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Establishment of the No-tillage Transplanting Cultivation of High Quality Rice "Hitomebore" with a Single Basal Application of Controlled Availability Fertilizer in Pot Seedling Box in Cold Regions

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Summary

No-tillage (NT) transplanting cultivation of high quality rice "Hitomebore" with a single basal application of controlled availability fertilizer (CAF) in pot seedling box in cold regions compared to that of conventional tillage (CT) system was studied in Andisol at Kawatabi. The N release of CAF from POCU S100 and POCU SS100 during the nursery stage were 4.4% and 3.2%, respectively. The N released from POCU SS100 during the nursery stage didn't reduce seedling growth compared to that from POCU S100. The plant height and total leaf numbers of main culm of NT plots were similar to the CT plots. The linear type of polyolefin coated urea (POCU) 30, in combination with sigmoid type of POCU S100 and POCU SS100 applied as basal fertilizers, increased the number of tillers at the initial growth stage of rice. The brown rice yields of all the NT plots were 5.23-6.16 t/ha, which was higher compared to that of the CT plots (4.52 t/ha). The highest yield was obtained in POCU SS100 NT plots. Sigmoid type of POCU S100 and POCU SS100 in NT plots increased the number of spikelets per m^2.

In Japan the total area of rice harvested has decreased drastically since 1970 (1). This was brought about by the political control of rice cultivation because of over production. Therefore nowadays, for farmers, the quality of rice is becoming a greater issue than quantity because the price of high quality rice is much higher than that of average rice. At the same time, farmers wanted to reduce the production and labor cost. About 40% of total rice cultivated land in Japan was situated in cold regions. Farmers in the hilly and mountainous areas of Miyagi prefecture are actually earnest about cultivating the high quality rice of Hitomebore because of its high quality and relatively high resistance to cold. 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.

Saigusa *et al.*, (2) reported that the heading date of rice in pot seedling plots was 5 days earlier than those in mat seedling plots. 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 and the yield and quality of high quality rice "Hitomebore" in cold regions can be improved by pot seedling cultivation in combination with polyolefin coated urea (POCU) (3). However, up to present, there is no recommendation on a cultivation method of no-tillage transplanting of pot seedlings with single basal application of controlled availability fertilizer (CAF) as a total N fertilizer in a nursery box of high quality rice "Hitomebore". Therefore, it is necessary to examine the growth and related characteristics of pot seedlings of Hitomebore rice in no-tilled fields in cold regions.

The objective of this study is to establish the no-tillage transplanting cultivation of high quality rice "Hitomebore" with a single basal application of CAF in pot seedling box in cold regions.

Materials and Methods

This experiment was carried out in 1996 in the Experimental Farm of Tohoku University, Narugo, Miyagi prefecture. The soil used in this study is classified as a medial, mesic Alic Pachic Melanudand (4). Transplanting density was 24 hill per m^2. Sigmoid type of POCU S100 (30 days lag time) or SS 100 (40 days lag time) was used as a single basal application of total N at the rate of 5 and 7g/m^2 in a nursery box at the time of sowing. The duration of nursery stage of pot seedling is about 40 to 45 days. Linear type of POCU 30 at the rate of 2 g/m^2 was broadcast on the seedling box of 5 gN/m^2 plot to improve the initial growth of rice at the time of transplanting. The respective treatments are as follows:

1) POCU S100-CT = POCU S100 (7 gN/m^2) in conventional tillage plot
2) POCU (S100+30)-NT = POCU S100 (5 gN/m^2) + POCU 30 (2 gN/m^2) in no-tilled plot
3) POCU S100-NT = POCU S100 (7 gN/m^2) in no-tilled plot
4) POCU (SS100+30)-NT = POCU SS100 (5 gN/m^2) + POCU 30 (2 gN/m^2) in no-tilled plot
5) POCU SS100-NT = POCU SS100 (7 gN/m^2) in no-tilled plot

No-tillage treatments were sprayed with 4.1 La.i. ha^{-1} of isopropyl ammonium = N (phosphomethyl) glycinide to control weed at 20 days before transplanting. The experimental fields were submerged in water from 10 days before transplanting. Rice straw was scattered on the surface of soil for NT treatments. Transplanting date was 11 May 1996. The characteristics of pot seedlings were shown in Table 1.

The plant length of pot seedlings raising with POCU were slightly shorter

TABLE 1. *Characteristics of pot seedling*

Types of seedling	Plant height (cm)	Leaf number	Leaf color	Tiller/ seedling	Dry weight (mg/plant)		Total N (%)
					Shoot	Root	
Control	12.5	6.3	33.6	0.3	43.2	25.3	3.36
POCU S100 (5)	12.4	6.7	36.1	1.7	49.8	22.8	4.31
POCU S100 (7)	11.9	6.5	38.0	1.4	45.3	21.1	4.33
POCU SS100 (5)	11.1	6.8	36.0	1.6	45.5	26.9	4.21
POCU S100 (7)	9.9	6.8	38.3	1.8	45.7	22.4	4.12

POCU S- Sigmoid type of polyolefin coated urea

(9.9–12.4 cm) than that of conventional pot seedlings (12.5 cm). Leaf age and leaf color value of these seedlings were larger than those of conventional ones. Pot seedlings raising with POCU were produced about 1.6 tiller per seedling within the nursery stage. The dry matter and N% of shoot were greater in pot seedlings raising with POCU than those of conventional pot seedlings. However, the root dry weight of these seedlings was lower than that of convantional pot seedlings. The N% of pot seedlings raising with POCU S100 was greater than those of pot seedlings raising with POCU SS100. From the dissolution experiment, it was found that only 4.4% and 3.2% N were released from POCU S100 and POCU SS100, respectively, during the nursery stage. The cumulative mean air temperature surrounding the pot seedlings was 861 during the nursery stage. From the above mentioned results, it was clear that the N released from POCU S100 and POCU SS100 did not affect seedling growth in the nursery stage. However, it seemed that the N released from POCU SS100 during the nursery stage was not harmful to seedling growth compared to POCU S100. The seedlings were shown in Fig. 1.

Results and Discussion

Plant height

The plant height of rice in 1996 is shown in Fig. 2. Up to the end of June, the height of rice in POCU S100-NT plot was lower than that in POCU S100-CT plot. However, finally there were no significant differences between the plant height of rice in these two plots.

Leaf age

Leaf ages of rice of POCU S100-NT and POCU S100-CT plots are shown in Fig. 2. It was observed that after 26 days of transplanting, leaf age of rice in POCU S100-NT plots was smaller than that in POCU S100-CT plots. Finally the

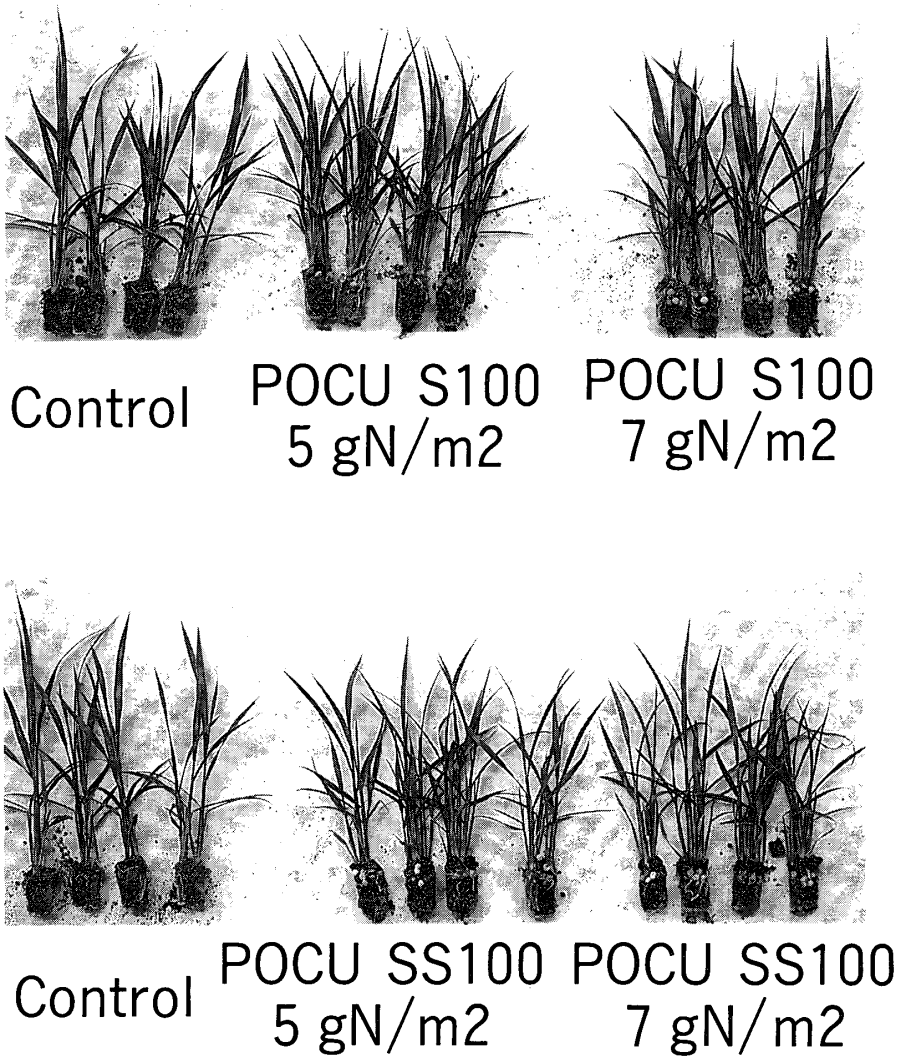

FIG. 1. Pot seeding of rice raised by polyolefin coated urea (POCU)
White particle: Sigmoid type of POCU (POCU S100, POCU SS100)

total leaf numbers of main culm of POCU S100-NT and POCU S100-CT plots were 15.5 and 15.7, respectively.

Leaf color value

The leaf color values of different treatments are also shown in Fig. 2. The leaf color values were almost the same among the treatments at the early growth stage. From the middle of June, the leaf color values of rice in POCU S100 and POCU SS100 plots were larger than those of POCU (S100+30)-NT and POCU (SS100+30)-NT plots, reflecting the nitrogen release characteristics of POCU S100 and POCU SS100. On the other hand, the leaf color values of rice in POCU S100-CT plots were increased from the middle of June, due to the lower number of tillers per m^2 and the higher mineralization of soil nitrogen in CT plot. Kaneta

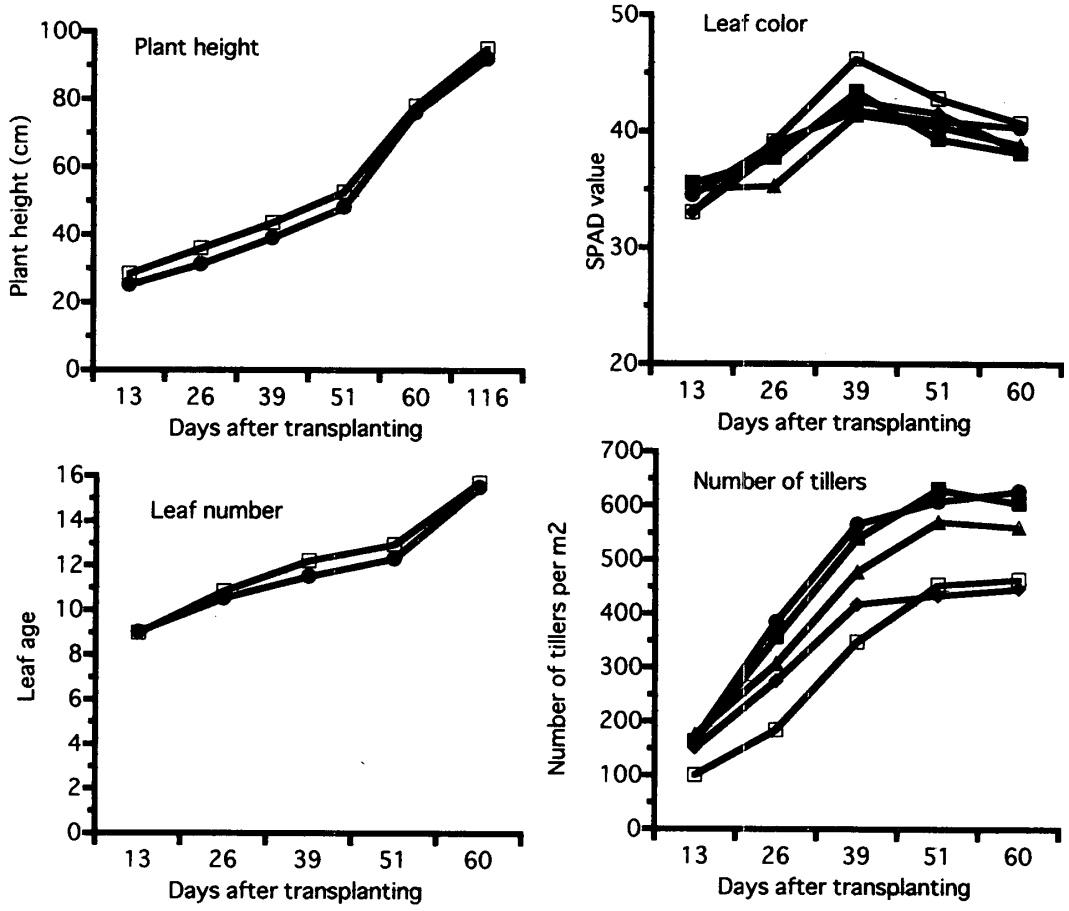

FIG. 2. Growth charcteristics of pot seedling in no-tillage transplanting system.
—□— POCU S100-CT —●— POCU S100-NT —■— POCU (S100+30)-NT —•— POCU SS100-NT —▲— POCU (SS100+30)-NT
NT : No-tillage, CT : Conventional tillage

et al., (5) and Phillips *et al.*, (6) reported that the native soil nitrogen of the NT system has a lower mineralization rate as compared to conventional tillage.

Number of tillers per m²

The number of tillers/m² of rice in each treatment is shown in Fig. 2. It was found that rice in the POCU S100-NT and POCU (S100+30)-NT plots produced larger numbers of tillers /m² than those in POCU SS100-NT and POCU (SS100+30)-NT plots throughout the growing season. However, up to the end of June, POCU SS100-NT plot produced a larger number of tillers per m² than that of POCU S100-CT. After that, the number of tillers per m² of POCU S100-CT plot increased more than that of POCU SS100-NT plot. Finally, the number of productive tillers/m² of rice in POCU (S100+30)-NT, POCU S100-NT, POCU (SS100+30)-NT and POCU SS100-NT plots were 486, 452, 440 and 406, respectively, whereas, the number of tillers/m² is 345 in the POCU S100-CT plot. From

the above results, it was clear that the linear type of POCU 30 in combination with POCU S100 or POCU SS100 increased the number of tillers per m^2 of pot seedlings more than did POCU S100 or POCU SS100 plot in the NT transplanting system. POCU S100 plot produced larger number of tillers than did POCU SS100 plot. It seemed that the N release from POCU SS100 was delayed at an earlier growth stage than that of POCU S100. Therefore, the number of tillers of POCU SS100 plot was smaller than that of POCU S100 plot.

Heading date and cumulative temperature

The heading date and cumulative temperature during the 40 days after heading were shown in Table 2. Pot seedling with NT treatments put forth their heads on the 8th of August, that is 6 days earlier than the heading date of mat seedling treatments. The cumulative temperature for the 40 days after heading of rice in pot seedling NT plot was 803°C, whereas that in the mat seedling plot was 777°C, that was 26°C more in the pot seedling NT plot. But in 1996, it was still 77°C smaller than the requisite cumulative temperature of 880°C for 40 days after heading.

Yield and yield components

The yield and yield components of rice are shown in Table 3. The brown

TABLE 2 *Heading date and cumulative temperature for 40 days after heading*

Type of seedling	Tillage system	Heading date	Cumulative temperature (°C) for 40 days after heading
Pot seedling	No-tillage	8 th August	803
Mat seedling	Conventional tillage	14 th August	777

TABLE 3. *Yield and yield components of rice in no-tillage transplanting system*

Treatments	Number of panicles/m^2	Number of spikelets/ panicle	Number of spilelets /m^2 ($\times$1,000)	1,000 kernal weight (g)	% of ripened grains	Yield (t/ha)
POCU S100-CT	345	61	21.0	23.3	92.4	4.5
POCU (S100+30)-NT	486	57	27.7	23.2	91.0	5.7
POCU S100-NT	452	66	29.8	23.3	88.3	6.1
POCU (SS100+30)-NT	440	57	25.1	23.9	87.8	5.2
POCU SS100-NT	406	69	28.0	24.1	91.3	6.2
KSD at 5%						0.4

CT : Conventional tillage, NT : No-tillage

rice yields of POCU (S100+30)-NT and POCU S100-NT plots were 5.70 and 6.13 t/ha, and those of POCU (SS100+30)-NT and POCU SS100-NT were 5.23 and 6.16 t/ha, respectively. The rice in POCU S100-CT plot produced the lowest yield (4.52 t/ha). The rice in POCU S100-NT and POCU SS100-NT plots produced larger number of spikelets/panicle than did POCU (S100+30)-NT and POCU (SS100+30)-NT plots and thus increased the number of spikelets per m^2. This might affect the increase of rice yield. Initial growth of rice in NT system was improved by the combination of linear type (2 gN/m^2) and sigmoid type (5 gN/m^2) of fertilizers. However the yield of brown rice was inferior to that of rice treated sigmoid type (7 gN/m^2) of fertilizer reflecting small number of spikelet/panicle. Extra amonts of nitrogen matching to initial growth increase in these plots should be applied to increase number of spikelet/panicle and consequentlly rice grain yield. The rice in POCU S100-CT produced the lowest number of spikelets per m^2 due to the smaller number of productive tillers. There were no significant differences between the thousand kernel weight of rice in POCU (S100+30)-NT and POCU S100-NT plots. Whereas, those in POCU (S100+30)-NT and POCU S100-NT plots were smaller than those of POCU (SS100+30)-NT and POCU SS100-NT plots. The percentage of ripened grains/panicle in POCU SS100-NT pot seedling plot was greater than that in POCU (SS100+30)-NT plot, which might affect the increase of rice yield of these plost. On the other hand, the percentage of ripened grains/panicle in POCU (S100+30)-NT plot was greater than that in POCU S100-NT plot. It seems that the fertilizer of POCU S100-NT and POCU SS100-NT plots can supply an adequate amount of N at the reproductive stage to produce larger number of spikelets.

From the above results, it was concluded that the no-tillage transplanting system of pot seedlings with a single basal application of POCU S100 or POCU SS100 in combination with or without POCU 30 in a nursery box is a suitable cultivation method to reduce the labor cost and the use of fossil fuel. Furthermore, research is needed to innovate the transplanting machine method of pot seedlings in no-tilled paddy field.

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