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Recent Development in Rice Seedling Raising in Japan, with Special Reference to the "Nursling Seedlings"*

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ABSTRACT : Recently, a nursery mat made from rock wool has realized transplanting of the younger seedlings with the ordinary transplanting machines for Chibyo and Chubyo(3 and 4~5 leaved seedling, respectively). The seedlings defined as the "Nyubyo" or "Nursling seedlings" became possible to achieve economic profits from the reduction in both working time and costs. It being widely noticed as a strategy to solve the difficulties in current rice cultivation. The nursling seedlings are 1.4 to 2.5 leaves and height at 4.5 to 7cm, grown 4 to 7 days after seeding. They maintain still up to 50 to 80% of their nutrients in the endosperm, and can grow by using only their own nutrients for a certain period of time after transplanting. Nursling seedlings take 2 days in the nursery chamber at 32℃ after seeding, and 2 days in the greening house at 25℃. This is only 4 days, all together, to make the nursling seedlings of 1.5 leaves which are ready for transplanting. Watering is only needed once at the sowing time. It only takes 1 or 2 waterings even to raise a seedlings for a period of 7 days. The number of nursery boxes can be reduced because it is possible to sow more densely(220 to 240g per box), thus it only needs seedlings of 15 to 16 boxes per 10 a which leads to a reduction in facilities and space needed. Temperature during the nursery period can be artificially adjusted more precisely which may lead to the prevention of temperature stress. The nursling seedlings can root rapid by because the crown roots from the coleoptile node begin to emerge immediately after transplanting. They show strong resistance to low temperature(12℃) and deep-planting. There is no danger in the rooting of the seedlings even if half of their height is buried into the soil. Moreover, it can root at a rate of up to 65 to 80% even if the full height of the seedlings is buried. They show also strong resistance to submergence(10~15cm). The nursling seedlings tend to grow by producing tillers from lower nodes. It is therefore, necessary to control to keep the proper numbers of tillers per unit area. They have no fear in the delay of heading and their yield components can be so well balanced that the same level of yield was achieved with the nursling seedlings compared to that with Chibyo. It was further suggested that if the surplus tillers can be avoided by such cultivation practices, the number of grain per panicle can be kept greater and higher yield can be realized. Practical experiments with the nursling seedlings conducted in 1989 and 1990 by farmers in various areas showed exciting results. The nursling seedlings will become widely spread, or at least occupy an important position in Japanese and also in Korean rice cultivation techniques.

1. Recent situation of rice seedling raising in Japan

Mechanical transplanting was brought to the rice cultivation of Japan in the early 1960s and has spread all over the country.

When this technique was first employed, 3-leaved seedlings which are called "Chibyo"

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or young seedlings were used. However, Chibyo are so young and small compared to former hand-planted more mature seedlings with 6 to 7 leaves, that farmers felt uneasy about mechanical transplanting and the resulting yield. They were also afraid that a delay might occur in the heading date in northern and mountainous regions.

As a result, more advanced seedlings with 4 to 5 leaves, which are called "Chubyo" or middle seedlings had been used in the mechanical transplanting. At present, Chubyo has been increased to 35% of all area of Japan's paddy field. Also, a transplanting machine for "Seibyo" or mature seedlings which have 6 to 7 leaves has been put into practical use, but it is limited to less than 3.0%.

The continued advanced development of Japan's industries during the past 20 years absorbed massive labor from agriculture which resulted in a trend that the labor in rice cultivation is largely attributed to elderly people. This brought about the present situation in which seedling raising of rice becomes the task of aged people and women.

A striking tendency subsequently comes into existence in the simplification of the techniques of seedling raising. For instance, the non-heating raising method, in which the nursery boxes are kept warm only by a covered vinyl sheet has been in general circulation instead of using electric-heated raising equipment. This simplified raising without using electric heating was successful in its spread over the country which was largely depended on unusual long period of warm spring in April. Its success was also due to the employment of fungicide chemicals to prevent seedlings from diseases owing to untimely cold weather.

Since the late 1980s, sparse seeding was also one of the more recent recommended methods, by which good seedlings could be obtained despite the simplified care by aged labors. According to former procedure, about 200g of rice seeds can be seeded in a nursery box(30 ×60 ×3cm) for raising Chibyo. However, 120 to 150g of seeds is recommended today. For Chubyo, 80 to 120g of seeds have become popular instead of 150g.

As a matter of fact, the sparse seeding needs more nursery boxes for the same area of the paddy field. For Chibyo planting, 20 boxes were formerly used, but now about 30 to 35 boxes are needed. Accordingly, it needs wider space and more facilities such as bed soil, nursery box, vinyl sheet, vinyl house etc, for the seedling raising. Also, the costs of seedling raising has increased.

At the present time, due to the surplus of rice which results in a reduction in the price of rice products, and increased pressure for free trade in rice, it becomes a large challenge in rice cultivation to lower the production costs as much as possible.

2. The development of rice cultivation with the nursling seedlings

It may be thought that direct planting, as normally conducted in the United States and other countries, can serve as a possible way to lower the production costs of rice.

However, it has been shown that in Japan it is difficult to conduct direct planting because of Japan's particular climate, variety of rice, irrigation system, etc. Large scaled experiments directed by the Ministry of Agriculture, Forestry and Fisheries until recently failed to suggest the possibility of direct seeding rice cultivation in Japan. This can be also explained by the present situation in which only less than 0.3% of the area of paddy fields in Japan are under direct seeding.

Accordingly, efforts aimed at mechanical transplanting of seedlings younger than Chibyo have been attempted for nearly 10 years by myself and other researchers. Whole list of the papers including some Korean workers are presented at finis of the present report. If the seedling raising period can be shortened, labor and material inputs could be reduced. Dense seeding and the reduction in the number of nursery boxes can also be achieved if the seedlings are small.

Research aimed at the realization of these methods are fortunately under rapid development. The seedlings younger than Chibyo have the draw back that their root spread into the bed soil is too weak to be used for mechanical transplanting because of the absence of interlocking roots which result from the undevelepment of crown roots. Fortunately, this problem has recently been solved, due to the invention of a specialized nursery mat made from rockwool by Nippon Steel Chemical(Shinnittetsu Kagaku) Co. Ltd. who started to sell this product in 1989. Employment of this particular mat can produce the root spread into the mat much stronger, which leads to the realization of mechanical transplantion of the younger seedlings with the ordinary transplanting machines already employed in the transplanting of Chibyo or Chubyo.

The seedlings younger than Chibyo were defined in 1990 by the Ministry of Agriculture, Forestry and Fisheries as the "Nyubyo". This definition was based on the researchs conducted by some pioneer workers. Nakatani(1986) used first this name "Nyubyo" in his paper. Also I have used the same name for about 30 years when I carried out investigations on mechanical transplanting. I therefore feel proud that the "Nyubyo" has recently become the integrated name. I named it "nursling seedling" in English term and use it for the first time at the present report.

Consequently, it becomes possible to achieve economic profits from the reduction in both working time and costs as compared to that in using either Chibyo or Chybyo. The nursling seedlings are therefore being widely noticed as a strategy to solve the difficulties in current rice cultivation.

Below, I will present the results of my research work concerning the characteristics of the nursling seedlings.

3. Characteristics of the nursling seedlings

(1) The optimum age of the nursling seedlings for transplanting.

Tables 1~3 are results of experiments to find out the optimum stage to transplant nursling seedling.

The seedlings of 2-leaved age are the most adequate for transplanting and seedlings between 1.4– to 2.5-leaves are qualified for the nursling seedlings. The figures for nursling seedlings are shown in Fig. 1. Their plant height range is 4.5~7cm according to the duration of nursing and the number of leat.

Nursling seedling maintain up to 50 to 80% of their nutrients in the endosperm as shown in Fig. 2. Accordingly, they can maintain their growth using only their own nutrients for a certain period of time after transplanting.

Fig. 3. schematically shows the internal structure of the nursling seedling of 1.4, 2.0 and 2.5 leaves, respectively. There are initials

Table 1. Characters of nursling seedlings at different ages.

Seedling age		1.0	1.4	2.0	2.5
Days after seeding		3	4	5	6
Seedling(top) length	mm	22.3	44.4	53.0	58.6
Coleoptile	mm	11.2	12.9	13.3	13.4
First leaf	mm	22.3	12.9	26.4	25.9
Second leaf	mm				
leaf sheath		–	21.5	27.4	35.2
leaf blade		–		24.6	23.4
Third leaf	mm				
(emerged)					(12.6)
Root					
number		2.3	4.1	4.0	4.8
length of the longest root	mm	41.4	58.9	60.8	54.9

* Emergence period(2 days after seeding) at 32℃, and thereafter greening period at 25℃ takes 1, 2, 3 and 4 days, respectively.

(Hoshikawa & Shoji, 1990)

Table 2. Characters of rooted and established seedlings* transplanted at different seedling ages.

Age of transplanted seedling		1.0	1.4	2.0	2.5
Plant age		2.4	2.7	2.8	3.0
Plant height	mm	69.6	111.4	122.1	162.6
First leaf	mm	24.1	24.5	24.0	23.6
Second leaf	mm				
leaf sheath		40.8	48.0	46.5	46.3
leaf blade		22.9	22.6	23.5	23.5
Third leaf	mm	24.0	63.4	75.6	116.3
Fourth leaf		–	–	–	0
Root					
number		5.2	7.1	7.7	8.3
length of longest root	mm	41.4	71.4	72.1	75.6

*Sampled and measured on 6 days after transplanted.
Rooting condition 25/17℃, day/night.
(Hoshikawa & Shoji, 1990)

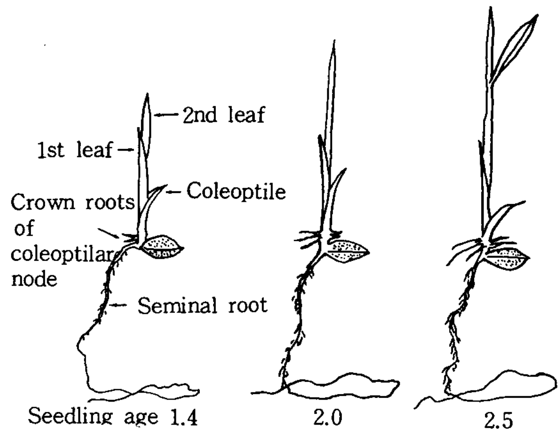

Fig. 1. Outer morphology of nursling seedings of 1.4, 2.0 and 2.5 leaf-ages.
(Hoshikawa, 1990)

of the fourth leaf and of the second-node tiller in 2.0-leaved seedlings. In 2.5-leaved seedlings, primordium of the fifth leaf is just before differentiation and crown roots from the coleoptilar node are rather elongating. Roots

Table 3. Length of individual roots in the seedlings of 1.0, 1.4, 2.0 and 2.5 ages and their length of 6 days after transplant(mm).

Age of seedling transplanted	1.0	1.4	2.0	2.5
Roots*	Trans plant → After 6 days	Trans plant → After 6 days	Trans plant → After 6 days	Trans plant → After 6 days
S	47.5 → 41.4	58.9 → 71.4	60.8 → 72.1	54.9 → 75.6
C−1	4.1 → 35.2	17.6 → 60.6	13.8 → 64.0	25.3 → 59.1
C−2	1.3 → 26.8	7.0 → 48.3	6.6 → 50.3	18.2 → 44.3
C−3	19.7	3.5 → 42.8	3.2 → 41.5	8.8 → 38.7
C−4	10.5	0.4 → 16.8	0.5 → 27.6	5.2 → 31.1
C−5	4.1	16.8	0.4 → 15.1	1.2 → 26.0
I−1		11.0	6.5	0.4 → 20.2
I−2		2.2	3.4	8.6
I−3			0.5	2.9
I−4				1.8
	(84.8)	(180.5)	(196.9)	(194.3)

* S : Seminal root, C : Coleoptilar roots, I : 1st-node roots.
( ) : Total root length of a plant.

(Hoshikawa & Shoji, 1990)

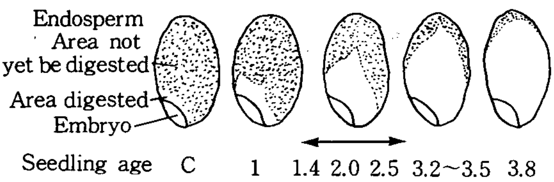

Fig. 2. The progress of digestion of endosperm according to germination and seedling growth proceeds.
(Hoshikawa, 1991)

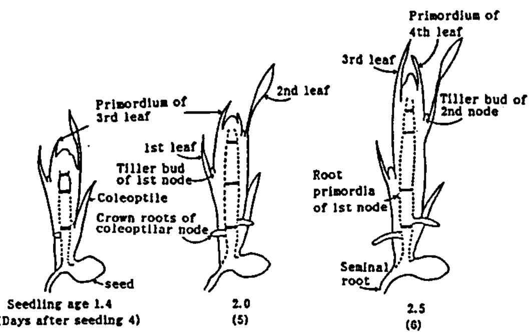

Fig. 3. Anatomical illustrations of nursling seedlings of 1.4, 2.0 and 2.5 seedling ages.
(Hoshikawa, 1991)

from the first node are in the beginning stage of differentiation.

(Here, the term incomplete leaf is not used, but the leaf which emergences next to the coleoptile is usually counted as the first one.)

(2) The nursery characteristics of raising nursling seedlings.

The nursling seedlings show the following advantages in their nursery characteristics.

1) Nursery period is short.

At first, the emergence period takes 2 days in the nursery chamber at 32 degrees centigrade after sowing, and 2 days in the greening house at 25 degrees. This is only 4 days, all together, to make the nursling seedlings of 1.5 leaves which are ready for transplanting. It no longer takes the 6 to 7 days to wait for a seedlings of 2.5 leaves.

2) It requires less labor.

It requires less labor to make the nursling seedlings because of the shortened nursing period.

Watering is only needed once at the sowing time. It only takes 1 or 2 waterings even to raise a seedlings for a period of 7 days.

Another advantage is that the beginning of the nursery work can be delayed about 10 days compared to that in the Chibyo, and about 10−20 days to that of the Chubyo. Besides, it reduces the overlap between the raising of the seedlings and other agricultural activities.

3) It needs fewer nursery boxes and a smaller area.

The number of nursery boxes can be reduced because it is possible to sow more densely(220 to 240g per box), and from this it only needs seedlings of 15 to 16 boxes per 10 a, which leads to a reduction in facilities and space needed.

4) The prevention of temperature stress.

Temperature during the nursery period can be artificially adjusted more precisely which may lead to the prevention of temperature stress(e.g. disease by *Pythium* fungi) resulting from unexpected high or low temperatures.

(3) The rooting characteristics of the nursling seedlings.

1) The immediate emergence of roots.

The nursling seedlings are characterized by a rapid rooting. After transplanting, crown roots from the coleoptile node(Fig. 4, noting that there consistently exists 5 roots which emergence with the first group of crown roots) begin to emerge immediately, and this results in the rapid rooting of the seedlings. The rapid successive emergence of the first, second, and third leaves, can also be found.

2) Resistance to environments.

Since the nursling seedlings can still continue their growth even after transplanting through keeping the endosperms as a nutrition

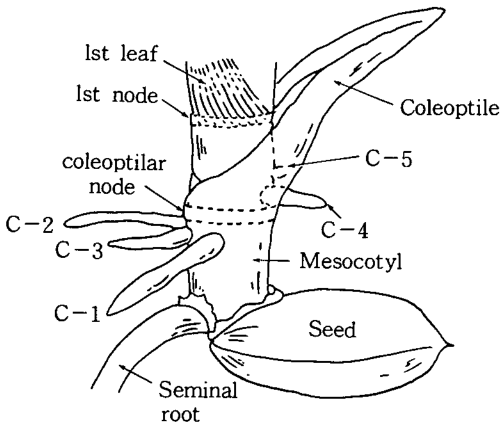

Fig. 4. Illustration for rooting of nursling seedlings. Coleoptilar node roots C_1, C_2 and C_3 develop at lower than coleoptilar node and C_4 and C_5 appear from just over than coleoptilar node through the coleoptile.
(Hoshikawa & Shoji, 1990)

source, they show strikingly higher rooting strength (resistance to environments) than the Chibyo, Chubyo and more mature Seibyo.

(a) Strong resistance to low temperature.

The nursling seedlings can reach the status of rooting(establish) under lower temperatures than Chibyo. Resulting from my experiment, as shown in Table 4, the limitting low temperatue for rooting is 12℃(daily mean temperature), and it indicates that the nursling seedlings is the most resistant to low temperature compared to all other kinds of rice seedlings.

(b) Strong resistance to deep-planting.

Deep-planting can not be avoided because the nursling seedlings are small. However, there is no danger, in the rooting of the seedling even if half of their height is buried into the paddy soil. Moreover, it can root at a rate of up to 65 to 80% even if the full height of the seedlings is buried(Fig. 5 and 6).

(c) Strong resistance to submergence.

The nursling seedlings can reach the status of rooting and break to emergence from irrigated submergence even if it is transplanted to a depth of 10 to 15cm(Table 5). An actual state of transplanting of Nyubyo is shown in Fig. 7.

(4) The growth of the nursling seedlings in paddy field.

The nursling seedlings tend to grow by producing tillers from lower nodes(usually from

Table 4. Limiting low temperatures for rooting of rice seedlings.

Kinds of seedlings	Age	Nursery condition	Limiting low temperature ℃
Mature seedlings	6.5	Flooded	15.5
(Seibyo)	6.5	Protected semiirrigated	14.5
	6.5	Upland	13.5
Middle seedlings	5.5	Non-heating	13.5
(Chubyo)	5.0	〃	13.5
Young seedlings (Chibyo)	3.2	Heating or non-heating	12.5
Nursling seedlings (Nyubyo)	1.4	Heating	12.0

(Hoshikawa, 1990)

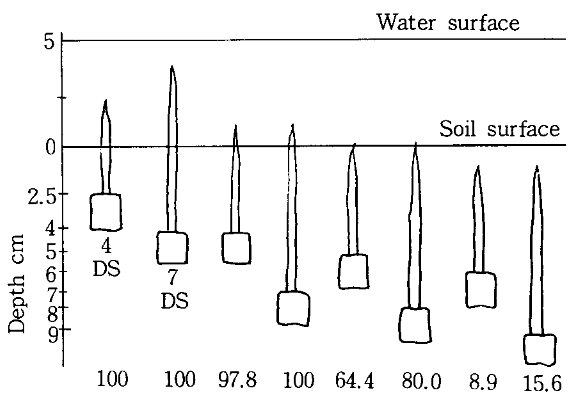

Fig. 5. An experiment showing the tolerance for deep planting of nursling seedlings (4DS : 4 days after seeding, 1.4 leaf-age, and 7DS : 7 days after seeding, 2.5 leaf-age).
(Hoshikawa, 1991)

the first to the third nodes). It is therefore necessary to control the production of early tillers in order to prevent rank growth and to keep the proper numbers of tillers per unit area. Thus, the stem becomes thick and can bear big panicles.

Heading of plants transplanted as nursling seedlings is almost the same to that with the Chibyo if the two kinds of seedlings are transplanted at the same time, which indicates that there is no fear in the delay of heading in plants grown from the nursling seedlings(Fig. 8).

Yield components can be well balanced since the number of panicles can be kept higher which compensates for the small size of panicles resulting from the existence of a little too many tillers in a single hill or in a community. The same level of yield was achieved with the nursling seedlings compared to that with the Chibyo(Table 6).

It was further suggested that if the surplus tillers can avoided by such cultivation practices, as deep irrigation and reduction of basal nitrogenous fertilizer, the numbers of grain per panicle can be kept greater, and higher yield can be realized.

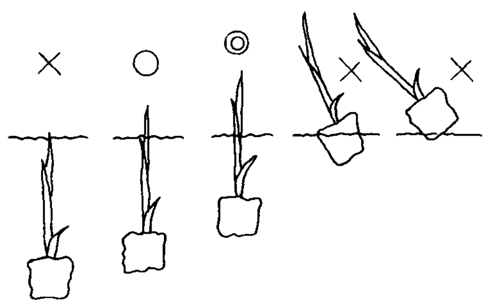

Fig. 6. Transplanting depth and rooting activity. Seedlings shallow planted are easy to float.

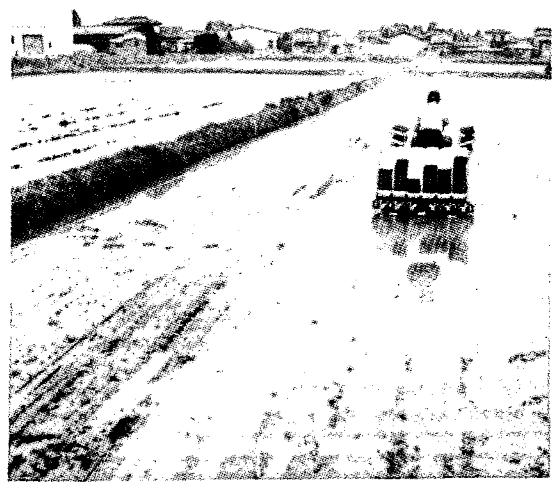

Fig. 7. Transplanting of nursling seedlings. Seedlings planted were almost submerged because they are so small, however there was nothing to fear about establishment.

Table 5. Effects of flooding after transplanting on the rooting and establishment of seedlings.

Depth of irrigation (cm)	Plant age (leaves)	Plant height (mm)	Crown roots from coleoptilar node Number of roots	Total length(mm)	Percentage of rooted (established) seedlings (%)
0	2.2	63.2	5	62.5	100.0
3	2.2	73.1	5	42.9	100.0
6	2.1	80.9	5	29.8	100.0
10	2.1	80.9	5	15.5	98.0
15	2.0	82.4	5	20.7	100.0

* All seedlings were transplanted at 1.4 seedling age. They had were grown 5 days at biotron, 17/12℃(day/night), and then were sampled for examination.

(Hoshikawa, 1990)

4. Experimental results and prospects of rice cultivation with the nursling seedling

(1) Practical results bv farmers.

Fig. 8. An experimental rice field in ripening stage(Oct. 3, 1990 in Sendai). Field planted nursling-seedlings on May 7 (right) had a fine crop of rice as well as that of planted "young seedlings" on May 6(left).

Practical experiments with the nursling seedlings conducted in 1989 and 1990 by farmers in various areas showed exciting results.

The Simbo Farm in Ojiya City in Niigata Prefecture, employed nursling seedlings(cv. Koshihikari, 18.3 hills per m^2) and obtained a record yield of up to 690 kg per 10a(brown rice), while the yield of the control area with Chibyo was only 576(Table 7). Also the Hayasaka Farm in Shikama Machi, Miyagi Prefecture, achieved a yield, with nursling seedlings of 660kg per 10a(cv. Sansanishiki) while the control field of Chubyo yielded only 560. In many other areas, such as in Prefectures of Aomori, Akita, Iwate, Toyama, Tochigi, Mie, Saga etc., the same yield levels as stated above, or even higher levels were achieved. Cases of yield reduction with the nursling seedlings were rarely found in 1990.

Table 6. Difference of yield components between nusling seedling rice culture and young seedling rice culture.

Seedlings	Number of panicles /hill	Number of panicles /m^2	Number of grains /panicle Total	Number of grains /panicle Ripened	Percentage of ripened grains	1000 Grain weight (g)	Yield of brown rice (kg /10a)
Nursling	21.5	476	74.0	55.3	74.8	20.6	536.6
Young	19.3	427	75.0	58.5	78.0	20.5	507.3

* Data were based on experiments conducted in 1989 and 1990. (Hoshikawa, 1991)

Table 7. Result of nursling seedling rice cultivation practice by Shimbo Farm in Ojiya City, Niigata Prefecture, 1990.

Seedlings	Nursling seedlings		Young seedlings
Planting density	16.8 hills /m^2	18.3 hills /m^2	15.1 hills /m^2
Yield of brown rice(crude) kg /10a	637.6	702.9	581.6
1,000 grain weight g	21.6	22.6	23.3
Brown rice screened			
with 1.8mm mesh kg /10a	600.0	675.8	572.3
with 1.7mm mesh kg /10a	613.9	689.5	576.6
Rice screenings kg /10a	23.8	13.4	4.9

* Nursling seedlings were transplanted on April 27, young seedlings on May 2. Cv. Koshihikari used. (Ojiya Agricultural Cooperative Association. 1990)

(2) Prospects of rice cultivation with the nursling seedling.

There has appeared a general trend in 1991 that both national and prefectural agricultural experiment stations in no small numbers are making efforts to carry out researches on rice cultivation using the nursling seedlings. I am expecting that these experiments are sure to succeeded, and the nursling seedling rice cultivation will becomes no doubt to the public recommendation.

The nursery techniques with the nursling seedlings are still under investigations from various aspects. Further approaches to practical techniques in the paddy fields such as the problem of using herbicides and pesticides, etc., should also be carried out.

Nevertheless, satisfactory results have already been shown by the leading farmers who courageously challenged rice cultivation with the nursling seedlings. It can be hoped that in the present when the reduction of agricultural costs becomes the most striking problem, further challenges in rice cultivation with nursling seedlings will be carried out to realize a high-yield, low cost, and an improved quality of rice.

I have heard that research on seedlings younger than Chibyo have been conducted, and experiments are also attempting in Korea. According to information revealed by a Japanese maker who examined the market of Korea relating to the possibility of rice cultivation with the nursling seedlings by employment of rockwool mat, it is believed that there is not a tendency for the spread of the nursling seedling in Korea because it is using the natural soil as the seed bed. I do not agree with this thinking. Considering that both Japan and Korea are advancing in the same way concerning to the relationship between industry and agriculture, I would predict that along with the development of mechanical transplanting and the senility of labors and need to lower production costs in Korea, rice cultivation with the nursling seedlings will become widely spread, or at least occupy an imporant position in Korea's rice cultivation techniques.

I sincerely hope that my information about one of the newest rice culturivation techniques in Japan, the employment of nursling seedlings, can be of some value to Korean crop scientists and farmers.

References

1. Dakeishi, S., and Y. kamata 1989. Fertilization and plant growth in the rice cultivation with infant seedlings. Rep. Tohoku Branch Crop Sci. Japan 32 : 5－7.
2. Himeda, M. 1990. The destination of investigation works on seedling raising for machine transplanting. －A history of seedling raising technique up to the development of Nyubyo－ Fumin Kyokai ed. Birth of the rice cultivation with Nyubyo. Fumin Kyokai, Tokyo. 143－53.
3. Hoshikawa, K. 1990. "Nyubyo" －its character-ristics and techniques of raising－ Fumin Kyokai ed. Birth of the rice cultivation with Nyubyo. Fumin Kyokai, Tokyo. 43－126.
4. Hoshikawa, K. 1990. Physiology and ecology of the nursling seedlings which has appeared recently. Fumin 1990－4 : 78－81.
5. Hoshikawa, K. 1990. Rice cultivation technique with nursling seedlings. Nogyo Gijutsu Taikei, General Crops, Suppliments 12(522) : 2－8.
6. Hoshikawa, K. 1991. A new low-cost rice cultivation techniques with transplanting of nursling seedlings. Green Rep. 130 : 1－2.
7. Hoshikawa, K. 1991. Rice cultivation using the nursling seedlings. Healthy seedling raising for stable and high yielding rice cultivation. 2. Zenkoku Nogyo Shimbun 1991. 1. 18.
8. Hoshikawa, K. and K. Shoji 1990. Nursling seedlings, their optimum ages for good rooting and the mechanism of rooting.

Japan. Jour. Crop Sci. 59(Sp. 2) : 173 −174.
9. Imai, Y., T. Takano and S. Maruho 1986. Studies on infant seedling transplantation for rice cultivation. 1. Nursing period and growth of seedlings. Rep. Hokuriku Crop Sci. Soc. 21 : 75~76.
10. Imai, Y., Y. Nagasawa, and S. Maruho 1986. Studies on infant seedling transplantation for rice cultivation. 2. Effect on greening and hardening periods in growth of seedlings. Rep. Hokuriku Crop Sci. Soc. 21 : 77~78.
11. Imai, Y. 1987. Rice cultivation by transplantation with infant seedlings. Nogyo Gijutshu 42 : 11 : 490~495.
12. Imai, Y., S. Naruho, Y. Sasaki, M. Koide and T. Takano 1987. Studies on infant seedling transplantation for rice cultivation. 1. Nursing period and growth of seedlings. Rep. Niigata Agr. Expt. Sta. 36 : 1~8.
13. Jimbo, K. 1988. Raising method of dense-seeding and short-time nursing rice seedlings for machine transplanting, and cultivation technique after transplanting. Kongetsu no Nogyo 32, 2 : 32~35.
14. Kamata, Y., K. Fukuda, and S. Dakeishi 1985. Raising method for infant rice seedlings. Res. Tohoku Agriculture 37: 15−16.
15. Kamata, Y., K. Fukuda and S. Dakeishi 1987. Machine transplanting method with infant rice seedlings. I. Seddling raising method and the adaptability to transplanting machine. Res. Tohoku Agriculture 40 : 31−32.
16. Kamata, Y., K. Fukuda, and S. Dakeishi 1987. Machine transplanting method with infant rice seedlings. II. Irrigation management on the early growth stage in paddy field. Res. Tohoku Agriculture 40 : 33−34.
17. Kinoda, N., T. Nakahori and M. Namioka 1986. Nursing method of short-time Chibyo and their growing habit in paddy field. Res. Tohoku Agriculture 39 : 11~12.
18. Kinoda, N. 1987. Nursing method of short-time Chibyo. Kongetsu no Nogyo 31 (2) : 20~23.
19. Komatsu, Y., Y. Mastuo and Y. Uemura 1987. Adaptability of greened rice seedlings to the machine transplantation. Rep. Shikoku Br. Crop Sci. Japan 24:1~6.
20. Kon, K. 1990. Use of short-time Chibyo for low cost rice production. Kikaika Nogyo 1990. 2 : 15~17.
21. Konno, K. 1989. Effects of transplanting method with rice seedlings of emerged stage on the growth after transplanting and yield. Rep. Hokkaido Danwakai, Breeding and Crop Sci. Soc. 29 : 56.
22. Matsushima, S., Y. Washio, I. Nishiyama, Y. Ishizaki, S. Kumano and Y. Kameishi 1986. Examination of the rice cultivation method intermediate between direct seeding and transplanting. Agr. & Hort. 61 : 511−518.
23. Nakatani, H. 1986. Studies on rice cultivation using endosperm seedlings for mechanical transplantation. 1. Cultivating method of endosperm seedlings and early stage growth. Rep. Hokuriku Crop Sci. Soc. 21 : 49~50.
24. Nakatani, H. 1987. Practice and problems in the rice cultivation with "Nyubyo" trans-planting. Agr. & Hort. 62 : 403−407.
25. Nakatani, H. 1987. Studies on rice cultivation using endosperm seedlings for mechanical transplantation. 2. On the irrigation depth after transplantation and its varietal difference. Rep. Hokuriku Crop Sci. Soc. 22 : 5~7.
26. Ogawa, T. and N. Yamazaki 1989. Raising method of Nyubyo of rice and growing habit after transplantation. Rep. Hokkaido Danwakai, Breeding and Crop Sci. Soc. 29 : 57.
27. Okuma, M., Y. shibata, K. Harada, and S. Furushiro 1987. Low-cost rice cultivation technique using short-time nursed seedlings. Rep. Kyushu Br. Crop Sci. Soc.

Japan 54 : 44~46.
28. Okuma, M., Y. Shibata, and K. Harada 1988. Nursing method of short-timed nursed rice seedlings and their transplanting method. Rep. Kyushu Br. Crop Sci. Soc, Japan 55 : 35−37.
29. Okuma, M. and K. Harada 1989. Low-cost rice cultivation technique using short-time nursed seedlings. Rep. Fukuoka Pref. Gen. Agr. Exp. Sta. A−9 : 33~36.
30. Saito, K. and K. Takahashi 1977. Establishment of seedling-scattering transplanting method of the endosperm rice seedlings. Rep. Fukui Agr. Expt. Sta. 14 : 15−26.
31. Saito, M. 1990. Studies to construct the transplant technique with emerged rice seedlings. Ⅰ. Optimum date for transplanting on the view points of seedling establish percentage and heading date. Rep. Tohoku Br. Crop Sci. Soc. Japan 33 : 32−34.
32. Saito, M. 1990. Studies to construct the transplant technique with emerged rice seedlings. Ⅱ. On tillering habit related with the duration of seedling raising and planting depths. Rep. Tohoku Br. Crop Sci. Soc. Japan 33 : 35−37.
33. Sho, A., T. Ishikawa, T. Umemoto and N. Ishikura 1990. Growing habits of rice plants after transplantation of the Nyubyo grown by an artificial nursery mat. Res. Tohoku Agriculture 43 : 19~20.
34. Shoji, S., A. Watanabe and K. Jimbo 1985. Raising method for short-time rice seedlings. Agr. & Hort. 60 : 545−548.
35. Sugihara O. 1974. Labor saving rice cultivation by seedling scatter method with one−leaf seedlings. Prompt Rep. Res. Fukui Agri. Expt. Sta. 11 : 5~8.
36. Sugihara, O. and M. Kurihara 1975. Establishment of a labor-saving rice cultivation method with scattering the one-leaf seedlings. Rep Fukui Agr. Expt. Sta. 12 : 1~10.
37. Takano, T., Y. Sasaki, M. Koide, Y. Imai and S.Naruho 1987. Studies on infant seedling transplantation for rice cultivation. 3. Materials for seedling raising and the grouth of seedlings. Rep. Hokuriku Crop Sci. Soc, 22 : 9~10.
38. Tankano, T., S. Naruho, S. Abe, H. Nagasawa, M. Koide, K. Yano and Y. Imai 1990. Studies on infant seedling transplantation for rice cultivation. 2. Growth habit and cultivation methods after transplantation. Rep. Niigata Agr. Expt. Sta. 37 : 43~50.
39. Uemura, Y. 1989. A rice cultivation method with the greened seedlings transplantation. Agr. & Hort. 64 : 391−394.
40. Watanabe, A., K. Jimbo and S. Shoji 1984. On the raising method for short-time and dense seeding rice seedlings. Rep. Tohoku Br. Crop Sci. Soc. Japan 27 : 19−20.
41. Watanabe, A. and K. Jimbo 1985. On the raising method for short-time and dense seeding rice seedlings. Ⅱ. Rep. Tohoku Br. Crop Sci. Soc. Japan 28 : 5−6.
42. Yang, W. H., Y. D. Yun, M. T. Song, M. H. Lee, M. S. Lim, and R. K. Park 1989. Machine transplanting cultivation with infant rice seedlings. Ⅱ. Effects of raising temperature, duration and nutritional residue in endosprem on seedling growth after transplanting. Korean Jour. Crop Sci. 34 : 434−439.
43 .Yun, Y. D., Y. B. Oh, M. S. Lim, R. K. Park, and S. H. Park 1989. Machine transplanting cultivation with infant rice seedlings. Ⅰ. Effects of different nursery soil and plumule length on the infant rice seedlings for machine transplanting. Korean Jour. Crop Sci. 34 : 428−433.