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Screening for Rice Germplasms with Specially-Elongated Mesocotyl

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Abstract: The lengths of mesocotyl in the seedlings of 84 lowland rice varieties and 12 upland rice varieties were measured following the treatments of daylight and darkness during germination. The elongation of mesocotyl in the varieties tested was inhibited under daylight condition, and the mesocotyl of all the varieties elongated variably under darkness condition. The elongated lengths of the mesocotyl in upland rice, ranging from 0.36 cm to 1.61 cm with an average of 0.81 cm, was obviously longer than those in lowland rice, ranging from 0.12 cm to 1.56 cm with an average of 0.42 cm. Among 14 rice varieties with over 1 cm of mesocotyl length, five belonged to upland rice, and nine to lowland rice. The possible utilization of the elongated-mesocotyl rice germplasm in varietal improvement, direct-seeded planting and seed purity testing were discussed.

Key words: mesocotyl elongation; screening; germplasm; rice

Rice, *Oryza sativa* L., is a monocotyledonous plant of the Gramineae. Rice mesocotyl refers to the structure between radicel and embryo in rice seedlings. The elongation of mesocotyl is related directly to rice seedling emergence from soil. In general, the elongated length of mesocotyl is correlated to the depth of the seeds in soil, but this correlation varies with rice varieties [1]. The studies on rice mesocotyl revealed that mesocotyl elongation is determined primarily by genotype [2,3]. When rice seeds germinate in soil, the mesocotyl elongation directly affects the formation of rice seedlings [4,5]. In the current rice breeding programs, many rice breeders focus mainly on improving rice yield and grain quality, but pay little attention to mesocotyl length, one of the most important agronomic characters for direct seeding. Along with the popularization of 'Efficient Agriculture' in recent years in China, simple and labor-saving technique of direct seeding becomes increasingly attractive. However, few studies were reported on screening and utilization of rice germplasms with the elongated mesocotyl. In the present study, the mesocotyl length of seedlings in different types of rice varieties was compared following different treatments of light regime so as to understand the causes of mesocotyl elongation and to identify the mesocotyl-elongated germplasms. This work may also provide useful information for the breeding and cultivation of rice varieties adapted to direct seeding, and for the testing of seed purity.

MATERIALS AND METHODS

Materials

Ninety-six rice varieties with good agronomic performance and characters were selected and used in the present study including 84 lowland and 12 upland rice varieties.

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Measurement of the length of rice mesocotyl

Treatment One: Seed germination under daylight

Plump, dry and disease-free rice seeds were selected and used in the experiment of seed germination, 10 seeds per variety as a replicate and two replicates for each variety. The methods of seed germination followed the *National Standard of the Rules for Agricultural Seed Testing* (GB/T3543.4-1995) [6]. At 10 days after treatment, germination boxes were moved out, and the length of rice mesocotyl was measured.

Treatment Two: Seed germination under darkness

Five or six layers of absorbent paper was laid at the bottom of germination box, and saturated with distilled water. Ten plump, dry and disease-free rice seeds were selected and lined on the paper as a replicate, two replicates for each variety. All germination boxes were covered with opaque paper, and then transferred into a growth chamber. At 10 days after treatment, the germination boxes were moved out and the length of rice mesocotyl was measured [6-8].

Mean data of the two replicates were used for the analysis of mesocotyl elongation.

RESULTS

Elongation of rice mesocotyl under daylight

The result indicated that the mesocotyl in 96 rice varieties did not elongate under daylight condition. This may be due to the suppression of the genes which mediates the elongation of mesocotyl and the decomposition or passivation of enzymes under daylight condition.

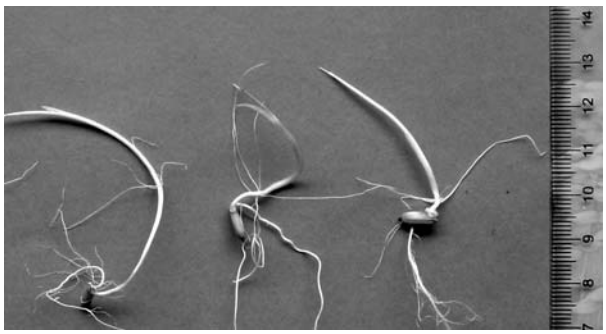

Fig. 1. Elongated lengths of the mesocotyl of rice.

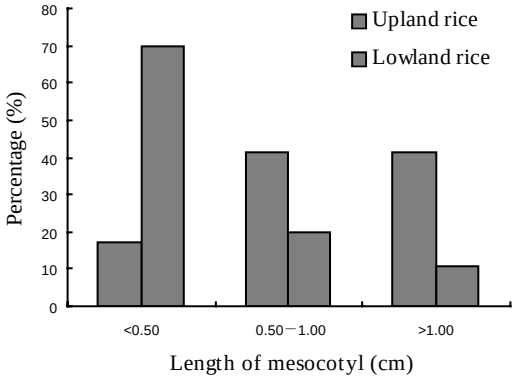

Fig. 2. Distribution of mesocotyl lengths of upland and lowland rice.

Elongation of the rice mesocotyl under darkness

The mesocotyl of all the varieties tested elongated more or less uner darkness (Fig. 1). In general, the elongated lengths of the mesocotyl in upland rice, ranging from 0.36 cm to 1.61 cm with an average of 0.81 cm, were obviously longer than those in lowland rice, ranging from 0.12 cm to 1.56 cm with an average of 0.42 cm. Among 14 rice varieties with over 1 cm of mesocotyl length, five were upland rice, and nine were lowland rice, accounting for 41.5% of the total upland rice varieties and 10.7% of the lowland rice varieties, respectively (Table 1, Fig. 2). Therefore, upland rice had longer length of mesocotyl and higher proportion for the elongated mesocotyl. This may be closely related to the characteristics of upland rice seeds germinating under a thicker layer of paddy soil. So far, there is uncertainty of the relationships between mesocotyl length and lodging resistance and water supply in the upland rice.

DISCUSSION

Low seedling emergence is one of the three main obstacles (weed infestation and lodging proneness for the other two) affecting the development of direct-seeded planting in rice [4,5]. In recent years, a large series of candidate semi-dwarf varieties were developed as a result of progressing rice breeding oriented for direct-seeded planting system [9]. However, these genotypes still showed low seedling emergence due to inadequate mesocotyl elongation especially when applied in direct-seeded planting in upland. Therefore, screening of especially elongated mesocotyl germplasms and genetic breeding based on these germplasms for more adaptable genotypes are effective approaches to overcoming low seedling emergence in

Table 1. Selected rice germplasms with specially-elongated mesocotyl.

Rice variety	Origin	Rice type	Variety type	Mesocotyl length（cm）
Zhonghan 021	China	Upland rice	indica	1.23
IR60080-46A	IRRI, Philippines	Upland rice	indica	1.28
Vandana	Colombia	Upland rice	indica	1.45
Handao	China	Upland rice	japonica	1.61
IAPAR9	Brazil	Upland rice	indica	1.00
Chunjiang 012	China	Lowland rice	japonica	1.20
99-98	China	Lowland rice	japonica	1.48
CH155	China	Lowland rice	indica	1.11
R2071	China	Lowland rice	japonica	1.56
Ning 1081	China	Lowland rice	japonica	1.00
JAVA14	Brazil	Lowland rice	javanica	1.08
Suyunuo	China	Lowland rice	indica	1.50
Hongmi	China	Lowland rice	japonica	1.19
Z215	China	Lowland rice	indica	1.41

direct-seeded planting.

Compared with lowland rice, upland rice requires capability in seedling emergence besides tolerance to drought as sown in an increased depth of soil [4,9]. Zhonghan 021 (IAPAR 9/Bing 97264) and 99-98 (JAVA 14/Chungjiang 11) were developed in recent years as direct-seeding dwarf upland rice varieties with good grain quality and also as two rice germplasms with the specially- elongated mesocotyl. They both were originated from the germplasms of the elongated mesocotyl of IAPAR9 and JAVA 14. Therefore, the rice germplasms with the elongated mesocotyl could be used as donors to breed direct-seeding rice varieties through screening mesocotyl elongation at seedling stage, raising the efficiency of rice breeding and speeding up the breeding for the direct-seeding varieties used in lowland and upland.

Dilday et al. studied the genetics of rice mesocotyl and found that mesocotyl elongation could be inherited stably from generation to generation [2,3]. Using the repeatable character that the mesocotyl elongation is restricted under daylight and but, functions in the dark [10,11], we can simply, directly and precisely detect the mesocotyl elongation in the seedlings of different rice varieties, determine the purity of rice seeds in the varieties with the elongated mesocotyl and discriminate the truth of rice seeds.

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REFERENCES

1 Zhou D C. Talking about mesocotyl growth of corn during seed bourgeon again. *Bullet Biol*, 1991, (9):10. (in Chinese)
2 Redon E D, Mackill D J. Mapping quantitative trait loci for seeding vigour in rice using RFLP. *Theor Appl Genet*, 1996, **92**:395-402.
3 Dilday R H, Mgonja M A, Wells B R. Plant height vs. mesocotyl and elongation in rice: linkage or pleioutropism. *Crop Sci*, 1990, **30**:815-818.
4 Chen J G, Zhang Y Z, Zhou Y. Regulation of foxtail millet mesocotyl growth by gibberellins and abscisic acid in etiolated seedlings. *J Nanjing Agric Univ*, 1997, **20**(1):13-17. (in Chinese with English abstract)
5 Hu S H, Guan X C. Test seed of Shanyou 63 speediness by rice mesocotyl length and the colour of bud vagina. *Seed*, 1999, (6): 64. (in Chinese)
6 China National Standard Publishing Company. Rules for Agricultural Seed Testing. GB/T3543.1-3543.7, 1995. 34-47.
7 Jin Q Y, Ouyang Y N, Lu Y L, Xu Y C. Some cultural techniques question and countermeasure about rice direct sowing in south China. *Chinese Agril Sci Bull*, 2001, **17**(5): 44-48. (in Chinese)
8 Cao L Y, Zhu J, Yan Q C, He L B, Wei X H, Chen S H. Mapping QTLs with epistasis for mesocotyl length in a DH population from indica-japonica cross of rice (*Oryza sativa* L.). *Chinese J Rice Sci*, 2002, **16**(3):221-224. (in Chinese with English abstract)
9 Cao L Y, Zhu J, Ren L F, Zhao S T, Yan Q C. Mapping QTLs and epistasis for seeding vigor in rice (*Oryza sativa L.*). *Acta Agron Sin*, 2002, **28**(6)：809-815. (in Chinese with English abstract)
10 Zhu D F, Yan X Q. Survey of rice direct sowing and cultivation in overseas. *Crop & Cult*, 1997, (1-2): 102-103. (in Chinese)
11 Li X Q, Jin L G, Zhou L Z. Characteristics of direct of sowing double-cropped hybrid rice and its cultural techniques in coastal region of southern Zhejiang. *J Zhejiang Agric Sci*, 1998, (3):115-117. (in Chinese)