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Effective Screening Method for Viviparous Germination of Rice

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ABSTRACT: The viviparity of 28 rice varieties was tested at 25 days after heading(DAH), 35DAH, and 45DAH in the laboratory and field condition for 12 days. The incubation temperature was 20/10°C (day/night), 25/15°C and 30/20°C in the laboratory test, and under field water conditions in the field test. The biggest varietal difference of viviparity was found in the laboratory test when examined at 45DAH with the 6-day incubation under 25/15°C. At this conditions the mean viviparous ratio was 32.1% with the range of 53.9 and the variance of 259.5. In the field test, the significant varietal difference in the viviparity was also found in the lodging treatment at 45 DAH for 6 days. Correlation coefficient analysis between the field and laboratory tests was highly significant from 4 days after incubation at 45 DAH and after 6-day incubation at 35 DAH, and correlation coefficient was higher as incubation days in the laboratory and submerged days under field water became longer. Considering the correlation between the field and laboratory tests, varietal difference of viviparity and convenience of testing, the laboratory test at 45 DAH for 6-day incubation under 25/15°C was the most efficient evaluation method for the viviparity of rice cultivar.

Keywords : viviparity, viviparity evaluation, varietal response, rice.

Yield loss and quality deterioration of rice have been frequently reported due to the adverse weather conditions that cause the viviparous germination with lodging. Therefore, the cultivation of varieties with low viviparity is one of the prior considerations to minimize yield loss. The development of rice varieties with low viviparity requires a lot of time for investigation of genetic resource and evaluation of various rice lines. Accordingly, precise and efficient evaluation methods for viviparity of rice are in need.

Rice seeds have capability to germinate from 7 days after pollination but their growth is not normal and usually take longer time of about 26 days to germinate, but in 14 days after pollination, the germination rate and days to germination of rice seeds became close to the fully matured ones (Cho, 1987). According to Kushihoochi (1971), rice seeds started to show viviparous germination at about 18 to 20 days after heading and its rate rapidly increased from about 27 days after heading.

There have been various investigation methods of viviparity in the previous rice researches; 1) field observation at 25, 35, and 45DAH by inducing lodging (Ju *et al.*, 2000), 2) induction of viviparity by the artificial raining treatment in pot culture (Hong *et al.*, 1999), 3) induction of viviparity immediately after harvest by soaking panicles in the water at 25°C to 30°C (Lee *et al.*, 1985), 4) incubation at constant temperature of 25°C after dormancy breaking treatment of rice harvested in dough, yellow ripe, and full ripe stage (Park *et al.*, 1984), 5) incubation under alternating day/night temperature regime of 29/21°C and 23/18°C with the photo period of 15 and 13 hrs (Lee *et al.*, 1985).

As stated above, viviparity of rice panicles has been tested at various temperature and also at different maturing stages. The viviparity was investigated at constant temperature of 30°C by Hong *et al.* (1980) and at 20°C by Cho *et al.* (1987). However, Suh *et al.* (1994) reported that the better varietal difference in viviparity was found when measured at 6 days after the incubation with 25/15°C in rice panicles harvested at 40DAH in comparison to the alternating temperature treatments of 20/10 and 30/20°C at 20, 30, and 35DAH. Rho (1990) stated that viviparity test in petri-dishes showed close results with the direct incubation of intact rice panicles.

Although there have been many studies on the viviparity of rice, the each test was different in terms of induction method, harvesting time of panicle, incubation temperature, and measurement time after incubation. Therefore, objective of this study was to establish the efficient evaluation methods of varietal difference in viviparity. Field and laboratory tests were carried out on 28 rice varieties commonly cultivated.

MATERIALS AND METHODS

The field experiment was conducted at the paddy field of Kyonggido Agricultural Research and Extension Services. Twenty-eight rice varieties including recently developed ones were examined in this experiment. Seeding was done on 15, April and 35-day-old seedlings were transplanted with the planting density of 30×15 cm on 21 May, 1999. Fertilizers of N, P, and K were applied with 110-58-57kg/ha, respectively, according to the standard split application (5:3:2) method.

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To induce viviparity at exact time after flowering, panicles of each variety were tagged according to flowering date. For the field evaluation of viviparity at 25, 35, and 45DAH, six panicles of each variety from different hills were placed into the irrigated water by gently bending stems toward ground and kept their panicles under water for 12 days (lodging treatment). Field water temperature was measured during the experimental period by placing max. -min. thermometer under the irrigated water (Table 1). Field plots were irrigated as needed to keep the panicles wet throughout the experiment. The plots were arranged with the randomized complete block design with 3 replications.

For the examination of viviparous germination in the laboratory conditions, fifteen panicles from each experimental unit were harvested at 25, 35, and 45DAH based on each heading date. Harvested panicles were laid on a presoaked cotton sheet placed on the bottom of plastic box of 25 W×25 L×8 H cm, covered with another cotton sheet, and incubated for 12 days with the 12/12h photo period of day/night at the temperature of 20/10°C, 25/15°C, and 30/20°C. Germinated seeds were counted every other day for 12 days both in the field and in the laboratory test.

RESULTS AND DISCUSSION

Treatment stage and incubation temperature in the laboratory test

Analysis of viviparity examined at 25, 35 and 45DAH under the incubation temperature of 20/10, 25/15, and 30/20°C is presented in Table 2. The biggest varietal difference of viviparity was found with incubation of panicles harvested at 45DAH for 6 days under 25/15°C. At this conditions the cumulative viviparous grain ratio was 32.1% with the range of 53.9 and variance of 259.5. The significant varietal difference was also found by testing panicles harvested

Table 1. Maximum and minimum field water temperature averaged over 12 days after initiation of lodging treatment in each variety.

Variety	Heading date	Temperature (°C)					
		25DAH		35DAH		45DAH	
		Max. temp.	Min. temp.	Max. temp.	Min. temp.	Max. temp.	Min. temp.
Nonganbyeo	8. 8	30.0	22.1	25.8	19.4	24.5	15.9
Heukjinjubyeo	7.22	29.9	19.6	29.2	21.2	29.6	22.0
Naepoongbyeo	8. 4	29.8	21.7	28.2	21.3	23.3	16.9
Hwasunchalbyeo	8.10	29.7	22.2	24.8	18.4	25.0	15.5
Jinbubyeo	7.23	29.6	19.8	29.2	21.2	29.1	21.8
Janganbyeo	8.11	29.6	22.0	24.2	17.9	25.0	15.3
Shinsunchalbyeo	8.11	29.6	22.0	24.2	17.9	25.0	15.3
Hwasungbyeo	8.11	29.6	22.0	24.2	17.9	25.0	15.3
Kwanganbyeo	8.11	29.6	22.0	24.2	17.9	25.0	15.3
Soorabyeo	8.11	29.6	22.0	24.2	17.9	25.0	15.3
Odaebyeo	7.27	29.4	20.3	29.8	21.9	27.0	20.4
Ansanbyeo	8. 3	29.3	21.3	29.0	21.8	23.5	17.1
Daejinbyeo	8. 3	29.3	21.3	29.0	21.8	23.5	17.1
Dasanbyeo	8.12	29.1	21.8	23.8	17.4	25.0	15.0
Bongkwangbyeo	8.12	29.1	21.8	23.8	17.4	25.0	15.0
Anjungbyeo	8.12	29.1	21.8	23.8	17.4	25.0	15.0
Seojinbyeo	8.13	29.0	21.8	23.5	17.1	25.0	14.7
Andabyeo	8.13	29.0	21.8	23.5	17.1	25.0	14.7
Obongbyeo	8.13	29.0	20.1	29.8	21.7	28.2	21.3
Seoanbyeo	8.13	29.0	21.8	23.5	17.1	25.0	14.7
Daeanbyeo	8.14	28.2	21.3	23.3	16.9	25.4	14.7
Juanbyeo	8.14	28.2	21.3	23.3	16.9	25.4	14.7
Hwajungbyeo	8.15	27.4	20.8	23.7	16.7	25.3	14.7
Hwamyeongbyeo	8.16	27.0	20.4	23.8	16.5	25.2	14.6
Hwajinbyeo	8.16	27.0	20.4	23.8	16.5	25.2	14.6
Dongjinbyeo	8.17	26.3	19.8	24.0	15.9	25.2	14.5
Ilpoombyeo	8.20	24.8	18.4	25.0	15.5	23.7	13.2
Chuchungbyeo	8.21	24.2	17.9	25.0	15.3	22.8	12.2

Table 2. The viviparous germination rate and their variation of 28 rice varieties under the different temperatures and incubation time.

Days after heading	Statistic	20/10°C†						25/15°C						30/20°C					
		2‡	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
25	Mean	0.0	0.0	0.0	0.3	1.2	3.0	0.0	0.3	1.4	4.2	7.9	12.2	0.0	1.3	6.5	14.4	20.4	27.5
	Range	0.0	0.1	0.3	4.1	4.7	12.9	0.3	4.0	7.2	13.8	18.6	19.6	0.1	12.3	17.1	41.2	15.9	26.2
	Variance	0.0	0.0	0.0	0.6	2.0	9.6	0.0	0.6	3.5	15.0	19.6	19.1	0.0	7.0	26.2	72.2	24.2	37.2
35	Mean	0.3	0.9	2.4	5.9	11.4	17.1	0.5	7.6	21.4	32.7	40.1	46.8	1.2	16.3	35.2	44.3	53.2	60.3
	Range	5.6	7.6	7.2	11.2	26.2	20.4	5.8	36.5	44.9	40.5	19.6	15.0	14.0	51.8	47.0	19.0	43.6	24.6
	Variance	1.2	2.2	5.0	17.6	53.0	47.3	1.6	123.1	182.9	87.7	29.2	19.3	8.8	257.8	194.1	27.4	73.0	31.9
45	Mean	0.6	1.8	4.0	8.2	17.3	28.7	2.8	10.6	32.1	49.9	61.7	69.9	4.4	25.6	50.6	63.8	73.6	79.9
	Range	10.5	5.9	13.8	27.2	27.2	34.6	26.4	35.4	53.9	47.4	26.7	31.4	43.3	52.2	48.0	41.3	35.8	15.0
	Variance	4.1	3.2	12.2	32.8	69.5	85.2	31.3	75.4	259.5	137.9	70.4	52.1	73.4	229.5	152.3	83.8	82.7	21.5

†Diurnal incubation temperature of 12/12hrs (day/night).
‡Days after incubation.

Table 3. The mean viviparous germination rates and their variation under the field condition at the different days after heading.

Statistic	25DAH†						35DAH						45DAH					
	2‡	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
Mean	0.1	2.2	5.3	9.1	13.0	17.6	1.4	6.2	16.2	26.0	35.0	44.2	3.5	9.2	17.2	25.2	34.2	43.8
Range	0.8	26.2	17.3	10.8	11.8	15.1	8.4	18.3	26.1	24.6	21.1	35.8	38.4	34.6	37.9	28.0	22.0	20.9
Variance	0.0	32.6	16.4	11.7	9.5	11.2	5.8	27.0	78.2	56.2	40.7	66.9	66.6	51.8	85.0	56.2	44.6	42.1

†DAH : days after heading.
‡Days after the lodging treatment to induce viviparous germination.

at 25DAH with incubation for 12 days under 30/20°C and at 35DAH with incubation for 4 days under 30/20°C. The viviparous grain ratio, range and variance at 25DAH were 27.5%, 26.6 and 37.2, respectively, and those at 35DAH were 16.3%, 51.8, and 257.8, respectively.

However, the figures of viviparous grain ratio, range, and variance were lower compared to those at 45DAH with 6-day incubation under 25/15°C. Therefore, the most efficient method for the evaluation of varietal difference in the viviparity of rice under this experimental conditions was considered to measure it after 6-day incubation under 25/15°C with rice panicles harvested at 45DAH. These results was similar to the report by Suh *et al.* (1994) who concluded that proper laboratory test for viviparity was 6-day incubation under 25/15°C using the panicles harvested at 40DAH. The greater viviparous grain ratio, range, and variance at 45DAH compared to those at 25DAH and 35DAH was confirmed by Cho *et al.* (1988) who observed higher viviparous grain ratio in the order of 45>40>35>30>25DAH.

Evaluation time for viviparity test in the field

The field evaluation for viviparity of rice was conducted by inducing artificial lodging at 25, 35, and 45DAH. The biggest varietal difference in the viviparity was found at 45DAH as measured after 6 days of the lodging treatment since it showed higher viviparous grain ratio (17.2%), range (37.9) and variance (85.0) compared to other treatments (Table 3). At 35DAH the variance of viviparity among the tested varieties was the largest (78.2) after 6-day incubation under field water but the averaged viviparous grain ratio and its range were lower than those at 45DAH. At 25DAH viviparous germination rate was too low to tell the varietal difference regardless of incubation days possibly due to immaturity of kernel.

Correlation coefficients of viviparous germination rate between the field and laboratory tests

To compare the difference in viviparity between the field and laboratory tests (25/15°C), correlation coefficient analyses were performed and their results were presented in Table 4 and 5. There were highly significant positive correlations between the field and laboratory tests at 45 DAH in all of the incubation time periods except 2-day incubation, in which viviparous grain ratio was less than 5%. However, correlation analysis on viviparous grain ratio at 35DAH showed highly significant correlation from 6- to 12-day incubation. These results can be attributed mainly to difference in viviparous grain ratio depending on maturing stage. In general,

Table 4. Correlation coefficient of viviparous germination rate at 45 days after heading(DAH) between the field and laboratory tests.

		Field test at 45DAH					
	Days after treatment†	2	4	6	8	10	12
Laboratory test at 45DAH (25/15°C)	2	0.953**	0.848**	0.632**	0.506**	0.442*	0.405*
	4		0.918**	0.760**	0.669**	0.652**	0.648**
	6			0.496**	0.492**	0.597**	0.683**
	8				0.558**	0.653**	0.750**
	10					0.696**	0.785**
	12						0.763**

†Days after incubation or under field water.

Table 5. Correlation coefficient of viviparous germination rate at 35 days after heading(DAH) between the field and laboratory tests.

		Field test at 35DAH					
	Days after treatment†	2	4	6	8	10	12
Laboratory test at 35DAH (25/15°C)	2	0.288	0.313	0.323	0.430*	0.418*	0.397*
	4		0.579*	0.570**	0.629**	0.440**	0.563**
	6			0.652**	0.733**	0.769**	0.733**
	8				0.830**	0.581**	0.819**
	10					0.885**	0.873**
	12						0.872**

†Days after incubation or under field water.

Table 6. Classification of varieties based on the viviparous germination rates in the laboratory test at 45DAH with the incubation temperature of 25/15°C for 6 days.

Classification	Name of variety
Very low (0~10)	Andabyeo, Nonganbyeo, Dasanbyeo, Chucheongbyeo, Heukjinjubyeo
Low (11~30%)	Odaebyeo, Ilpoombyeo, Hwasungbyeo, Seoanbyeo, Kwanganbyeo, Soorabyeo, Daejinbyeo, Ansanbyeo, Janganbyeo, Obongbyeo
Intermediate (31~60%)	Sinsunchalbyeo, Seojinbyeo, Hwajungbyeo Jinbubyeo, Anjungbyeo, Naepoongbyeo, Hwamyeongbyeo, Juanbyeo, Daeanbyeo
High (61~100%)	Hwajinbyeo, Hwasunchalbyeo, Dongjinbyeo Bongkwanbyeo

correlation coefficient was higher as incubation days in laboratory and submerged days under field water were longer.

Comparison between the laboratory and field tests of viviparity

As stated above, the proper evaluation of viviparity was to test at 6 days after incubation with the diurnal temperature of 25/15°C at 45DAH in the laboratory or to test at 6 days after the lodging inducement at 45DAH in the field. The field test is much more difficult than the laboratory test especially with many varieties, because it requires inducement of lodging and daily-counting of viviparous grains in the paddy field. The varietal distribution based on viviparous grain ratio from laboratory test measured at 6 days after the incubation with 25/15°C at 45DAH were presented in the Table 6.

In the laboratory test, the number of varieties showing viviparous grain ratio of below 10% were 5 including Andabyeo and Chucheongbyeo. There were 10 varieties including Odaebyeo and Ilpumbyeo in the range of 11~30% viviparous grain ratio and nine varieties including Shinsunchalbyeo were in the range of 31~60% viviparous grain ratio. Four varieties including Hwajinbyeo and Bongkwangbyeo showed the viviparous grain ratio over 61%. Andabyeo and Dasanbyeo which are indica/japonica type had less viviparous grain ratio compared to japonica varieties. In addition, the late-maturing varieties such as Dongjinbyeo and Hwamyeongbyeo had higher viviparous grain ratio compared to the early-maturing varieties such as Odaebyeo and Obongbyeo. This result was different from the previous reports by Hong *et al.* (1980), Cho *et al.* (1988), and Park *et al.* (1984) that early-maturing varieties showed greater viviparous grain ratio than mid- and late-maturing varieties. It seemed that accumulation of substances causing dormancy played greater role than environmental differences faced by the different maturity groups.

In conclusion, the examination of viviparity in the laboratory at 45DAH after 6-day incubation under 25/15°C would be an efficient method, considering the correlation with the field observation, outstanding varietal difference and convenience of testing.

REFERENCES

Cho, D. S. 1987. Studies on the viviparous germination in rice. I. Effects of harvesting and seeding time. Res. Rep. Agr. Sci. Chungbuk Nat. Univ. 5(1):3-13.

Cho, D. S-., I. B. Kim, T. Yun, S. K. Park and C. K. Kwun. 1987. Studies on the viviparous germination in rice. (I) Effects of harvesting and seeding time. Rep. Agr. Sci. Chungbuk Nat. Univ. 5(1):3-13.

Hong, K. G., Song, J. K. Park, K.Y. Chung, D. J. Ryu and J. B. Lee. 1980. Studies on the viviparous germination in current rice vrieties. Res. Report of Kyonggi ARES. (1):29-34.

Hong, K. P., W. K. Joung, Y. G. Kim, and D. J. Kang. 1998. Lodging and viviparous germination of rice cultivars and operation efficiency of combine harvester in lodging field. Report of Kyongnam ARES. p. 30-39.

Hong, K. P., W. K. Joung, Y. G. Kim, and D. J. Kang. 1999. Varietal variation of viviparous germination in rice. *Korean J. Crop Sci.* 44(suppl. 1):9-11.

Ju, Y. C., S. W. Han, Y. C. Cho and K. Y. Park. 2000. Effects of submerged condition, temperature, and ripening stages on viviparous germination of rice. *Korean J. Crop Sci.* 45(1):20-25.

Kushihoochi, 1971. Agricultural Technology Series(Crop) I. Agriculture and Fishery Technology Society. p. 318-319.

Lee, D. J., M. H, Lee., S. H. Park and Y. D. Rho. 1985. Study on the cause of viviparous germination and the development of inhibition technique. Annual Research Report of National Crop Experiment Station, RDA p. 451-455.

Lee, M. H., S. H. Park., R. K. Park. 1985. Effects of viviparous germination rate on yield and rice quality. 1985 Annual Research Report of National Crop Experiment Station, RDA. p. 477-480.

Park, K. B. and Park, R. K. 1984. Studies on the viviparous germination of indicajaponica type varieties in paddy field. *Korean J. Crop Sci.* 29(1):15-18.

Rho, Y. D. 1990. Germination of rice varieties in relation to germination. Res. Rep. Agr. Sci., Kyonghee Univ. p. 68-74.

Suh, K.H. and Y. W.Kim. 1944. Varietal difference in viviparous germination at different days after heading temperature conditions in rice. *Korean J. Crop Sci.* 39(2):187-192.