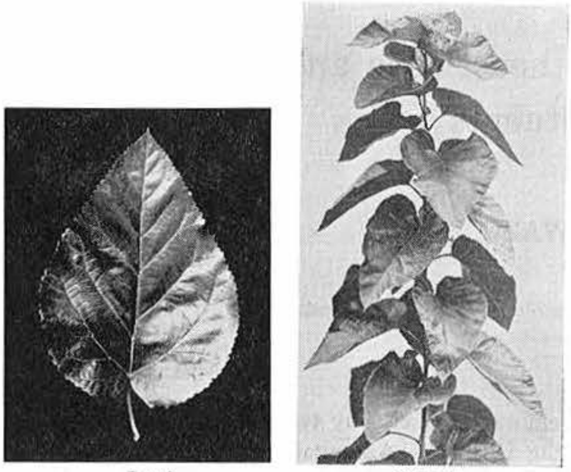
Leaf Shoot

Fig. 4. Leaf and shoot of Fukayuki.



Leaf Shoot

Fig. 5. Leaf and shoot of Wasemidori.



Leaf Shoot

Fig. 6. Leaf and shoot of Atsubamidori.

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