Rice Yield-Decrease Resulting from the Continuation of Direct-Sowing Culture*

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Direct-sowing culture of lowland rice is being practiced in several areas of warm regions in Japan. This method has been introduced with a purpose of saving the labor of transplanting, facilitating the farm mechanization or providing a countermeasure for insufficient irrigation water at transplanting.

However, it has been recognized in some areas in the Kanto district that the grain yield decreases from year to year when the direct-sowing culture is adopted continuously on the same paddy fields. For the direct-sowing culture in this district, rice is sown directly on dry fields during a period from late April to early June, and submerged about 40–50 days after seeding when the rice plants are at the 6–7 leaf stage.

The yield-decrease caused by the continuation of direct-sowing culture was already reported by Koshizuka[2] and Isayama et al.[1]. They suggested that this phenomenon used to occur on well-drained paddy fields rather than on ill-drained ones. The present author has carried out several experiments to clarify the cause of this phenomenon and to find out countermeasures for it.

Actual status of the occurrence in farmer's fields

A field survey conducted by the author in the Kanto district revealed that about one thirds of farmers who adopted the direct-sowing culture of rice recognized the yield-decrease caused by repeated practice of direct-sowing.

These farmers who recognized the yield-decrease are characterized by the fact that they practiced the direct-sowing culture on well-drained paddy fields, with denser seeding rates, heavier fertilization and more frequent nitrogen topdressing as compared with other farmers. On the other hand, these farmers apply less amount of organic substances such as compost or rice straw to their paddy fields than other farmers do.

Effect of continued direct-sowing culture on growth and yield of rice

A field experiment was carried out on a well-drained paddy field to know the effect of number of years of continued practice of direct-sowing culture in relation to different nitrogen application levels.

Plant growth and grain yields as related to the number of years of continued direct-sowing culture and fertilizer application levels are given in Figs. 1 and 2, respectively. The result indicates a general tendency that more yield-decrease occurs as the direct-sowing culture is continued for more years. This tendency is more apparent in plots without nitrogen application than in plots with heavy nitrogen application.

However, it can be noticed by detailed comparisons of growth and yield in each plot that the greatest decrease in growth and yield occurred in the second year of direct-sowing culture, whereas the decreases in following

* This study was made when the author belonged to the Central Agricultural Experiment Station, Konosu.

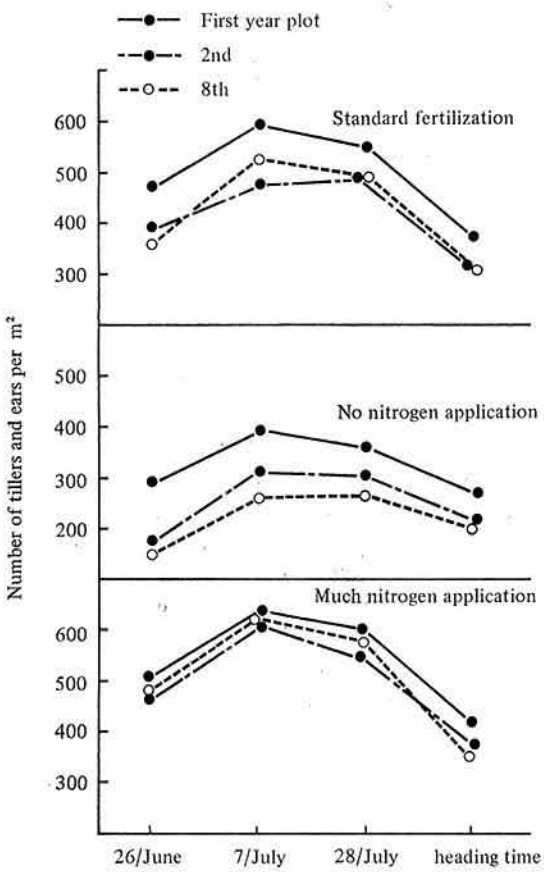

Fig. 1. Effect of continued direct-sowing culture on growth of rice plants at different nitrogen application levels (In alluvial paddy fields, 1969)

years were very small, except in the no nitrogen application plots.

Inorganic nitrogen in soil

Contents and forms of inorganic nitrogen in paddy field soils, which were kept unflooded after the seeding in an initial growing stage are shown in Table 1. Amount and form of inorganic nitrogen in the soil at the first year of direct-sowing culture were apparently different from those at the second year and the 8th year.

In the first year plot, the content of total inorganic nitrogen was higher than those in the second year and 8th year plots although that of nitrate nitrogen was lower. However,

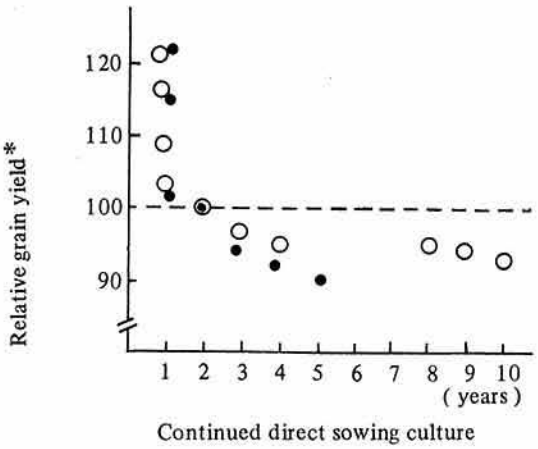

Fig. 2. Relationship between rice yield and number of years of continued direct-sowing culture. (Standard fertilization plot, 1968—1971)
○···Alluvial paddy soil
●···Diluvial paddy soil
*···Grain yields expressed by taking the yield of the second year of direct-sowing culture as 100.

such remarkable differences in soil inorganic nitrogen were not recognized between the second year plot and the 8th year plot.

The silica content in rice plants was also higher in the first year plot than in other plots, while there was no apparent difference between the second year plot and 8th year plot.

These results indicate that there is an increased availability of nitrogen and silica in soil in the first year plot. It can be suggested that these factors may be responsible for the better growth and yield of rice in the first year of direct-sowing culture.

Nitrogen-supplying potential of soil

Both the contents of total nitrogen and total carbon in soil were decreased from year to year according to the continuation of direct-sowing culture as shown in Fig. 3.

It was also found that the ammonification of soil organic nitrogen, as expressed by the "effect of soil-temperature rising" and the "soil-drying effect" on ammonification in

Table 1. Amount of inorganic nitrogen in soil during the initial growing stage, when the soil was kept unflooded after sowing

Fertilization	continuation of direct sowing (years)	Inorganic nitrogen in the soil (mg/100 g dry soil) 13th/June NO_3-N	NH_4-N	Total	27th/June NO_3-N	NH_4-N	Total	Ratio of nitrate nitrogen to total inorganic nitrogen (%) 13th/June	27th/June
Standard	1	5.3	9.0	14.3	1.2	3.2	4.4	37	27
	2	8.5	3.3	11.8	3.3	0.6	3.9	72	85
	8	10.0	2.0	12.0	3.7	0.5	4.2	83	88
No nitrogen	1	0.2	1.4	1.6	0.3	0.3	0.6	13	50
	2	0.6	0.8	1.4	0.6	0.2	0.8	43	75
	8	0.5	0.7	1.2	0.5	0.2	0.7	42	71
Much nitrogen	1	—	—	—	3.2	8.2	11.4	—	28
	2	—	—	—	4.8	3.0	7.8	—	62
	8	—	—	—	4.3	2.1	6.4	—	67

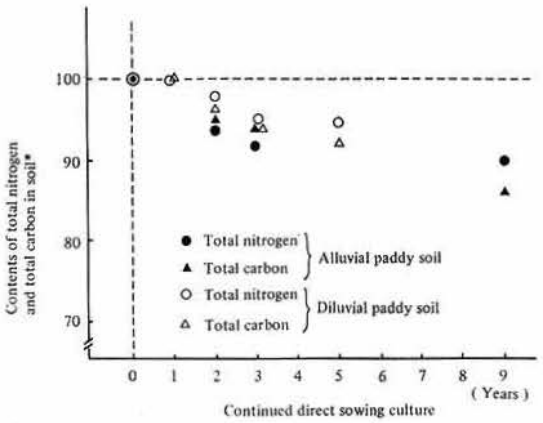

Fig. 3. Effect of continued direct-sowing culture on total nitrogen and total carbon contents of soil.
* Contents expressed by taking the contents in "no direct-sowing plot" as 100.

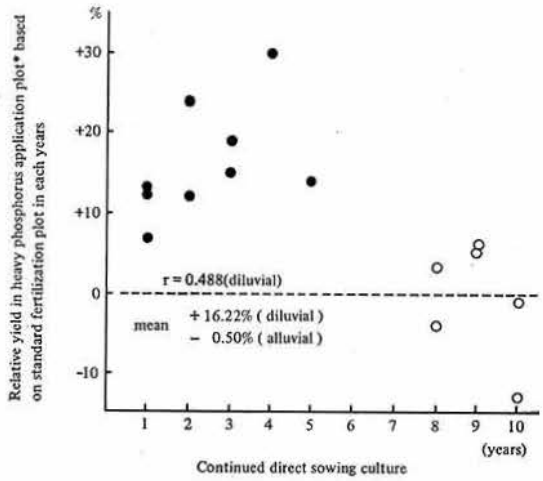

Fig. 4. Relationship between the effect of heavy phosphorus application on rice yields and the continuation of direct sowing culture.
○···Alluvial paddy soil
●···Diluvial paddy soil
*···Yield in heavy phosphorus application plot as expressed by the difference from that of standard fertilization plot in each year.

incubation tests, was decreased from year to year as the direct-sowing rice culture continued.

It can be suggested, therefore, that the continuation of direct-sowing culture results in the decrease in easily decomposable organic matter of soil, and hence the decrease in nitrogen-supplying potential of soil, which causes decreased yields of rice.

Phosphorus nutrition of rice plants

The rice yield-decrease resulting from the continuation of direct-sowing culture could be observed more apparently in diluvial paddy soil than in alluvial.

Contents of available phosphorus in soil and phosphorus contents in rice plants were lower in diluvial paddy field than in alluvial.

Heavy phosphorus application gave a

remarkably good effect to growth and yield of direct sowing rice in diluvial paddy soil, but not in alluvial. This effect observed in the diluvial paddy soil was more apparent in the long term direct-sowing plot than in short term one, as shown in Fig. 4.

The yield-decrease which frequently occurs in well-drained diluvial paddy fields due to continued direct-sowing culture can be attributed, if not fully but at least partly, to a limited phosphorus absorption of plants, because the phosphorus availability is low in diluvial soils.

Countermeasures to the rice yield-decrease due to continued direct sowing culture

1) Improvement of fertilization

Increased rates of nitrogen application or more frequent topdressing of nitrogen are effective to promote the growth of rice plants and to prevent the yield-decrease in continued direct-sowing culture.

An increased phosphorus application is also effective in preventing the yield-decrease especially in paddy fields low in available phosphorus content of soil[4].

2) Increase of nitrogen-supply potential of soil

Supply of organic substances like compost or rice straw is effective in preventing the lowering of nitrogen-supplying potential which occurs by continued direct-sowing culture[5].

3) Improvement of cultural system

The alternation of direct-sowing culture and transplanting culture was tested[6], as a possible countermeasure.

When the continuation of direct-sowing culture, which lasted for more than 10 years, was interrupted by 2–3 years of transplanting culture, the subsequent direct-sowing culture gave better growth and yield than the continuous direct-sowing culture. This effect was more apparent in well-drained paddy field than in ill-drained one. Thus, the rotation of direct-sowing and transplanting cultures proved to be an effective measure in preventing yield-decrease.

Moreover, this rotation system is expected to be effective in increasing land utilization of paddy field with the combination of winter crops.

Namely, the direct-sowing culture of rice can give more advantage to winter crops (wheat, barley, vegetables and grasses) than the transplanting culture, because it offers a porous structure of soil favorable for drainage, harrowing and growth of winter crops.

On the other hand, the transplanting culture is suitable to following winter crops, because rice plants are grown in nurseries before harvesting winter crops.

Thus, the advantage of direct-sowing and transplanting culture can be utilized alternately in a system of 3 croppings in 2 years.

References

1) Isayama, E. & Ogawa, S.: Future vision of direct sowing culture of paddy rice in Saitama Prefecture. *Nogyo-Gijyutsu*, 26, 69–72 (1971) [In Japanese].
2) Koshizuka, T.: Why the rice yield decrease when they are planted continually in direct *sowing culture. Noen.*, 43, 475–487, 1835–1838 (1968) [In Japanese].
3) Uemura, Y., Miyasaka, A. & Moriya, M.: Studies on the causes of rice yield decrease resulting from continual direct sowing culture. I. Effects of continual direct sowing culture on the movement of inorganic nitrogen in the soil and on the growth and yield of rice. *Proc. Crop. Sci. Soc. Japan*, 40, 449–454 (1971) [In Japanese with English summary].
4) Uemura, Y. & Miyasaka, A.: Studies on the causes of rice yield decrease resulting from continual direct sowing culture. 2. In relation to phosphorus nutrition. *Proc. Crop Sci. Soc. Japan*, 42, 116–122 (1973) [In Japanese with English summary].
5) Uemura, Y. & Miyasaka, A.: Studies on the causes of rice yield decrease resulting from continual direct sowing culture. 3. In relation to the nitrogen supplying potentiality of soil. *Proc. Crop Sci. Soc. Japan*, 43, 174–179 (1974) [In Japanese with English summary].
6) Uemura, Y. & Miyasaka, A.: The alternation of direct sowing and transplanting as a counterplan for the rice yield decrease due to continuance of direct sowing culture. *Proc. Corp Sci. Soc. Japan*, 46, 414–422 (1977) [In Japanese with English summary].