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journal or publication title	Tohoku journal of agricultural research
volume	51
number	3/4
page range	49-59
year	2001-03-31
URL	http://hdl.handle.net/10097/30023

Tohoku Journal of Agricultural Research
Vol. 51 No. 3-4, March 2001
Printed in Japan

No-tillage Transplanting System of Rice with Controlled Availability Fertilizer in the Nursery Box
II. Improvement of the initial growth or rice in the no-tillage transplanting system

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(Received, Jan. 31, 2001)

Abstract

The effect of linear type of polyolefin coated urea (POCU) 10 or 30 in combination with sigmoid type of POCU S100 in the nursery box on the improvement of the initial growth of rice in no-tillage transplanting system was studied in light clay soil (alluvial soil) and clay loam soil (Andisol) in Miyagi prefecture, Japan. POCU-10 or POCU-30 (short release type of POCU) in combination with POCU S100 was remarkably more effective in increasing the leaf color value and the number of tillers than those in the POCU s100 treatments, reflecting the rapid release of N from POCU-10 or -30 at the initial growth stage. POCU-10 or POCU-30 in combination with POCU s100 increase the dry matter yield at young panicle initiation stage. The N recoveries from the linear type of POCU-10 and POCU-30 at the young panicle initiation stage were 41 and 30%, and 33 and 34% in light clay soil and clay loam soil, respectively. At the harvest time, they were 53 and 53%, and 51 and 68% in light clay soil and in clay loam soil, respectively. The yields of brown rice of NTS 30 were almost the same or higher than those of NTS, whereas those of NTS 10 tended to be lower because of a fewer number of spikelets per m^2.

key words : Initial growth, No-tillage transplanting system, ^{15}N, Polyolefin coated urea, Rice.

The no-tillage (NT) transplanting system of rice with a single basal application of sigmoid type of controlled availability fertilizer (CAF) in a nursery box had been practiced. However, in this system, slower release of N from sigmoid type of polyolefin coated urea (POCU s)-100 and lower N mineralization from no-tilled soil cause slower growth of rice at the initial growth stage, and thus may reduce the grain yield on the Pacific Ocean side of the Tohoku district. Consequently, farmers are not so interested in this method for their rice production

Part of this work was presented at the annual meeting of the Japanese Society of Soil Science and Plant Nutrition in April, 1996

because of the slower growth of rice at the initial growing stage. Kaneta *et al.* (1) and Phillips *et al.* (2) reported that the native soil nitrogen of the NT system has a lower mineralization rate as compared to conventional tillage. Therefore, the improvement of the initial growth of rice in the NT transplanting system is very important to overcome the above problems. The objective of this experiment is to improve the initial growth of rice in no-tillage transplanting system in two paddy soils.

Materials and Methods

Field experiments were conducted during 1995-1996 on clayey alluvial soil at Furukawa (flat area) and Andisol at Kawatabi (hilly area), Miyagi prefecture, Japan. Rice (*Oryza sativa.* L. cv. Hitomebore) was used as a test crop. The clay alluvial soil and Andisol is classified as fine textured strong glay soil and humic wet Andosols, respectively (Classification of Cultivated Soils in Japan (3)). The texture of clay alluvial soil and Andisol was light clay and clay loam, respectively. Three treatments NT with straw (NTS), NTS 10 and NTS 30 were tested in three plots. Sigmoid type of POCU (Polyolefin Coated Urea) s100, as a source of CAF was used as a single basal application of total nitrogen of 70 kg N ha^{-1} in a nursery box at the time of sowing for NTS treatments, and the rate of these fertilizer was 50 kg N ha^{-1} for NTS 10 and NTS 30 treatments. Linear type of POCU-10 or POCU-30 at the rate of 20 kg N/ha was also broadcasted by hand on the surface of the seedling box just before transplanting for NTS 10 and NTS 30 treatments. No-tilled fields were sprayed with 4.1 L a.i. ha^{-1} of Isopropyl ammonium=N (phosphomethyl) glycinide at 20 days before transplanting. The experimental fields were submerged in water 10 days before transplanting. Rice straw was scattered on the surface of soil. Planting density was 24.2 hills m^{-2} (30 cm $\times$ 13.75 cm).

Linear type of ^{15}N polyolefin coated urea POCU 10 and 30 (3.21 atom % of ^{15}N POCU-10 and 3.23 atom % of ^{15}N POCU-30) were used for determining the efficiency of these fertilizers. Three micro plots (30 cm $\times$ 30 cm) were used for each fertillizer, and each micro plot contained two hills of rice. Five seedlings were transplanted per hill.

Leaf color of completely developed uppermost leaf of the main culm of the 9 selected hills was measured by chlorophyll meter (Minolta Co. Model SPAD-502). Number of tillers, and yield components of 9 selected hills in each plots were recorded. Grain yields of 35 hills of each plot were recorded at harvest. Nitrogen content of POCUs 100 was measured by the spectrophotometric method of Watt and Chrisp (4). At young panicle initiation stage (12th July) and at harvest, six averaged hills from each plots per treatment were sampled and separated into leaf blade, leaf sheath and stem, and panicles. Each part was oven-dried at 70°C for 48 h, and weighed Total N of each part of plant (leaf blade, leaf sheath and stem, and panicles) was determined by the method of Bremner and Malvaney (5). ^{15}N content of samples were analyzed by using JASCO ^{15}N analyzer (MODEL N-151).

Standard deviation and least significant difference (LSD) was used to determine significant differences among treatment. Statistical significance was accepted at 5% level.

Results and discussion

Cumulative N release

The cumulative N releases from the CAF (POCU s100 and POCU-10 or -30) with time during the raising of seedlings and throughout the growing period at Kawatabd, in 1995 and 1996 are shown in Fig. 1. The cumulative N releases from the POCU s100 were only 3.5% and 3.8% during the nursery stage in 1995 and 1996, respectively. After transplanting, the rate of N release from the POCU s100 gradually increased throughout the tillering stage and the young panicle formation stage. However, the releases of N from POCU s100 after 30 days of transplanting were only 6.5% and 25% in 1995 and 1996, respectively. Therefore, it is very difficult to supply the necessary amount of N to rice at the early growing

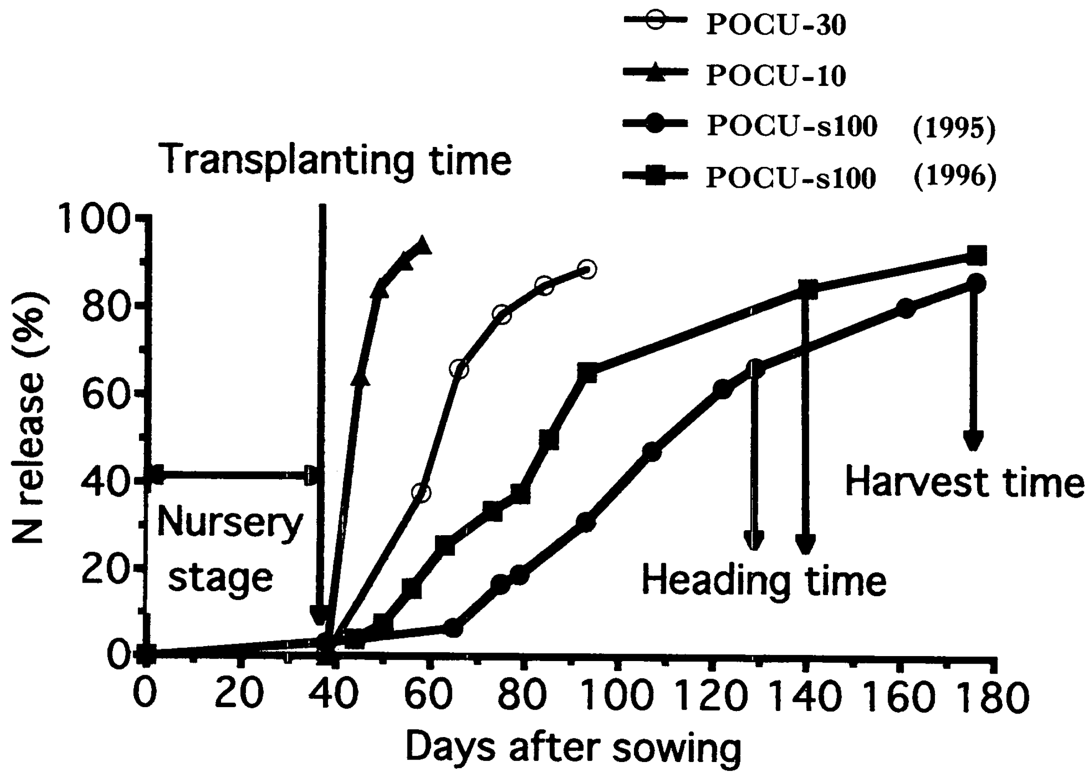

FIG. 1. Cumulative nitrogen release from POCU

stage by using just POCU s100. However, the releases of N from POCU s100 after transplanting in 1996 was faster than those in 1995, and might have an effect on the growth of rice. On the contrary, the N releases from POCU-10 after 6 days of transplanting were 64 and 52% in 1995 and 1996, respectively. Finally, after 19 days of transplanting, these were about 97% in both years. On the other hand, the cumulative N releases from the POCU-30 at 6 and 19 days of transplanting were 19% and 18%, and 50% and 49% in 1995 and 1996, respectively. This N release from POCU continued up to 60 days after transplanting, which might have an effect on the dry matter yield, N uptake and growth of the rice plant.

Leaf color value

The effects of the linear type of POCU-10 or -30 on leaf color value of rice plants at the early growth stage in 1995 and 1996 are shown in Table 1. The leaf color values of rice plants at the early growth stage in NTS 10 and NTS 30 treatments were significantly greater than those of NTS treatments in both types of soil, reflecting the releasing characteristics of linear type of POCU-10 and POCU-30, which may affect the number of tillers per unit area.

Number of tillers per m^2

The effects of the linear type of POCU-10 or -30 on number of tillers/m^2 of rice plants at the early growth stage in 1995 and 1996 are shown in Table 2. In 1995, it was found that the rice plant in NTS 10 and NTS 30 treatments of light clay soil produced a larger number of tillers per m^2 than that in NTS treatments. In 1996, there was no clear difference in the number of tillers per m^2 among the treatments because of faster release of nitrogen from POCUs100. Similar results were obtained in clay loam soil.

From these results, it was clear that the linear type of POCU-10 or POCU-30 in combination with POCU s100 increased the number of tillers/m^2 compared to that of POCUs100 only. Although, this effect was more prominent in 1995 than that in 1996 in all types of soil. Normally, the nitrogen release from POCUs100 depends on soil temperature. It seems that the soil temperature during the nursery stage was larger in 1996 than that in 1995. Therefore, the N release from POCUs100 in 1996 after transplanting was faster than that of N release from POCU in 1995. For these reason, it seems that the faster release of N from POCUs100 may compensate the requirement of N at the initial growth stage of rice after transplanting in 1996.

Dry matter production

The total dry matter of the rice plant at young panicle initiation stage in 1995 and 1996 is shown in Fig. 2. In 1995, the dry matter yields of the rice plants in NTS 10 and NTS 30 treatments were significantly greater than those in NTS

TABLE 1. *Effects of linear type of POCU on leaf color value of rice*

Light clay (Alluvial soil)										
Treatments	SPAD value									
	Date									
	24th May		6th June		20th June		26th June		11th July	
	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996
NTS	32.5 (±0.9)	24.4 (±1.1)	30.4 (±2.1)	35.4 (±1.9)	37.9 (±1.3)	46.1 (±0.8)	42.9 (±1.1)	45.0 (±1.8)	40.0 (±1.6)	41.3 (±2.1)
NTS 10	30.9 (±1.2)	25.5 (±2.6)	34.8 (±0.7)	36.7 (±0.8)	36.7 (±1.2)	48.7 (±0.9)	43.5 (±0.8)	47.0 (±0.2)	40.8 (±1.2)	41.3 (±0.3)
NTS 30	30.7 (±1.5)	24.4 (±1.6)	35.0 (±1.2)	35.3 (±0.4)	35.3 (±1.2)	48.1 (±0.7)	45.7 (±0.7)	48.1 (±0.9)	40.5 (±2.9)	42.5 (±1.6)

Clayloam (Andisol)										
Treatments	SPAD value									
	Date									
	24th May		6th June		19th June		1st June		10th July	
	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996
NTS	29.7 (±2.4)	23.0 (±1.5)	29.7 (±1.1)	32.3 (±1.9)	38.0 (±0.5)	44.7 (±0.8)	39.5 (±0.8)	41.8 (±1.8)	40.2 (±0.4)	40.3 (±2.1)
NTS 10	27.8 (±1.1)	25.0 (±1.4)	32.2 (±1.1)	35.6 (±0.8)	39.7 (±1.7)	45.4 (±0.9)	39.8 (±1.2)	42.9 (±0.2)	40.2 (±0.7)	40.6 (±0.3)
NST 30	27.8 (±1.4)	24.0 (±0.9)	33.3 (±1.3)	33.8 (±0.4)	41.4 (±1.2)	45.4 (±0.7)	40.7 (±1.0)	42.7 (±0.9)	41.1 (±0.8)	41.0 (±1.6)

NTS: No-tillage with rice straw
Numbers in parenthesis are standard deviation

TABLE 2. *Effects of linear type of POCU on number of tillers*

Light clay (Alluvial Soil)								
Treatments	Number of tillers per m²							
	Date							
	6th June		20th June		26th June		11th July	
NTS	113 (±13.1)	145 (±12.7)	221 (±20.2)	338 (±27.8)	377 (±15.2)	396 (±20.4)	465 (±43.2)	558 (±35.2)
NTS 10	111 (± 8.2)	149 (± 5.8)	307 (±14.3)	345 (±16.7)	440 (±12.3)	400 (±24.2)	480 (±28.5)	559 (±43.2)
NTS 30	114 (±10.5)	130 (±11.2)	332 (±15.3)	312 (±21.5)	434 (±14.0)	383 (±18.2)	533 (±26.5)	555 (±26.2)

Clay loam (Andisol)								
Treatments	Number of tillers per m²							
	Date							
	6th June		19th June		1st June		10th July	
NTS	115 (±15.6)	107 (±19.7)	207 (±18.1)	286 (±23.5)	394 (±16.5)	407 (±18.2)	443 (±24.2)	587 (±30.2)
NTS 10	121 (±12.2)	95 (±14.7)	242 (±15.2)	276 (±26.5)	415 (±18.6)	416 (±20.0)	465 (±19.5)	598 (±28.2)
NTS 30	120 (±13.5)	96 (±20.6)	302 (±15.3)	285 (±16.2)	446 (±15.0)	394 (±15.6)	458 (±21.0)	595 (±26.5)

NTS: No-tillage with rice straw
Numbers in parenthesis are standard deviation

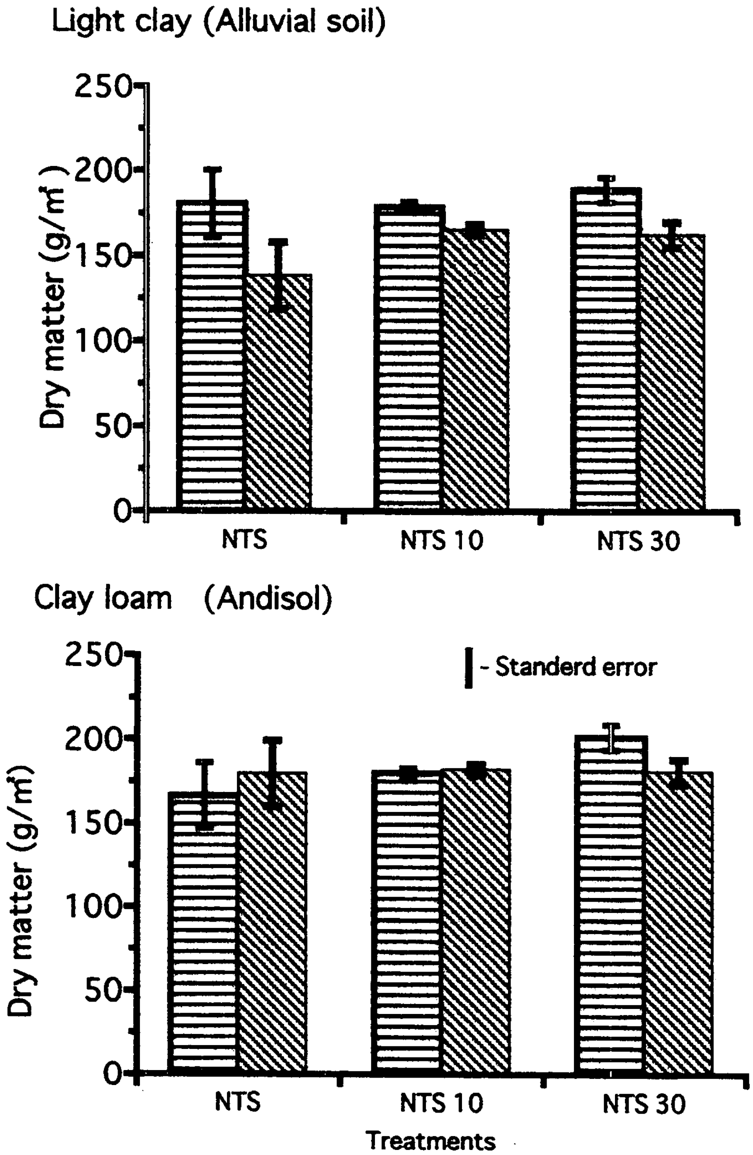

FIG. 2. Effects of linear type of POCU in combination with POCU s100 on dry matter yield at young panicle initiation stage. NTS: No-tillage with rice straw
1995 ▤, 1996 ▧

treatment in both types of soils. In 1996, there was no significant difference of dry matter yield among the treatments in light clay soil. However, in clay loam soil, the day matter yields of NTS 10 and NTS 30 were significantly greater than those of NTS treatments.

Recovery of controlled availability fertilizer

Recoveries of ^{15}N POCU-10 and POCU-30 in NTS treatments are shown in Fig. 3. The N recoveries from the linear type of POCU-10 and POCU-30 at the

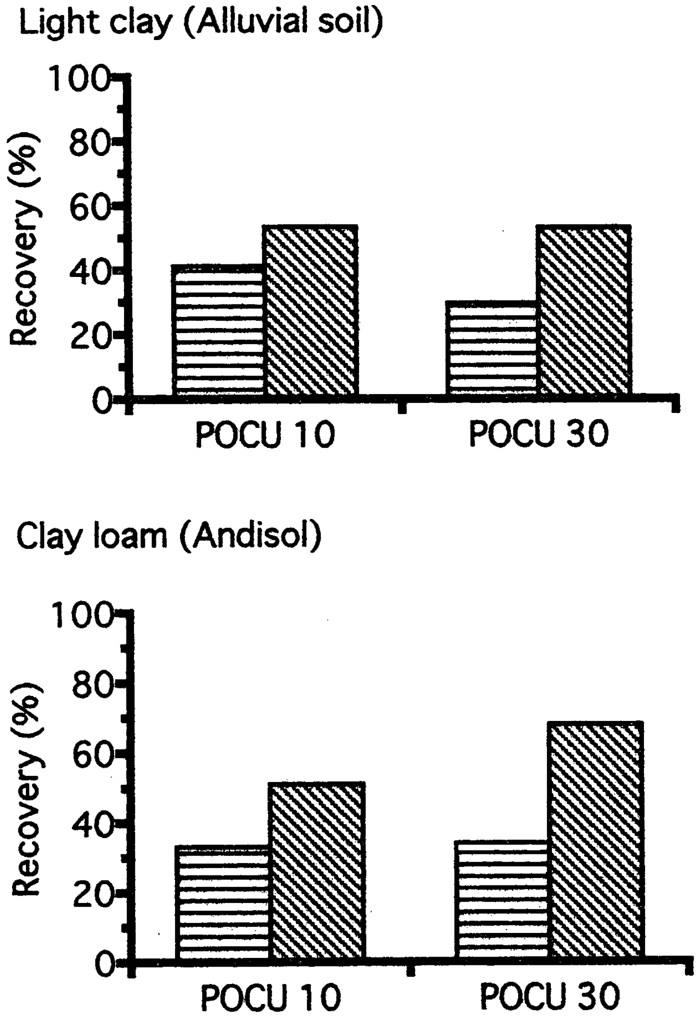

FIG. 3. Recoveries of linear type of polyolefin Coated Urea by rice plants
POCU 10 and 30-Linear type of Polyolefin Coated Urea
▤ At young panicle initiation stage ▧ At harvest time

young panicle formation stage were 41% and 30% and 33% and 34%, in light clay soil and clay loam soil, respectively. At the harvest time, the N recoveries from the linear type of POCU-10 and POCU-30 were 53% and 53% and 51% and 68% in light clay soil and in clay loam soil, respectively. From the Fig. 1, it was found that almost all of the nitrogen of POCU-10 or -30 was released by the panicle initiation stage. However, the N recoveries from the linear type of POCU-10 and POCU-30 at these stages were about 30-40%, and the N recoveries from the linear type of POCU 10 and POCU-30 were increased by the harvesting stage. It seems that the rapid decomposition of straw in the NT system may cause temporary immobilization of fertilizer N by encouraging the microbial activity at the early growth stage. However, in the long run, there will be an increase in the contents of soil ^{15}N due to mineralization of ^{15}N fixed by microorganisms.

Grain yield and yield components

Effects of linear types of POCU on brown rice yields are shown in Fig. 4. In 1995, the highest brown rice yield was obtained from NTS 30 treatment in light clay soil (5.73 Mg/ha), which is statistically the same as the yield of NTS and NTS 10 treatments (5.59 and 5.62 Mg/ha). In 1996, the grain yields among the treatments were not statistically different. However, the highest yield was obtained from NTS treatment (6.37 Mg/ha).

In clay loam soil, in 1995, the highest grain yield was obtained in NTS 30 treatments (5.82 Mg/ha). However, it is statistically similar to that of NTS treatment. The grain yields of NTS 10 (4.82 Mg/ha) treatment were statistically

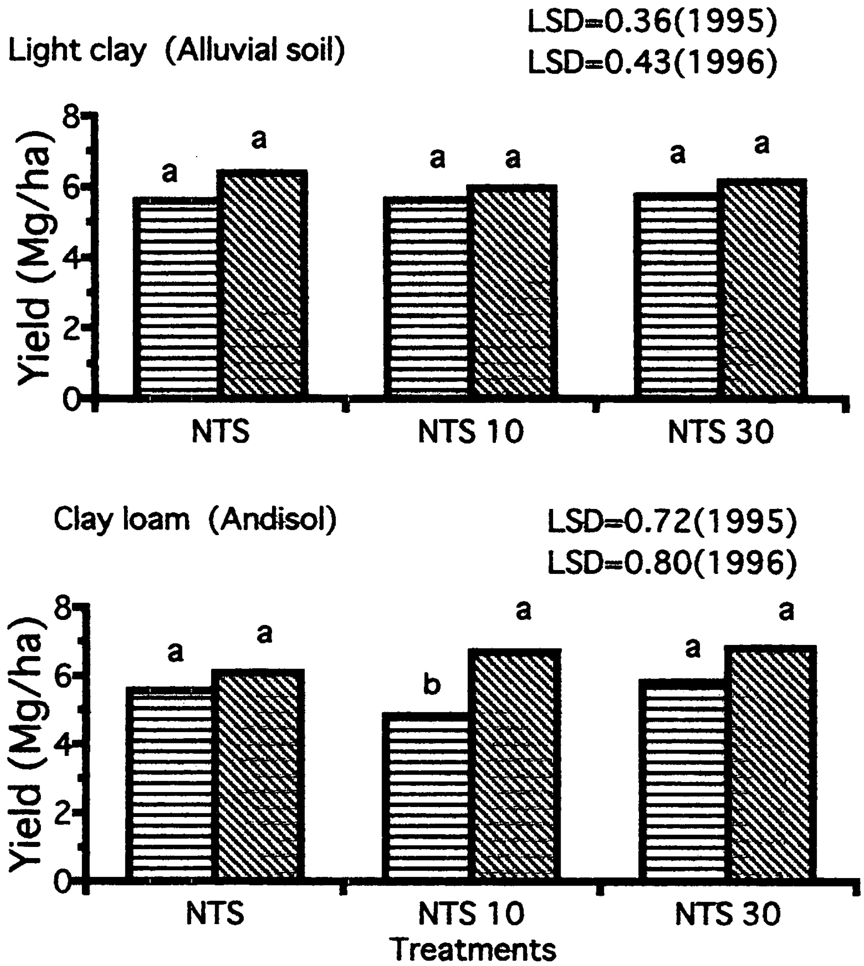

FIG. 4. Effects of linear type of POCU in combination with POCU s100 on yield of brown rice
NTS : No-tillage with rice straw ; POCU : Polyolefin Coated Urea.
1995 ▤, 1996 ▧

TABLE 3. *Effects of linear type of POCU on yield components of rice*

Soil types	Treatments	Number of panicles/m²		Number of spikelets/ panicle		Number of spikelets/m² (×1,000)		1,000 kernel weight (g)		% of ripened grains/ panicle	
		1995	1996	1995	1996	1995	1996	1995	1996	1995	1996
Light clay (Alluvial soil)	NTS	441	493	67	64	29.6	31.6	23.1	23.5	81.9	85.9
	NTS 10	477	456	61	68	29.1	31.0	23.2	23.4	83.3	85.7
	NTS 30	513	483	62	69	31.8	33.3	23.3	23.3	77.3	84
	LSD at 5%	—	—	—	—	—	—	—	—	4.3	—
Clay loam (Andisol)	NTS	440	470	66	68	29.0	32.0	23.7	23.4	79.6	81.3
	NTS 10	413	500	61	67	25.2	33.5	23.8	23.5	80.2	84.5
	NTS 30	439	459	65	73	28.5	33.5	23.8	23.7	85.6	85.3
	LSD at 5%	—	104	—	—	—	—	—	—	—	—

NTS : No-tillage with rice straw
LSD : Least Significant Difference

lower than those of other treatments. In 1996, the brown rice yields of NTS 10 and NTS 30 treatments were higher than those of NTS treatments. However, there were no significant differences of brown rice yields among the treatments.

The effects of the linear type of POCU-10 or -30 on yield components in 1995 and 1996 are shown in Table 3. There was no significant difference in the number of productive tillers per m² at harvest time among the treatments. In light clay soil, the number of spikelets per m² in 1995 and 1996 among the treatments was not statistically significant. However, the numbers of spikelets per m² in NTS 30 were greater than those of NTS 10 and NTS treatments. There were no definite effects of the linear type of POCU-10 and -30 on thousand kernel weight. The percentage of ripened grains per panicle was statistically significant only in 1995. However, there were no definite effects of the linear type of POCU-10 and -30 on percentage of ripened grains per panicle.

In clay loam soil, the linear type of POCU-30 in combination with POCUs100 increases the number of spikelets per m² more than those of the POCU s100. The thousand kernel weight in NTS 10 and NTS 30 were almost the same as NTS treatments. The percentage of ripended grains per panicle in clay loam soil were also similar among the treatment.

Overall, the numbers of spikelets per m² for NTS 10 treatment were lower than those of NTS 30 treatments, which might have an effect on brown rice yield.

It was found that the release of N from POCU-10 repidly increased at the early growth stage. It seems that the rice plant can readily absorb the necessary N at the early growth stage, which might increase the leaf color value, number of tillers per unit area and dry matter yield. The release of N from POCU-30 continued up to the young panicle formation stage. As a result, the number of spikelets per unit area for POCU-30 treatments were increased and ultimately increased grain yield.

From the above results, it may be concluded that the plots applied with POCU-30 tended to increase brown rice yield, but that of POCU-10 reduced grain yield because of a fewer number of spikelets per m^2. This may be improved by changing the ratio of POCU-10 to POCUs100 or by top dressing of nitrogen fertilizer at the late growing stage.

From the above results, it is concluded that the application of the linear type of POCU-10 or -30 in combination with POCUs100 in the no-tillage transplanting system is highly effective for initial growth or rice.

References

1) Kaneta, Y., Awasaki, H. and Murai, Y. The non-tillage rice culture by single application of fertilizer in a nursery box with controlled release fertilizer. *Jpn J. Soil Sci. Plant Nutr.*, **65**, 385-391 (1994). (in Japanese with English summary).

2) Phillips, R.E., Blevins, R.L., Thomas, G.W., Frye, W.W. and Phillips, S.H. No-tillage agriculture. Science **208**, 1108-1113 (1980)

3) Classification of Cultivated Soils in Japan, 2nd approximation. Classification Committee of Cultivated Soils. p. 75 (in Japanese) (1983).

4) Watt, G.W. and Chrisp, J.D. Spectrophotometric method for determination of urea. *Ana. Chemistry* **26**, 452-453 (1954).

5) Bremner, J.M. and Mulvaney, C.S. Total nitrogen, p. 595-622, in Page *et al.*, (eds.) Methods of Soil Analysis, part-2, Chemical and Mineralogical Properties, 2nd ed. Am. Soc. Agro. Madison WI. (1982).