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Effects of twice harvesting on total dry matter yield of rice

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Abstract

We examined the effect of twice harvesting of forage rice with the first harvest at the full heading stage on total dry matter yield in the cultivars Taporuri, Mohretsu, and Hinohikari and in line Saikaishi 253 in southwestern Japan. Taporuri produced the highest total dry matter yield, with a value 60% higher than that of Hinohikari. The first crop of Taporuri had a longer duration of vegetative growth than those of Mohretsu and Hinohikari, and had the highest dry matter yield because of its greater weight per tiller than Hinohikari and its more tillers per square meter than Saikaishi 253, which had a similar duration of vegetative growth. The second crops of Mohretsu, Taporuri, and Saikaishi 253 had longer vegetative growth and higher dry matter yields than Hinohikari. Dry matter yields of both crops were closely related to the duration of vegetative growth and the weight per tiller, but not to tillers per square meter. These results suggest that cultivars with a long duration of vegetative growth, high weight per tiller, and adequate tillers per square meter can produce high dry matter yield in both crops. There was a significant interaction ($P < 0.05$) in total dry matter yield between cultivar or line and cultivation type. The total dry matter yield of Taporuri in twice harvesting was about 10% higher than that in once harvesting, whereas that of Hinohikari was about 10% lower. The suitability for twice harvesting ([total dry matter yield in twice harvesting]/[total dry matter yield in once harvesting]) was significantly positively correlated ($r = 0.875$) with the increase in dry weight before the full heading stage, but significantly negatively correlated ($r = -0.903$) with the increase in dry weight between full heading and the yellow ripe stage. Thus, cultivars with a high increase in dry weight before full heading appear to be more suitable for twice harvesting than those with a high increase between full heading and the yellow ripe stage. In addition, our study showed that twice harvesting can prevent lodging in Taporuri, thereby increasing the suitability of this cultivar as a forage rice. Our results suggest that twice harvesting can be performed in southwestern Japan and warmer regions.

Keywords: Dry matter yield; Forage rice; *Oryza sativa* L.; Ratoon cropping; Rice; Twice harvesting

1. Introduction

The production of forage rice (*Oryza sativa* L.) is increasing in Japan owing to the improved control of rice grain production and the increasing demand for self-supporting forage (Sakai et al., 2003). Recently, several studies have reported techniques for the cultivation of forage rice (Yamaguchi and Matsumura, 2004; Kobayashi et al., 2006a,b). Because forage rice must have low production costs, high dry matter yield is essential. Although forage rice cultivars have been developed (Sakai et al., 2003), their dry matter yield tends to be very low in production areas. In addition, compared with cultivars that have a low dry matter yield, those with a high dry matter yield, such as the rice cultivar Taporuri often lodge during ripening after the heading stage. Since lodging reduces grain yield as a result of self-shading and a reduction in canopy photosynthesis (Setter et al., 1997), techniques are needed that will permit the cultivation of forage rice without lodging.

Twice harvesting (also called ratoon cropping) is the practice of obtaining a second crop from the stubble of a first crop (Jones and Snyder, 1987). Twice harvesting systems have been used in rice cultivation in the United States (Evatt and Beachell, 1960), Swaziland (Evans, 1957), India (Gupta and Mitra, 1948), Thailand and Taiwan (Iso, 1954), the Philippines (Parago, 1963), and China (Yang et al., 1958). Several studies have reported a high grain yield in the second crop in tropical areas (Chauhan et al., 1985). Reddy et al. (1979) reported that grain yield in the second crop of Intan in India was 159% of the yield of the first crop. Prashar (1970) reported that grain yield in the second crop of IR8 in Ethiopia was 8.7 t ha^{-1}. However, Yoshida and Hozono (1995) reported that grain yield in the second crop with Koshihikari and Kinuhikari in temperate

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southwestern Japan, was only about 30% of the yield of the first crop. In short, the potential grain yield in the second crop in tropical areas appears to be higher than that in temperate areas.

Several reports noted a correlation between grain yield, its components, and growth duration (Chauhan et al., 1985). Zandstra and Samson (1979) reported a significant correlation between grain yield and the number of tillers per square meter in the second crop. Haque (1975) reported a significant correlation between grain yield and growth duration of the second crop, whereas Das and Ahmed (1982) found no significant correlation between these traits. However, because these studies investigated food rice, the first harvest occurred at the maturing stage. Only a few reports have examined twice harvesting in which the first harvest occurred at the heading stage (Takahashi and Iida, 1963; Goto and Hoshikawa, 1987). Therefore, rice breeders have not yet determined the most effective selection criteria for forage rice in twice harvesting systems.

The objectives of the present study were thus to determine the effects of twice harvesting of rice in southwestern Japan, with the first harvest occurring at the full heading stage, on total dry matter yield, and to clarify the desirable traits for rice cultivars or lines suitable for use in twice harvesting systems and the differences in lodging between systems with a once harvesting and twice harvesting.

2. Materials and methods

The study was conducted on a Gray Lowland soil at the National Agricultural Research Center for Kyushu Okinawa Region (33°12′N latitude, 130°30′E longitude, 10 m a.s.l.), Chikugo, Fukuoka, Japan, in 2004 and 2005. The previous crop grown in the field was rice, and the same field was used for the experiments in both 2004 and 2005. In 2004, the experiment had a 4 (3 cultivars and 1 line) factorial design, arranged in a randomized complete block with three replicates. In 2005, the experiment had a 4 (3 cultivars and 1 line) × 2 (once and twice harvest cultivation types) factorial design, arranged in a split-plot with three replicates. The three cultivars were Taporuri, which is currently being tested for its suitability as a forage rice in southwestern Japan; Mohretsu, which is normally used as a forage rice in southwestern Japan; and Hinohikari, which is normally used as a food rice in southwestern Japan. The rice line Saikaishi 253 was also studied because it has acceptable performance as a forage rice in southwestern Japan. Mohretsu, Hinohikari, and Saikaishi 253 were developed in Japan, whereas Taporuri was developed in Taiwan. The cultivation types were twice harvesting, in which the first crop was harvested at the full heading stage and the second crop was harvested at the yellow ripe stage, and once harvesting, in which the harvest occurred at the yellow ripe stage (Fig. 1).

Germinated seeds were sown in late March and grown in a greenhouse. They were transplanted to a paddy field in late April. The mean number of fully expanded leaves on the main culm at transplanting was 4.2. The field received 50 kg N ha^{-1}, 22 kg P ha^{-1} and 42 kg K ha^{-1} in the form of chemical fertilizer broadcast by hand 3 days before transplanting, and the fertilizer was incorporated into the soil in such a way as to allow puddling. In 2004, plants received 50 kg N ha^{-1} in the form of ammonium sulfate at the maximum tiller number stage in the first crop and 25 kg N ha^{-1} in the form of ammonium

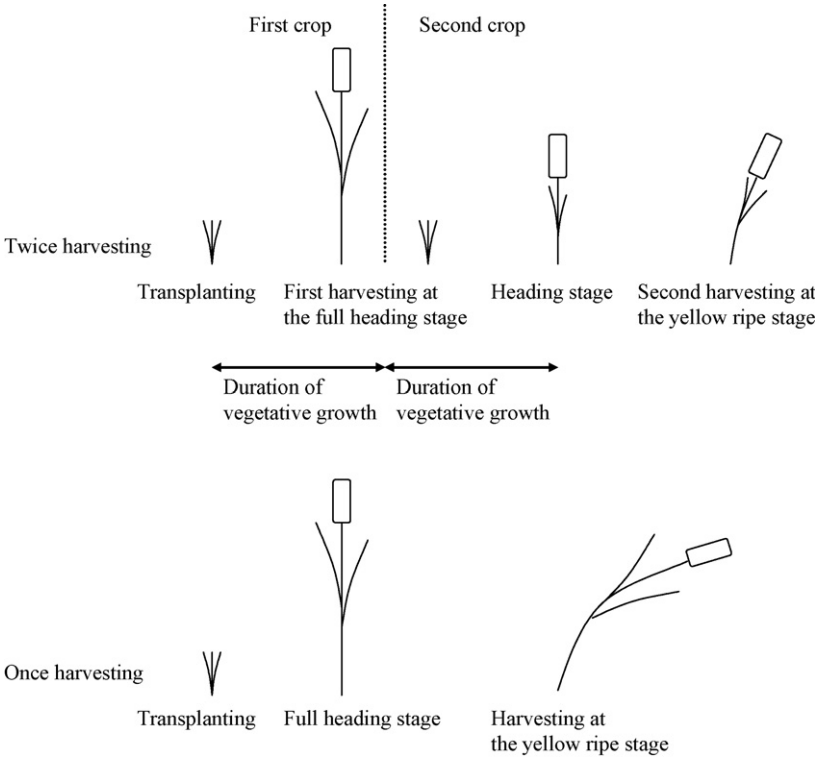

Fig. 1. Illustration of the twice and once harvesting treatments.