# Establishment of Cultivation Methods of Hitomebore Rice in Cold Regions

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# Establishment of Cultivation Methods of Hitomebore Rice in Cold Regions

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## Summary

Establishment of cultivation methods of Hitomebore rice in cold regions with pot mature seedlings was studied in comparison with that of mat young seedlings. The rooting capacity of pot seedlings was greater than that of mat seedlings. The number of leaves per main culm was larger in pot seedling plot than that of mat seedling plot. The tillering capacity of pot seedling was smaller than that of mat seedlings, but the percentage of productive tiller was larger in pot seedlings. Heading dates of rice in pot seedling plot were 5 days earlier than those in mat seedling plot. The nitrogen percentage of each part of rice grown in pot seedling plot was lower than those in mat seedling plot. Nitrogen perceentage of milled rice of pot seedling plot was lower than that of mat seedling plot and therefore the quality of milled rice was improved on the basis of nitrogen content. Yields of rice in pot seedling plot ranged from 445-679 g per $m^2$. The highest yield of pot seedling plot was obtained in Polyolefin Coated Urea dense planting cultivation, which was statistically similar to the highest yield of mat seedlings. Rice in pot seedling plot increased the percentage of ripened grains per panicle, which might affect the increase of the grain yield. From the above results, it is concluded that the yield and quality of Hitomebore rice in cold regions can be improved by pot mature seedling cultivation in combination with Polyolefin Coated Urea and dense planting.

The growth duration of a rice plant depends on the variety, cultural practices and environment under which it is grown. Tillering capacity and number of leaves per shoot of a variety are influenced greatly by the planting density, age of seedlings and rate of nitrogen applied. Matsushima (6) reported that narrow spacing increased the number of culms per $m^2$. Sato and Shibuya (8) reported that the number of culms per $m^2$ increased on dense plot rather than sparse plot. Akita and Tanaka (1) and Hoshikawa (4) reported that the number of culms per $m^2$ increases in young seedling plot rather than mature seedling plot. Sato and Shibuya (9) reported that the number of culms per $m^2$ was increased by POCU (Polyolefin Coated Urea) fertilizer cultivation rather than that of conventional

fertilizer cultivation.

In the previous study, it was also observed that the heading of pot mature seedlings was about 5 days earlier than that of mat seedlings and cumulative temperature for 40 days after heading was increased by pot mature seedlings in cold regions (Kawatabi). From the above mentioned, Hitomebore rice cultivation with pot seedlings is highly recommended in cold regions rather than that with mat seedlings. However, the farmers of Miyagi prefecture, usually use the mat seedlings for Hitomebore rice cultivation. The main technical differences between the pot and mat seedling rice cultivation methods are as following: a special type of seeder and larger space are required for raising pot seedlings, and a special type of transplanter is required for the transplanting of it. Up to present, there is no recommendation on a cultivation method of Hitomebore rice with pot seedlings. The objective of this paper is to establish a cultivation method of Hitomebore rice in cold regions with pot mature seedlings in comparison with that of mat young seedlings.

## Materials and Methods

This experiment was conducted in 1992-94 on Andisol (Medial, mesic, Alic Pachic melanudand) (Shoji et al., 10) at Experimental Farm of Tohoku University, Kawatabi, Naruko, Miyagi prefecture. Rice (*Oryza sativa.* L. cv. Hitomebore) was used as a test crop. Characteristics of pot and mat seedlings were shown in Table 1. Pot seedlings of 4.8-6.2 of leaf age and mat seedlings of 3.7-4.3 of leaf age were transplanted on the 7th of may. Transplanting density was 24.2 (Dense planting) or 18.2 (Sparse planting) hills/$m^2$. Bulk blend compound fertilizer (15-20-15) was applied as a single basal application at the rate of 70 kg N/ha, containing 80% polyolefin coated urea for POCU plot. Bulk blend readily available fertilizer (12-18-16) was applied as basal fertilizer at the rate of 5 g N per $m^2$. Ammonium sulfate was top dressed twice at the rate of 1 g N per $m^2$ at

TABLE 1. *Characteristics of pot and mat seedlings*

| Types of seedlings | Year | Plant length (cm) | Leaf age | DW/plant (mg) | | Nitrogen % of shoot |
|---|---|---|---|---|---|---|
| | | | | Shoot | Root | |
| Pot seedlings | 1992 | 10.8 | 4.8 | — | — | — |
| | 1993 | 16.0 | 5.7 | 44.6 | 24.4 | 2.55 |
| | 1994 | 12.7 | 6.2 | 46.8 | 24.8 | 3.35 |
| Mat seedlings | 1992 | 8.8 | 4.3 | — | — | — |
| | 1993 | 12.9 | 3.7 | 20.5 | 8.8 | 3.90 |
| | 1994 | 11.3 | 3.8 | 14.2 | 14.7 | 3.93 |

30 and 15 days before heading for conventional plots. Total nitrogen in plants was determined by the method of Bremner and Malvaney (2). Leaf number and nitrogen concentration of different parts of plants were measured only the treatment number 1 and 5. Statistical differences between the treatments were determined by Least Significant Difference (LSD) at 5% level of significance. Results were discussed mainly in 1992 and 1994, because the yield in 1993 was very low due to extremely abnormal weather. The treatments are as follows: 1) Pot POCU dense planting; 2) Pot POCU sparse planting; 3) Pot conventional dense planting; 4) Pot conventional sparse planting; 5) Mat POCU dense planting; 6) Mat POCU sparse planting; 7) Mat conventional dense planting: 8) Mat conventional sparse planting. In 1994, only the treatment numbers 1 and 5 was conducted.

## Results and Discussion

The average number of newly developed white roots per plant and the length of the largest root of pot and mat seedlings after 8 days of transplanting in 1992-1994 were shown in Table 2. It was found that in 1992, the number of newly developed white roots per plant of pot seedlings was greater than that of mat seedlings, and was statistically significant, but the length of newly developed largest root of pot seedlings was smaller than that of mat seedlings.

In 1993, the number of newly developed white roots per plant of pot and mat seedlings was approximately the same, but the length of newly developed white roots per plant of pot seedlings was statistically greater than that of mat seedlings. In 1993, nitrogen percentage of pot seedlings at the transplanting time was about 1.45% lower than that of mat seedlings (Table 1). As a result the number of white roots per pot seedlings was not so large in comparison with that of mat seedlings. The nitrogen percentage of pot seedlings can be improved by applying nitrogen fertilizer at the later nursery stage. In 1994, the number of newly developed white roots per plant and the length of newly developed largest root of pot seedlings was statistically greater than that of mat seedlings. From the above results, it may concluded that the rooting ability of pot seedlings seems to be greater than that of mat seedlings. Because the pot seedlings were raised in

TABLE 2. *Average number of newly developed white roots per plant and the length of its largest root of pot and mat seedlings after 8 days of transplanting.*

| Type of seedlings | Number of white root per plant | | | Length of newly developed largest root (cm) | | |
|---|---|---|---|---|---|---|
| | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| Pot seedlings | 6.4a | 9.2 | 12.4a | 5.2 | 5.5a | 7.6a |
| Mat seedlings | 4.8b | 9.3 | 7.9b | 5.7 | 4.7b | 4.0b |

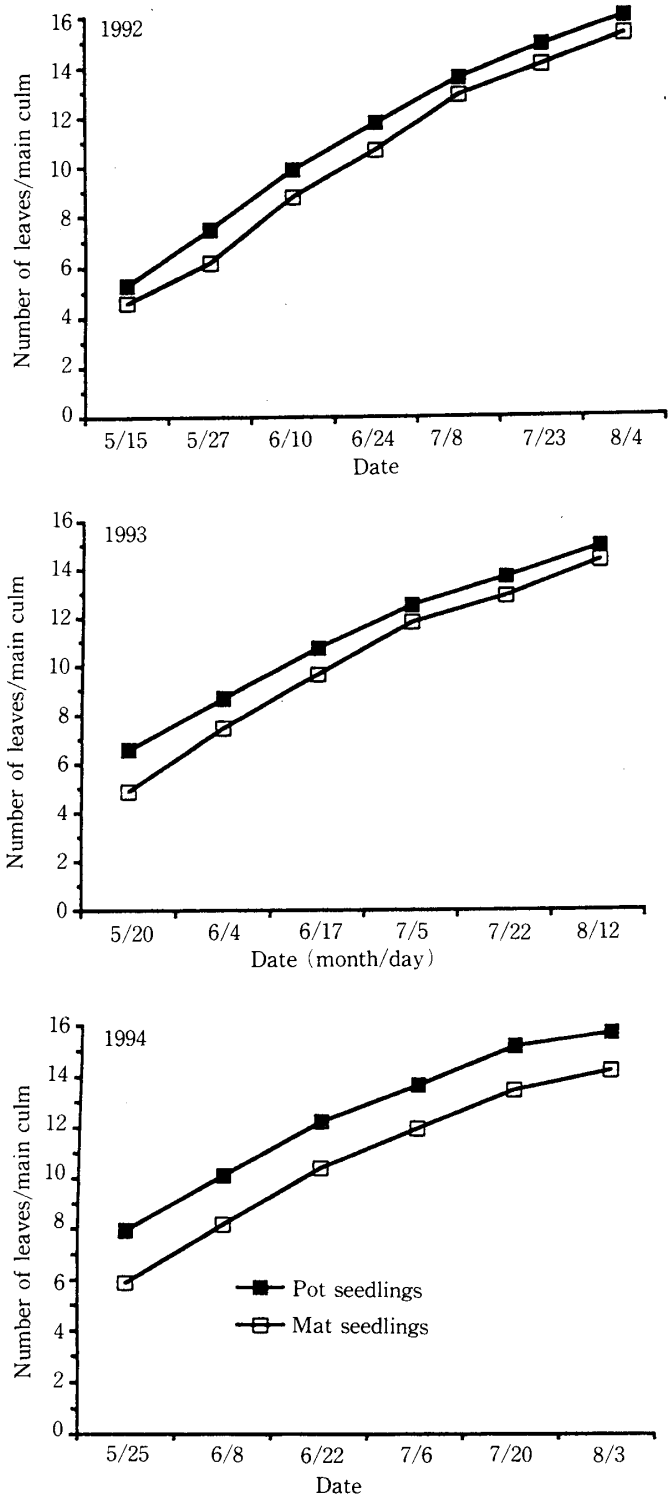


FIG. 1. Leaf age of rice in pot and mat seedling plots.

sparse planting conditions, the plant height, the number of leaves, and dry weight are superior to that of mat seedlings, and at the time of transplanting the pot seedlings could be pulled out without any damage to the roots. Therefore, the pot seedlings are easily accustomed to the field condition at the transplanting time, especially in cold regions and grow faster than those of mat seedlings.

Leaf ages of rice in pot and mat seedling plots are shown in Fig. 1. In 1992-1994, it was observed that at all stages of growth, leaf age of pot seedling plots was larger than that of mat seedling plots. Finally the total leaf numbers of main culm of pot and mat seedling plots in 1992 were 16 and 15.3, in 1993 were 15.1 and 14.5, and in 1994 were 15.8 and 14.3, respectively.

The heading date and cumulative temperature 40 days after heading were shown in Table 3. It seemed that the vegetative phase of rice in pot seedling plot was more advanced than that in mat seedling plot because the leaf age was always larger in pot seedling plot. As a result of advanced vegetative phase, in 1992, rice of pot seedling plots put forth their heads on the 9th-10th of August, that is 5 days earlier than the heading date of mat seedling plot. The heading date of rice in pot seedling plot in 1993 was delayed 9-10 days compared to that of 1992 due to extremely abnormal weather during panicle development stage. In 1994, the heading date of rice in pot seedling plot (6.2 of leaf age) was on the 31st of July and that of mat seedling plot was on the 4th of August. In 1992-93, the heading date of rice in dense planting plots was one day earlier than sparse planting plot of both types of seedlings. There were no difference in heading date between the different types of fertilizer treatments. In 1992, the cumulative temperature for 40 days after heading of rice in pot seedling plot was 838-847°C, whereas that in mat seedlings plot was 802-821°C that is 26-36°C larger in pot seedling plot. But it is still 33°C smaller than the requisite cumulative temperatures of 880°C for 40 days after heading. In 1993, the cumulative temperatures for 40 days after

TABLE 3. *Heading date and cumulative temperature for 40 days after heading*

| Treatment number | Heading date | | | Cumulative temperature (°C) for 40 days after heading | | |
|---|---|---|---|---|---|---|
| | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| 1 | 9th Aug. | 18th Aug. | 31st July | 847 | 768 | 987 |
| 2 | 10th Aug. | 19th Aug. | — | 838 | 758 | — |
| 3 | 9th Aug. | 18th Aug. | — | 847 | 768 | — |
| 4 | 10th Aug. | 19th Aug. | — | 838 | 758 | — |
| 5 | 14th Aug. | 23rd Aug. | 4th Aug. | 821 | 744 | 967 |
| 6 | 15th Aug. | 24th Aug. | — | 802 | 736 | — |
| 7 | 14th Aug. | 23rd Aug. | — | 821 | 744 | — |
| 8 | 15th Aug. | 24th Aug. | — | 802 | 736 | — |

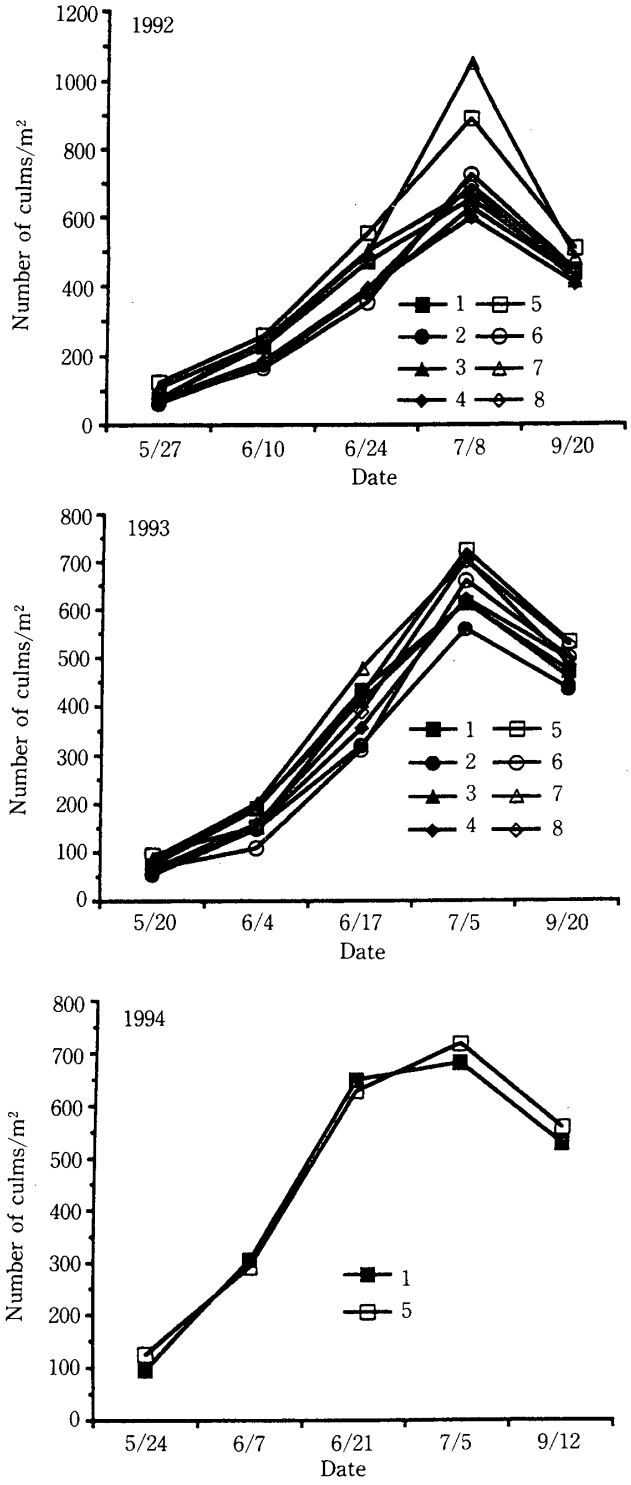


FIG. 2. Number of culms of rice in pot and mat seedling plots.

heading were significantly smaller than those in 1992 due to delayed heading. In 1994, both types of plots were fulfilled the requisite cumulative temperature for 40 days after heading. The cumulative temperature for 40 days after heading in pot seedling plot was 987°C, whereas that in mat seedling plot was 967°C.

The number of culms/$m^2$ of rice in pot and mat seedling plots in 1992-1994 are shown in Fig. 2. In 1992, it was found that rice in the pot seedling plot produced smaller numbers of culms/$m^2$ than that in mat seedling plot at the end of June. But the POCU and dense planting increased the number of culms per $m^2$ of both types of seedling plots. Finally, the number of culms/$m^2$ of rice in pot and mat seedling plots were 437 and 509, respectively, in POCU dense planting plot. In 1993, rice in mat seedling plot produced a larger number of culms per $m^2$ than that in pot seedlings in all plots. In 1994, the number of culms/$m^2$ of rice in pot seedling plot was almost same as that in mat seedlings plot up to the end of June. After that the number of culms/$m^2$ of rice in mat seedlings plot was greater than that in pot seedling plot. Finally, the number of culms/$m^2$ of pot and mat seedling plots were 529 and 560, respectively. So the tillering capacity of pot seedlings was lower than that of mat seedlings.

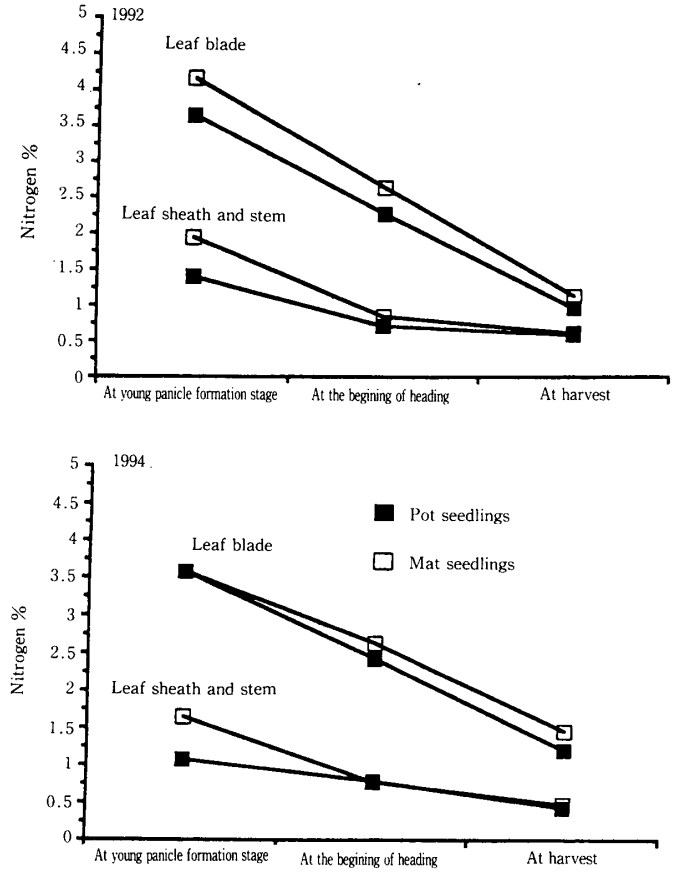


FIG. 3. Nitrogen concentration of rice in pot and mat seedling plots at different stages.

Nitrogen concentration of each part of rice in pot and mat seedling plots in 1992 and 1994 are shown in Fig. 3. In both years, the N concentration of leaf blade of rice in pot seedling plot was lower than that in mat seedlings plot. This suggested that N concentration decreased as the number of leaves, ineceased, because rice in pot seedling plot was larger in the number of leaves than that in mat seedling plot. Murata (7) reported that the growth stage of rice plants can be very well represented by the N concentration of leaf blade, because the N concentration of leaf blade decreases with maturity.

At harvest, the nitrogen concentration of panicle and milled rice of pot seedling plots were statistically lower than those of mat seedling plots (Fig. 4), which might affect the quality of rice. Lower N concentration of milled rice plays an important role on the quality of rice. Ebata and Shibata (3) reported that the lower protein content of milled rice showed better eating quality.

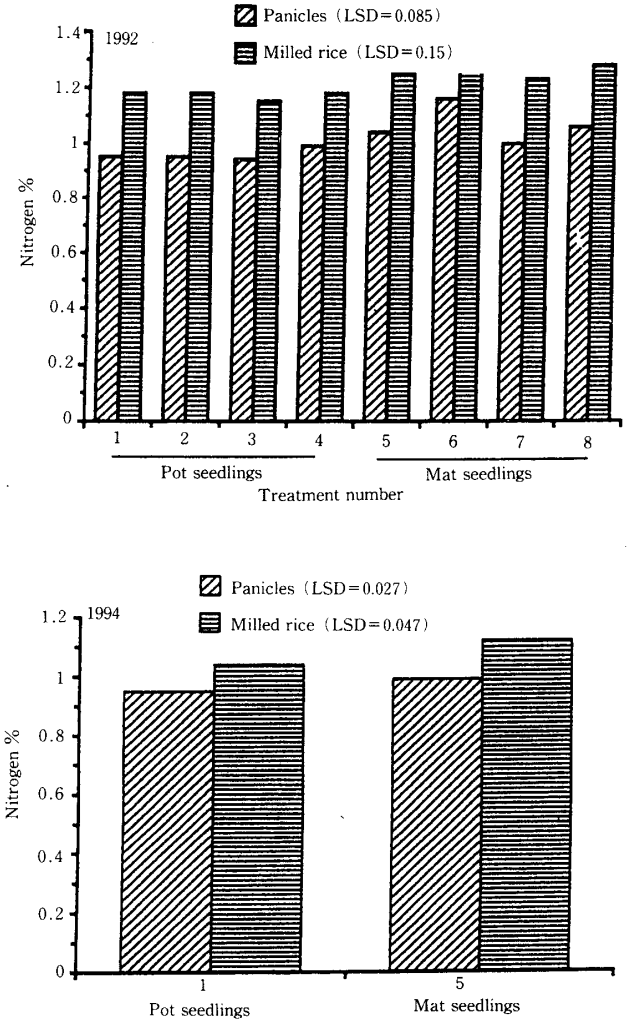


FIG. 4. Nitrogen concentration of panicles and milled rice in pot and mat seedling plots.

Cooking rice of high protein content is considered to show a hard, less sticky texture (Tamaki et al., 11), because protein restricts starch expansion by encircling starch granules and disturbs the water penetration (Little and Dawson, 5). Yamashita and Fujimoto (12) showed a negative correlation between N concentration of rice kernel and sensory evaluation score of eating quality. They also reported that the effects of nitrogen on eating quality were mainly caused by a decrease in viscosity and elasticity, and the increase in hardness was accompanied by an increase in protein content, rather than the changes in properties of rice starch.

Yield and yield components of rice in pot and mat seedling plots are shown in Table 4. The number of panicles/$m^2$ of rice in pot seedling plot was lower than that in mat seedling plot, but the number of spikelets/panicle and thousand kernel weight of rice in pot seedling plot were almost same as those of mat seedling plot. The percentage of ripened grains/panicle in pot seedling plot was greater than that in mat seedling plot, which might affect the increase of rice yield of pot seedling plot. In 1992, the brown rice yields of pot seedling plots were 445–547

TABLE 4. *Yield and yield components of pot and mat seedlings*

| Year | Treatment number | Number of panicles/$m^2$ | Number of spikelets/ panicle | % of ripened grains/ panicle | 1000 kernel weight (g) | Yield (g/$m^2$) |
|---|---|---|---|---|---|---|
| 1992 | 1 | 437 | 69 | 82.0 | 22.1 | 574a |
| | 2 | 428 | 76 | 65.7 | 22.0 | 470cd |
| | 3 | 415 | 62 | 87.3 | 22.5 | 505b |
| | 4 | 407 | 71 | 70.7 | 21.8 | 445d |
| | 5 | 509 | 68 | 72.1 | 22.1 | 552a |
| | 6 | 446 | 69 | 68.6 | 21.9 | 462cd |
| | 7 | 480 | 65 | 70.9 | 22.2 | 491bc |
| | 8 | 439 | 71 | 70.0 | 21.9 | 478bcd |
| 1993 | 1 | 464 | 69 | 10.2 | 17.7 | 59 |
| | 2 | 437 | 69 | 5.7 | 17.7 | 30 |
| | 3 | 460 | 69 | 9.0 | 19.1 | 55 |
| | 4 | 497 | 64 | 6.5 | 18.4 | 38 |
| | 5 | 534 | 61 | 3.9 | 17.4 | 20 |
| | 6 | 501 | 63 | 5.2 | 16.4 | 27 |
| | 7 | 485 | 58 | 3.4 | 18.0 | 17 |
| | 8 | 528 | 61 | 4.6 | 16.9 | 25 |
| 1994 | 1 | 529 | 61 | 91.8 | 22.9 | 679a |
| | 5 | 560 | 59 | 87.9 | 22.8 | 673a |

Values followed by the same letters in a column does not differ significantly.
In 1992, LSD=33.0; In 1994, LSD=6.92 (P=0.05)

g/m$^2$, and those of mat seedling plots were 462-552 g/m$^2$. The highest yield was obtained from mat POCU dense planting plot, which was statistically similar to the yield of pot POCU dense planting plot. In 1993, the yields of all plots were significantly smaller in comparison to the yield in 1992 due to a lower percentage of ripened grains per panicle and smaller 1000 kernel weight. In 1994, the yields of rice in pot and mat seedling plots were 679 and 673 g/m$^2$, respectively, but there were no gignificant differences between the grain yield of pot and mat seedling plots.

From the above results, it is concluded that the yield and quality of Hitomebore rice in cold regions can be improved by pot mature seedling cultivation in combination with POCU fertilizer and dense planting.

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