Growth Characteristics of Three Strains, M 28, M 32 and M 38 of *Morus acidosa* Griff. and Adaptability to Subtropical Regions

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In the Southwest Islands of Japan, especially Miyako and Yaeyama districts, sericulture has been evaluated as a complementary or side cash earning production in farm management and has been rapidly spreading recently.

All the mulberry varieties which are cultivated in Japan belong to any of three mulberry species, namely, *Morus bombysis* Koidz., *M. alba* L. and *M. lhu* (Ser) Koidz.. Such varieties, however, can not be cultivated at all in the Southwest Islands, partly because these varieties have a dormant period and their dormancy can not be broken in the Southwest Islands where the weather is very warm even in winter. Futhermore, the geographical location of mulberry fields in these districts is generally bad and most mulberry trees which are cultivated there are derived not from the vegetative propagation but from seedlings of *M. acidosa* Griff. (Japanese name is Shimaguwa) trees grown mainly near houses. Therefore, the productivity of mulberry leaves per unit area is generally low.[2)]

To improve the productivity of the mulberry leaves, it is very important not only to select excellent varieties but also to establish the methods of cultivation and propagation of Shimaguwa, which grows in these districts.

In the present paper, the growth characteristics of three Shimaguwa strains, M 28, M 32 and M 38 selected from seedlings obtained from natural crossing will be outlined.

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Selection of three Shimaguwa strains, M 28, M 32 and M 38

Three excellent strains were selected from naturally crossed seedlings of Shimaguwa at Laboratory of Reproductive Silkworm Egg, Sericultural Experiment Station (Miyazaki). These three strains (Plate 1)[7)] were named M 28, M 32 and M 38 (these are also called three M strains generally) and have the following features.

M 28 is rather resistant to lodging and the shoots are abundant in number in comparison with Ichinose *(M. alba* L.), the most popular mulberry variety. The tree regenerates the shoots vigorously and develops lateral shoots abundantly. The leaf of this strain is rather large and full. M 32 has rather an upright growth habit and the shoots are also rather abundant in number in comparison with Ichinose. The regeneration of shoots is very vigorous, but it has fewer lateral shoots than M 28. M 38, likewise, has rather an upright growth habit and the shoots are abundant in number.

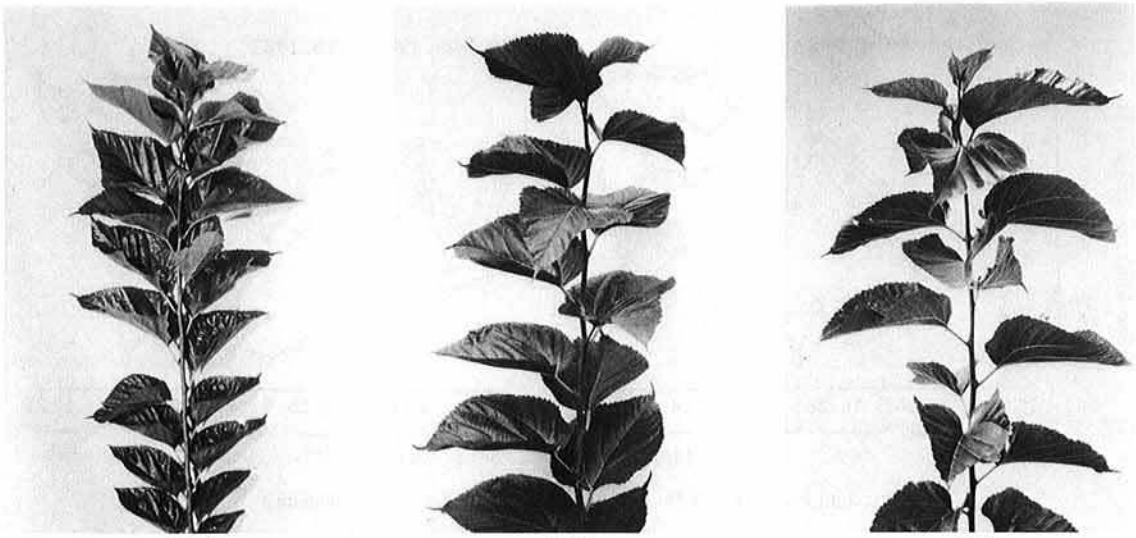
These three strains sprout about 10 to 14 days earlier in spring than Ichinose and the shoot growth stops in about mid-November in Miyazaki district, which is about a month later than Ichinose.

Propagation of M 28, M 32 and M 38 by softwood cutting method

The propagation method in Shimaguwa has not been established as an actual technique, partly

because Shimaguwa has fewer reserve substances as it utilizes the assimilated products directly for regeneration. In order to search for an efficient propagation method for Shimaguwa, a softwood cutting method was tried using younger shoots of M 28, M 32 and M 38.[3)]

Table 1 shows the survival ratio of cuttings and the percentage, number and weight of rootings 20 days after cutting. According to this table, the survival ratio of cuttings was 80 to 100% in Ichinose and the three M strains, so that there were scarcely any differences among the effects of the concentrations of IBA (Indole butyric acid). Also, these three strains had rooting percentages of 92 to 100, which had no relation to the concentration of IBA. The effect of IBA on the number and weight of roots varied among



M 28 M 32 M 38

Plate 1. M 28, M 32 and M 38 selected from naturally crossed seedlings of *Morus acidosa* Griff.

Table 1. The effect of IBA on the rooting ability in softwood cutting

Variety or strain	Concentration of IBA (ppm)	Survival ratio of cuttings (%)	Percentage of rooting (%)	Number of roots	Weight of roots (g)
Ichinose	0	93.3	100	16.6	1.1
	2.5	96.7	100	20.6	1.8
	5.0	93.3	100	43.8	2.2
	10.0	80.0	80.0	19.7	1.1
M 28	0	100	91.7	7.7	1.6
	2.5	100	100	6.8	1.7
	5.0	100	100	5.3	0.7
	10.0	96.7	91.7	8.7	1.1
M 32	0	100	100	25.6	1.3
	2.5	100	100	30.3	3.5
	5.0	100	100	51.7	1.8
	10.0	100	100	52.7	1.4
M 38	0	100	100	8.3	2.1
	2.5	100	100	11.4	2.5
	5.0	96.7	100	51.2	3.8
	10.0	96.7	91.7	54.1	2.8

Measurement was carried out 20 days after the cutting was inserted.

Table 2. Survival ratio of cuttings 70 days after inserted

Variety or strain	Concentration of IBA (ppm)			
	0	2.5	5.0	10.0
Ichinose	88.9	94.4	100	66.7
M 28	94.4	88.9	100	88.9
M 32	100	100	100	66.7
M 38	88.9	100	100	100

Ichinose, M 32 and M 38 except for M 28. The weight of roots was the heaviest at the concentration of 5.0, 2.5 and 5.0 ppm of IBA for Ichinose, M 32 and M 38, respectively. That of M 28 was slightly heavier at 2.5 ppm than the other concentrations.

The survival ratio of cuttings of M 28, M 32 and M 38 measured 70 days after cutting was not inferior to Ichinose (Table 2), so that it is ascertained that M 28, M 32 and M 38 can be propagated sufficiently by the

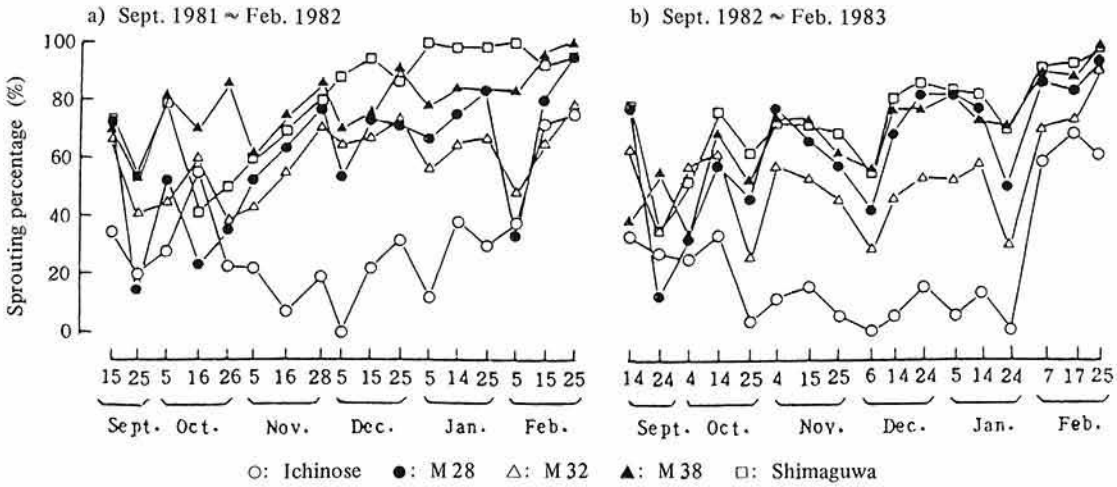


Fig. 1. Sprouting percentage (above Taisei stage) in total of 60 winter buds treated at 30°C for 15 days
Dates of abscissa: Dates on which cuttings were collected from shoots to keep them at 30°C.

Table 3. Sprouting percentage (above Taisei stage) in total of 20 top winter buds treated at 30 °C for 15 days

a) Sept. 1981~Feb. 1982 (%)

Variety or strain	Sept.		Oct.			Nov.			Dec.			Jan.			Feb.		
	16	25	5	16	26	5	16	28	5	15	25	5	14	25	5	15	25
Ichinose	65	35	75	100	65	60	20	40	0	45	60	35	90	70	65	100	95
M 28	90	33	100	65	60	100	100	100	100	100	100	100	100	100	65	100	100
M 32	100	100	95	85	100	100	100	100	100	95	100	100	100	100	90	100	100
M 38	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Shimaguwa	100	100	100	85	85	100	100	100	100	100	100	100	100	100	100	100	100

b) Sept. 1982~Feb. 1983

Variety or strain	Sept.		Oct.			Nov.			Dec.			Jan.			Feb.		
	14	24	4	14	25	4	15	25	6	14	24	5	14	24	7	17	25
Ichinose	80	55	60	85	5	30	45	15	0	10	45	15	25	0	90	95	80
M 28	100	50	75	100	95	100	100	90	85	100	100	100	100	75	100	100	100
M 32	100	90	100	100	70	100	100	90	80	95	100	100	85	50	100	100	100
M 38	95	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Shimaguwa	100	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Dates are the same as in Fig. 1

softwood cutting method in which the cuttings treated with IBA for improving rooting are planted into a cutting bed set in a field, covered like a type of tunnel with polyethylene film, and shaded with marsh-reed mats.

On the non-dormancy of M 28, M 32 and M 38

It is ascertained that the dormancy of winter buds of the variety Ichinose which is grown in a greenhouse under the temperature above 15°C can not be broken and subsequently the sprouting date is extremely delayed next spring.[9,10] Such unusual phenomena as sprouting delay and non-sprouting were observed among varieties like Ichinose in Amamioshima Island and Tanegashima Island.[9] Therefore, it is understood that the dormancy of winter buds is one of the factors that inhibit mulberry growth in flatlands of tropical and subtropical regions which do not experience low temperature in winter.

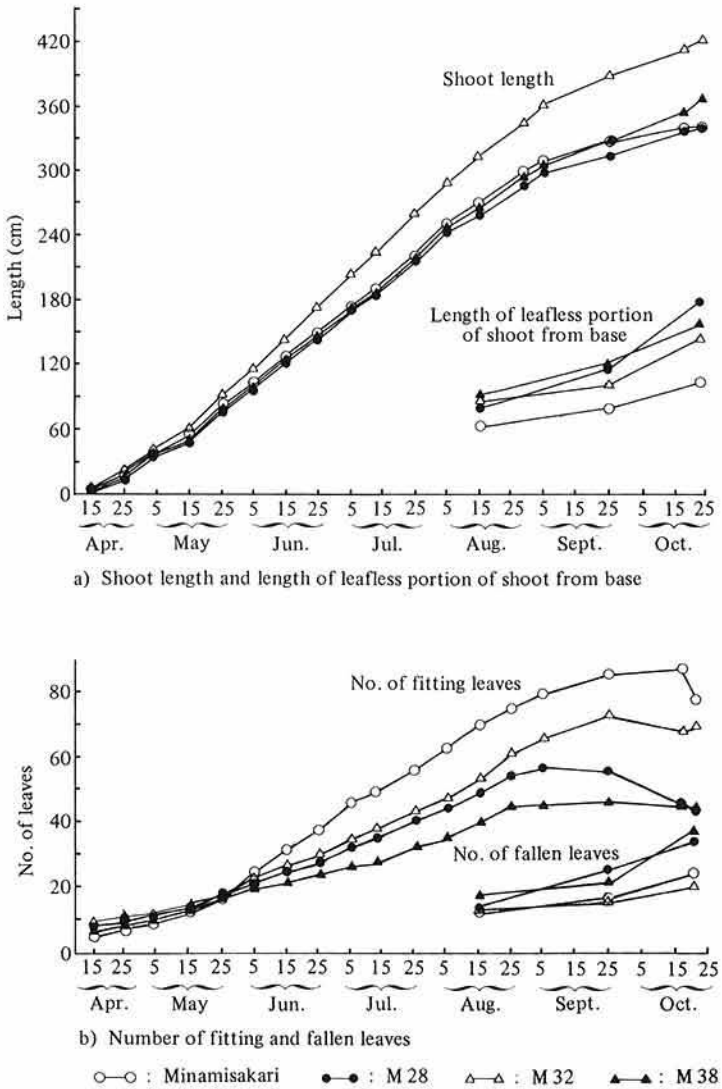


Fig. 2. Shoot development of M 28, M 32 and M 38 after spring pruning in Miyazaki district

In order to get information on the selection of mulberry varieties suitable for cultivation in subtropical regions such as the Southwest Islands, the sprouting percentage of winter buds was investigated by keeping shoots of Shimaguwa and three M strains, M 28, M 32 and M 38 at 30°C for 15 days during a period from September to February.[4] Fig. 1 and Table 3 show the sprouting percentage in total of 60 winter buds and 20 top winter buds, respectively.

According to Fig. 1 and Table 3, Shimaguwa gave a high percentage of bud sprouting, showing that it had no dormancy. M 28, M 32 and M 38 showed almost the same tendency as Shimaguwa, suggesting that these three strains had no dormancy as well. Accordingly, it was ascertained that three M strains had no resting period and that their buds are ready to sprout whenever the temperature becomes favorable. Therefore, these three strains are regarded as desirable strains for future selection of mulberry varieties suitable for the Southwest Islands.

Growth characteristics of M 28, M 32 and M 38 in Miyazaki district

Fig. 2 shows the shoot development after spring pruning in Miyazaki district.[5] M 28, M 38 and Minamisakari (*M. alba* L.) demonstrated the same tendency in shoot length, but M 32 consistently showed the longest shoots in comparison with the other three. Minamisakari showed a tendency of shorter length of a leafless portion at the base of shoots than three M strains. On the other hand, Minamisakari produced the most leaves, M 32 was next to Minamisakari, and M 38 was the least. It is supposed that one of the reasons why M 38 and M 28 had fewer fitting leaves than Minamisakari is the increase of fallen leaves of these strains.

Table 4 shows the yield and its components of M 28, M 32 and M 38 in the spring rearing season.[5] The amount of younger shoots was 2,584, 2,199 and 2,020 kg for M 32, M 28 and M 38, respectively, and that of M 32 was 15% higher than 2,238 kg of Minamisakari, which is one of the mulberry varieties suitable for the warmer districts of Japan.[1] Though three M strains were generally lower in the proportion of leaf weight than Minamisakari, it is supposed that especially M 32 will have an excellent ability in yield characteristics such as length of new shoots and weight per new shoot.

The growth of M strains after spring cut was examined in Miyazaki district.[4] According to the production structure (Fig. 3), it was manifested that M 28 showed a similar pattern to a broad-leaf type

Table 4. Yield and its components of M 28, M 32 and M 38 in Miyazaki district

a) Yield per plant

Variety or strains	No. of shoots	Amount of old shoots (g)	Amount of new shoots (g)	Amount of leaves (g)	Percentage of leaf (%)
Minamisakari	7	2,815	2,797 (2,238)	2,032	72.6
M 28	11	3,953	2,749 (2,199)	1,844	67.1
M 32	8	4,322	3,220 (2,584)	2,110	65.3
M 38	10	3,387	2,525 (2,020)	1,757	69.6

Figures in parenthesis: the amount of new shoots per 10 a

b) Yield components of the longest shoot

Variety or strains	No. of buds	No. of sprouted buds	Percentage of unsprouted buds (%)	Length of new shoots (cm)	No. of leaf	Weight per new shoot (g)	Weight per leaf (g)
Minamisakari	83	51	38.6	14.4	5.1	8.5	1.07
M 28	61	27	55.7	14.4	5.1	13.4	1.08
M 32	65	36	44.6	18.5	6.0	12.9	0.97
M 38	55	37	32.7	11.4	5.4	9.9	1.01

Measurement was carried out on May 30, 1983.

plant, M 32 to a graminious plant and M 38 and Minamisakari to a middle type. As to the amount of dry matter production M 32 was the greatest, M 38 followed and M 28 the lowest. Crop growth rate (CGR) differed with strains in July and August and the degree of CGR was the greatest in M 38, the second in M 32, the third in M 28 and the lowest in Minamisakari (Fig. 4-a). Although CGR is divided into net assimilation rate (NAR) and leaf area index (LAI), NAR showed a similar tendency to CGR (Fig. 4-b). This suggests that CGR is mainly dependent on NAR. LAI reached above 7 in all of M strains, while it was still 6 in Minamisakari (Fig. 4-c). These results make clear that dry matter production is

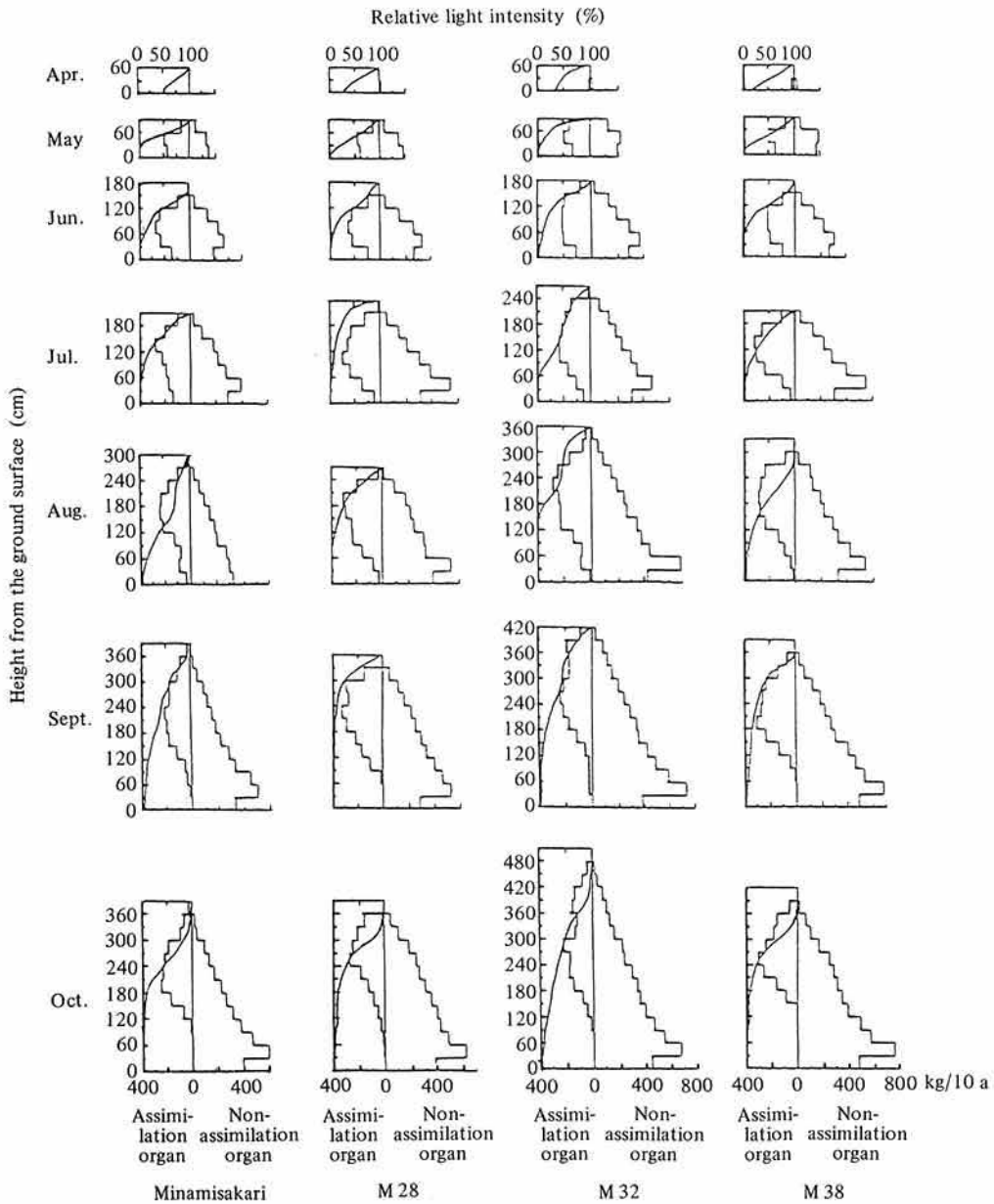


Fig. 3. Production structure of M 28, M 32 and M 38 in Miyazaki district

more vigorous in M strains than in Minamisakari.

Harvesting method for M 28, M 32 and M 38 in Yakushima Island

To establish a harvesting method of three Shimaguwa strains in the subtropical regions, the method by which mulberry leaves are harvested three times a year was examined for four years from 1980 to 1983 at the mulberry field of Yakushima Island, which is located in the subtropical region.[7] As shown in Fig. 5, the first harvest in a year was conducted by cutting previous year shoots at the base in late April (spring rearing season), the second was carried out in late July (summer and autumn rearing season) by intermediate cutting at the height of 70 cm from the base of the shoots regenerated after the first harvest, and the third was made in early November (early winter rearing season) by cutting at half length of the shoots regenerated after the second harvest. Table 5 shows the results such as the sprouting, shoot development and yield which were investigated in these harvesting dates.

According to Table 5, total yield of the three harvests was above 2,400 kg for three M strains and Shimaguwa. This yield was very superior to the yield (2,075 kg) expected in "two-years rotation of mulberry harvest" that Ono and Miyao (1977)[6]

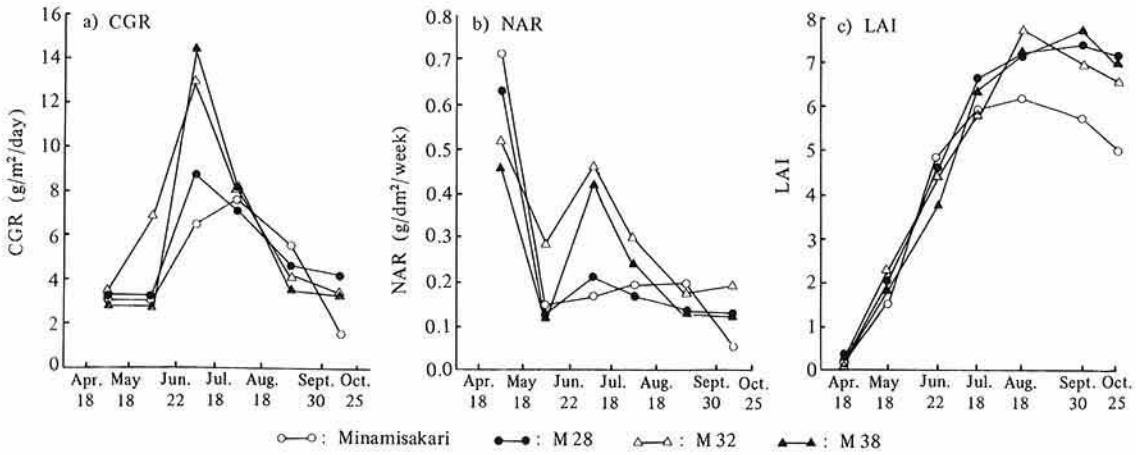


Fig. 4. CGR, NAR and LAI of M 28, M 32 and M 38 in Miyazaki district

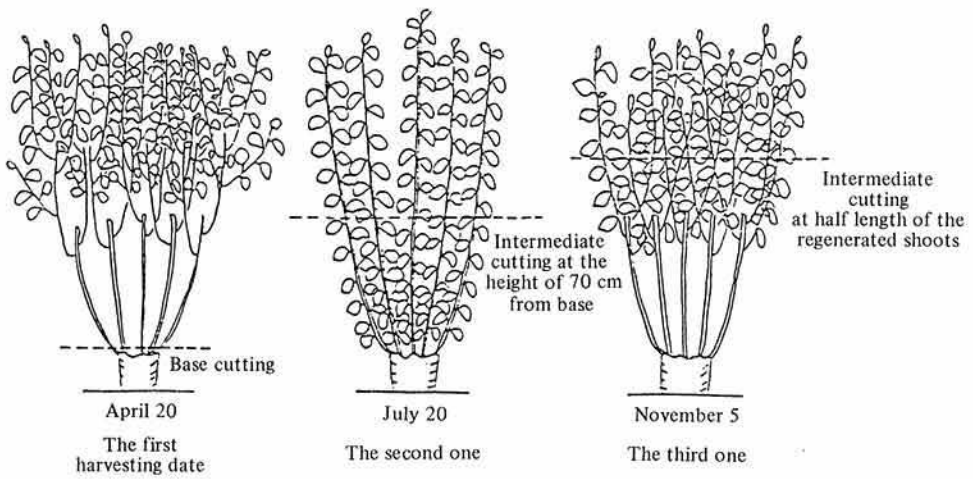


Fig. 5. Examination of the method by which mulberry leaves are harvested three times a year in Yakushima Island

Table 5. Growth and yield of M 28, M 32 and M 38 in Yakushima Island

(per 10 a)

Variety or strain	Spring rearing season (Apr. 20)				Summer and autumn rearing season (Jul. 20)		
	Sprouting date	New shoot length (cm)	No. of leaves	Amount of new shoots (kg)	No. of shoots	Length of the longest shoot (cm)	Amount of leaves (kg)
Shin-ichinose	Mar. 28	18.0	9.6	274	5.7	111	247
M 28	Mar. 5	31.4	11.2	1279	17.6	127	567
M 32	Mar. 11	47.1	13.5	1172	11.4	154	622
M 38	Feb. 15	43.2	13.9	1397	13.8	136	643
Shimaguwa	Feb. 9	35.7	11.6	1293	15.0	99	510

Variety or strain	Early winter rearing season (Nov. 5)			Total yield* (kg)	Index
	No. of shoots	Length of the longest shoot (cm)	Amount of leaves (kg)		
Shin-ichinose	6.0	110	220	741	100
M 28	24.2	163	698	2544	343
M 32	15.4	184	636	2430	328
M 38	16.7	160	690	2730	368
Shimaguwa	20.1	121	742	2545	344

Figures show the mean of the data measured in 1980 to 1983.
* Total of the amount of new shoots of Apr. 20 and the amount of leaves of July 20 and Nov. 5.

recommended as the harvesting method suitable for mulberry in Okinawa. But the variety Shin-ichinose (*M. alba.* L.) was very inferior to the other strains, showing that Shin-ichinose can not grow normally partly because of its dormancy. And furthermore, the method by which mulberry leaves are harvested three times a year, even though it was repeated for four years, did not have a bad effect on the vitality of trees. Therefore, it is considered that this harvesting method is very reasonable in establishing the harvesting method fitting to Shimaguwa in the subtropical region.

Judging from these results, it is ascertained that M 28, M 32 and M 38 are adaptable for cultivation in the subtropical region.

Conclusion

As mentioned above, three Shimaguwa strains, M 28, M 32 and M 38 are very vigorous in shoot development and dry matter production. And they have an excellent yield ability and high rooting activity in softwood cutting and there are no dormancy in them. Therefore, it is considered that M 28, M 32 and M 38 are desirable strains (or possible varieties) for the subtropical regions such as the Southwest Islands.

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