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Testing of Rice Stocks for Their Survival of Winter Cold

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Abstract: Rice cultivation is considered to be initiated by vegetative propagation of sprout from wild perennial stocks. To test whether any presently cultivated rice cultivar can survive the winter cold or not, rice stocks of several cultivars including *indica* and *japonica* types were placed in a shallow pool from October to April in 2015–2016 and 2016–2017. During the coldest period of the winter, the bases of the stocks were placed 5–6 cm below the surface of water, where temperatures ranged from 3 ºC to 5 ºC, while the surface was frozen for two or three times and covered with snow for a day. Only one cultivar, Nipponbare, a *japonica* type, survived the winter cold and regenerated sprouts in the end of April or early May. A possibility to develop perennial cultivation of rice or perennial hybrid rice is discussed.

Key words: rice stock; cold; Nipponbare; temperature; winter

It has long been believed that rice cultivation was initiated by seeding an annual type of *indica* subspecies (Chang, 1976). To explain such specific features of rice cultivation as submergence of soil and transplanting, the author proposed an idea that rice could have been domesticated by transplanting of regenerating sprout from perennial stocks which must have served as a primitive nursery bed (Ikehashi, 2007). Thanks to a detailed survey of wild rice throughout the Chinese continent for 1970–1980 (Wu, 1990), it is now clearly confirmed that a set of clones of wild rice exist in shallow swamps in Hunan Province and Jiangxi Province of China at the north latitude of 25º–30º, where the minimum temperature in winter goes down below -5 ºC. It is likely that the initial domestication of rice could have been started by vegetative propagation from such a wild perennial population.

Recently, Huang et al (2012) generated genome sequences from 446 geographically diverse accessions of wild rice species *Oryza rufipogon* as well as from 1 083 cultivated *indica* and *japonica* varieties, and constructed comprehensive maps of rice genome variation. They identified 55 gene sequences which have occurred during domestication. These gene sequences are proved to be commonly derived from a group of *japonica* rice in *O. sativa*, and are conserved among the cultivated rice. Accordingly, they concluded that the first domesticated type is from a specific population of *O. rufipogon* around the middle area of Pearl River basin in southern China, and that the *indica* type of *O. sativa* is subsequently developed from crosses between the *japonica* rice and local wild types as the initial cultivars spread into Southeast and South Asia. Their conclusion verifies the author's earlier view that the *indica* types are developed by sporadic hybridizations between initially domesticated *japonica* types and wild rice in the process of expansion (Ikehashi, 2009).

For further studies of domestication in rice, whether any presently cultivated rice could survive freezing temperature of winter cold or not will be interesting. If such a potential habit of presently cultivated rice is shown, that can be utilized to develop a new method of cultivation which needs no any seeding and transplantation. And a perennial type of hybrid rice can be developed.

MATERIALS AND METHODS

Initially, on 7 October in 2015, rice stocks of several cultivars including *indica* and *japonica* types were transferred to a small water pool after harvesting of their panicles from the experimental farm of Nippon University in Fujisawa, Japan. A small water pool or 'mini-marsh' (Fig. 1) which was initially made to raise small fishes and aquatic plants was used for the present test at the author's home garden near the university (longitude 139º30′ E, latitude 35º20′ N).

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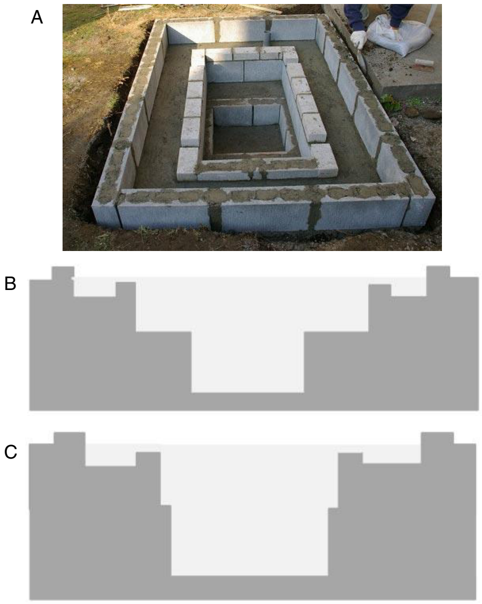

Fig. 1. Framing of an experimental mini-marsh.

A, Overview of the mini-marsh. Depth of shallow water is 13 cm, while medium water level is 33 cm and the deepest water level is 63 cm; B, Longitudinal section of the mini-marsh (180 cm); C, Cross section of the mini-marsh (120 cm).

The tested cultivars were as follows: IR36 (*indica*), Nipponbare (*japonica*), Mei-jiang-tsao (Hsien in Chinese), Nekken 2 [carrier of so-called wide compatibility gene (*WCG*) from Ketan Nangka, an Indonesian cultivar], F_1 hybrid between Nekken 2 and Mei-jiang-tsao.

Each of the stocks were planted in a pot as shown in Fig. 2-A. The diameter of its upper rim was 24 cm. Three grams of synthesized granular fertilizer (Register No. 9628) containing ammonium nitrogen (8%), soluble phosphorous (8%) and soluble potassium (5%) were applied to the bottom soil of each pot. The height of the stocks was about 50 cm (Fig. 2-A). The base of stocks was immersed into the water pool which consisted of three levels of depth as shown in Fig. 1. The deeper part of water pool is made to avoid any effect of sharp change of air temperature. Until the mid of November, the base of stocks were kept under 1–2 cm below the water surface (Fig. 2-A and -B), then to the end of March, the stocks were immersed 5–7 cm below water surface (Fig. 2-C). The level of immersion was adjusted by inserting bricks between the pot and the bottom of pool.

The initial purpose of the experiment is just to investigate survival of rice stocks and to see whether they could regenerate their sprout after winter. Because such a survival of rice stocks was uncertain, plant performances were recorded by photographs, but air and water temperatures were not regularly recorded. In the second testing from 2016 to 2017, the temperature was recorded more often.

RESULTS

Preliminary test from 2015 to 2016

Until the end of November, all the stocks retained some green leaves of tillers which grew after the harvest of panicles. From the beginning of December, the temperature of water (5–7 cm below the surface) ranged from 5 ºC to 10 ºC. The temperature measured at 10:00 am is mainly cited to show the daily temperature. Until the end of December, most of the stocks retained some greenish parts, but that of IR36 nearly withered, while the stock of hybrid showed discoloration but kept strength of straw (Fig. 2-C). The water temperature became lower than 5 ºC from the end of December. The water temperature was mostly around 5 ºC except a few warmer days in early January, and the regenerated green leaves from the

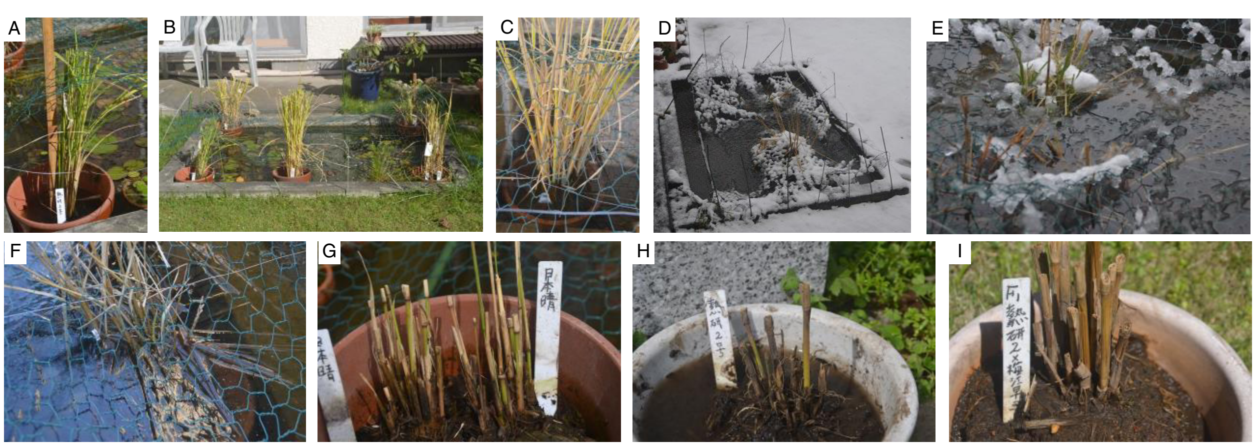

Fig. 2. Performance of rice stocks under cold and snow in 2015–2016.

A and B, Rice stocks removed from the farm of Nippon University to the mini-marsh, which was covered by net to protect fishes against bird on 8 October, 2015; C, The rice stocks of F_1 hybrid gradually discolored, but still kept strength of straw on 7 December, 2015; D, Rice stocks in the mini-marsh were covered with snow and ice on 19 January, 2016; E, Only the *japonica* type kept a green part of stock on 19 January, 2016; F, Surface water of the mini-marsh was frozen and a part of the *japonica* type retained greenish part on 25 January, 2016; G, The *japonica* type Nipponbare regenerated sprouts from basal nodes on 25 April, 2016; H, Nekken 2 showed discolored nodes on 25 April, 2016; I, The basal nodes of F_1 hybrid showed no greenish part on 25 April, 2016.