Varietal Difference in Salinity Tolerance during Germination Stage of Rice

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ABSTRACT

This study was conducted to find out a desirable screening condition for the salinity tolerance in germination of rice. Seeds of 33 rice varieties were tested in NaCl solutions with various concentration levels.

The germination percentage had a decreasing tendency with increasing NaCl concentration and inhibition concentration of 50% germination was 320mM. Standard deviation of germination percentage was highest (28.6) under 300mM NaCl. There was a highly significant correlation between the 50% germination concentration and the germination percentage at 20th day after seeding in 300mM NaCl. Also in 300mM NaCl, the germination percentage at 20th day after seeding was significantly correlated with the germination percentage at the 6th day after seeding.

The salinity tolerance on the basis of germination percentage at 6th day after seeding in 300mM NaCl, was strong in 'Hyangnambyeo', 'Ilmibyeo', 'Kancheogbyeo', and 'Namwonbyeo', while weak in 'Ansanbyeo', 'Odaebyeo', 'Nonganbyeo', 'Dasanbyeo', and 'Namcheonbyeo'.

Key words: rice, germination stage, salinity tolerance, varietal difference.

Direct seeding cultivation of rice, which reduces labor and production cost by omitting the nursery and transplanting work, can solve labor shortage problem and improve the real income of farm households. In 1996, the area of direct seeding cultivation of rice reached 10.5% (110,365ha) of the rice paddy area in Korea.

Direct seeding cultivation of rice is largely classified into two practical schemes; one is direct seeding on flooded paddy and the other is on dry paddy. The latter scheme can be subdivided according to the machine used and seeding method. Likewise, it is known that direct seeding on flooded paddy is more advantageous than that on dry paddy in the reclaimed saline land which has poor soil characteristics such as its high ground water level and its high salt concentration (Rhee, 1978; Um & Um, 1991).

However, direct seeding on flooded paddy has a shortcoming of instability of germination and seedling stand, and severe lodging, due to direct sowing on the flooded paddy surface (Lee et al., 1994; Lee et al. 1996). Seedling stand establishment is difficulty on reclaimed saline land due to saline soil (Bernstein, 1975; Choi et al., 1983; Lee & Seong, 1996).

For the stable production by direct seeding cultivation on the reclaimed saline land, the supply of direct seeding cultivation varieties which have strong salinity tolerance should be available. Especially, salinity tolerance in the germination stage for good seedling stand establishment should be emphasized. However studies on salinity tolerance of rice varieties have been conducted mainly with transplanting cultivation of rice and the studies on salinity tolerance during the germination stage in direct seeding cultivation are insignficant.

The objective of this study was to find a suitable screening test for germination salinity tolerance of rice varieties.

MATERIALS AND METHODS

Seeds of 33 rice varieties including Dongjinbyeo were obtained from the Rice Breeding Laboratory, National Honam Agricultural Experiment Station, RDA. Fifty seeds of each variety were placed in a 9 cm petri dish lined with two pieces of filter paper and 5ml of NaCl solution adjusted to nine levels of 0, 50, 100, 150, 200, 250, 300, 350, and 400mM. The seeds were germinated at constant temperature of 30℃ under dark condition. Split plot design with three replications was used.

Observation of germination was made from 2nd day to 20th day after seeding. Seeds were regarded as germinated when the plumule grew more than 2mm. Total germination percentage was the percent of seeds germinated until 20 days after sowing. Germination percentage was indicated as percentage of seeds germinated for specified period after seeding. The NaCl concentration that inhibited 50% germination of viable seeds was calculated by using the curvilineal regression of germination percentage under the different NaCl levels.

RESULTS AND DISCUSSION

The total germination percentage of rice varieties under the different NaCl concentration levels was observed as shown in Fig. 1. It was 96% in the control, and 93% up to 150mM NaCl. There is no significant difference between the total germination percentage in the control and that in 150mM NaCl. However, it was markedly reduced in more than 200mM NaCl and the NaCl concentration that inhibited 50% germination of viable seeds was 320mM as solved by the second order regression analysis.

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Received 23 Sep. 1997.

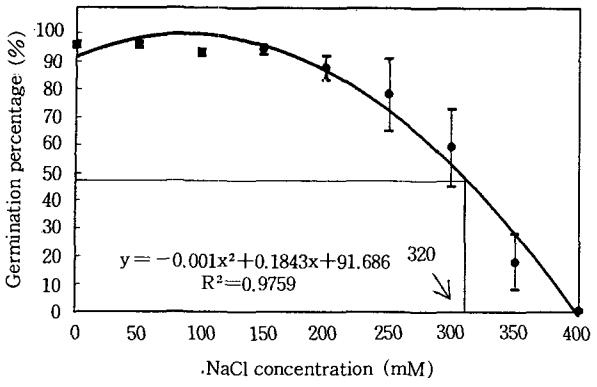

Fig. 1. The total germination percentage of 33 rice varieties under nine NaCl concentrations at 30℃.

The arrow symbol indicates the NaCl concentration that inhibited 50% germination of the viable seeds.

The standard deviations in germination percentage were relatively low up to 200mM NaCl. but 27.3 in 250mM NaCl and 28.6 in 300mM NaCl, and then decreased in above 350mM NaCl.

The NaCl concentration that inhibited germination of 50% of viable seeds in rice was 320mM NaCl and lower than that in Italian ryegrass (344mM NaCl) (Choi & Lee, 1995; Lee et al., 1995; Lee & Choi, 1995). Therefore, it is considered that the germination salinity tolerance of rice is lower than that of Italian ryegrass. Also the standard deviation in germination percentage was the highest in 300mM NaCl. So it is found that there is a remarkable variability of salinity tolerance among varieties in 300mM NaCl.

The NaCl concentration that inhibited 50% germination is used as a practical index in comparing the salinity tolerance among varieties (Thamir et al., 1992). However, it require a great deal of labor, because the NaCl concentration that inhibited 50% germination is calculated only after getting the curvilineal regression by examining the germination percentage in many different NaCl concentration. Accordingly, more brief method is necessary to examine the germination salinity tolerance of varieties and lines simultaneously.

As shown in Table 1, the NaCl concentration that inhibited 50% germination was highly correlated with germination percentage from 150mM NaCl to 350mM NaCl, and correlation coefficient was highest (0.918) in 300mM NaCl, indicating that the germination percentage of varieties in 300mM NaCl was closely related to the NaCl concentration inhibited 50% germination.

The NaCl concentration that inhibited germination of 50% of the sample varieties was the same as the NaCl concentration where germination percentage had the highest correlation coefficient with the NaCl concentration that inhibited 50% germination. Similar results were found for Italian ryegrass (Choi & Lee, 1995; Lee et al., 1995; Lee & Choi, 1995).

The average germination percentage of varieties in 300mM NaCl was observed according to the day after seeding (Table 2). Germination percentage was 65.4% at 2nd day after seeding in the control and more than 90% at 3rd day after seeding, but in 300mM NaCl, germination began at 4th day after seeding and germination percentage was also very low (52.5%) at 10th day after seeding. Standard deviation in germination percentage among varieties was very low in the control, but high in 300mM NaCl.

The correlation coefficient between the germination percentage at 20th day after seeding and the germination percentage at each day after seeding in 300mM NaCl is shown in Table 3. The germination percentage at 20th day after seeding and the germination percentage above 6th day after seeding showed a significant positive corre-

Table 1. Correlation coefficients between the NaCl concentration that inhibited 50% germination of viable seeds and the germination percentage in various NaCl concentration for 33 rice varieties.

	Germination percentage under each NaCl concentration (mM)								
	0	50	100	150	200	250	300	350	400
C50%†	0.327	0.154	0.526**	0.763**	0.828**	0.855**	0.918**	0.872**	0.109**

** Symbols are significant at 0.01 level.

† The NaCl concentration that inhibited 50% germination of viable seeds.

Table 2. The average germination percentage under the control and 300mM NaCl in 33 rice varieties.

	Days after seeding										
	1	2	3	4	5	6	7	8	9	10	20
Control	0.0 (0.0)†	65.4 (21.9)	92.2 (4.2)	95.5 (2.7)	95.8 (2.5)	95.8 (2.5)	96.1 (2.3)	96.1 (2.3)	96.1 (2.3)	96.1 (2.3)	96.1 (2.3)
300mM NaCl	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.8 (1.0)	12.2 (8.5)	23.4 (15.2)	37.8 (22.3)	45.8 (24.7)	49.9 (25.7)	52.5 (26.7)	59.4 (28.6)

† Standard deviation in germination percentage.

Table 3. Correlation coefficients between the germination percentage at 20th day after seeding and the germination percentage at each day after seeding in 300mM NaCl, and between the germination percentage at each day after seeding and NaCl concentration that inhibited 50% germination of viable seeds in 33 rice varieties.

	Germination percentage at each day after seeding										
	1	2	3	4	5	6	7	8	9	10	20
GP†	0.00	0.00	0.00	0.41*	0.44*	0.71**	0.91**	0.97**	0.98**	0.99**	1.00**
C50%‡	0.00	0.00	0.00	0.37*	0.42*	0.65**	0.93**	0.95**	0.95**	0.94**	0.92**

** Symbols are significant at 0.01 level.
† The germination percentage at 20th day after seeding in 300 mM NaCl.
‡ The NaCl concentration that inhibited 50% germination of viable seeds.

lation. The correlation between germination percentage at 6th day after seeding and the NaCl concentration that inhibited 50% germination was also significant. These results suggest that the order of germination percentage of varieties at 20th day after seeding was similar to that at 6th day after seeding. Therefore, it is not necessary to investigate the germination percentage until 20th day after seeding when the order of germination percentage of varieties is determined. Only the germination percentage at 6th day after seeding considered to be needed.

The correlation between the germination percentage of varieties in 300mM NaCl and the germination percentage at 6th day after seeding in the same solution is shown in Fig. 2 . It is recognized that there is an highly linear regression between the germination percentage at 20th day after seeding and that at 6th day after seeding, with a high positive correlation coefficient. Varieties were classified into strong, middle, and weak salinity tolerance on the basis of germination percentage at 6th day after seeding in 300mM NaCl. Ilpumbyeo (30), Donganbyeo (22) and Nagdongbyeo (13) belong to the strong when compared with the germination percentage at 20th day

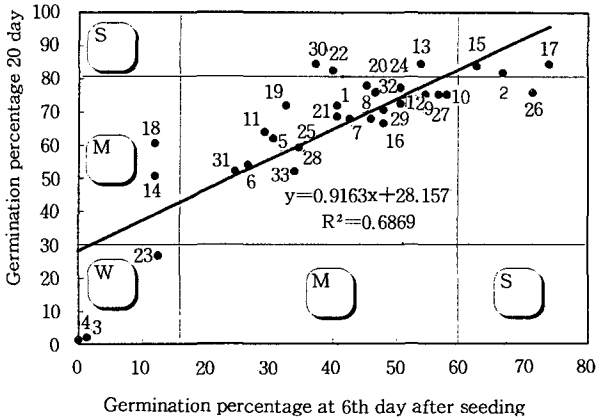

Fig. 2. Relationship between the germination percentage at 20th day after seeding and the germination percentage at 6th day after seeding in 300mM NaCl at 30℃.
Numbers of rice are the same as those in Table 4.
S, M, and W indicate strong, middle, and weak salinity tolerance on the basis of germination percentage, respectively.

Table 4. Classification of 33 rice varieties by salinity tolerance on the basis of germination percentage at 6th day after seeding in 300mM NaCl.

Degree of salinity tolerance	Rice variety		Number
Strong (above 37.8+22.3)†	Hyangnambyeo (17)‡	Ilmibyeo (26)	4
	Kancheogbyeo (2)	Namwonbyeo (15)	
Middle	Sobaegbyeo (10)	Palgongbyeo (27)	24
	Nagdongbyeo (13)	Dongjinbyeo (9)	
	Keuimobyeo (24)	Tamjinbyeo (12)	
	Unjangbyeo (29)	Daesanbyeo (16)	
	Keuimnambyeo (32)	Hwanambyeo (20)	
	Yeongnambyeo (8)	Daeyabyeo (7)	
	Donganbyeo (22)	Sinunbongbyeo (1)	
	Chucheongbyeo (21)	Ilpumbyeo (30)	
	Obongbyeo (25)	Hwayeongbyeo (28)	
	Sangjubyeo (33)	Unbongbyeo (19)	
	Hwasinbyeo (5)	Hwasanbyeo (11)	
	Kyehwabyeo (6)	Mankeuimbyeo (31)	
Weak (below 37.8~22.3)	Ansanbyeo (18)	Odaebyeo (14)	5
	Nonganbyeo (23)	Dasanbyeo (4)	
	Namcheonbyeo (3)		

† Germination percentage ± Standard deviation at 6th day after seeding in 300mM NaCl.
‡ Numbers of rice are the same as those in Fig. 2.

after seeding, but belong to the middle when compared with the germination percentage at 6th day after seeding. This result shows that the germination percentage at 20th day after seeding is more or less high but the initial germination percentage is low. It is considered that varieties which have high germination percentage at early days after seeding are more adaptable to the reclaimed saline land than that of the low ones if there is no significant difference in germination percentage in terms of the germination uniformity. However, because the temperature is low in seeding season of rice direct seeding cultivation in Korea, the mechanism of salinity tolerance which is related to low-temperature germinability should be considered to select salinity tolerance varieties for normal growth and development of rice in direct seeding cultivation on reclaimed saline land.

Varieties were classified into strong, middle, and weak salinity tolerance on the basis of germination percentage at 6th day after seeding in 300mM NaCl as shown in Table 4. Among the testing varieties, Hyangnambyeo, Ilmibyeo, Kancheogbyeo and Namwonbyeo had a strong salinity tolerance and Ansanbyeo, Odaebyeo, Nonganbyeo, Dasanbyeo and Namcheonbyeo were classified as a weak salinity tolerance varieties.

ACKNOWLEDGEMENTS

This study was supported by Korean Ministry of Education through research fund.

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