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Research Article

Evaluation of Cold Tolerance for Japonica Rice Varieties from Different Country

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Abstract: Low temperature is a major limiting factor for agricultural productivity in temperate areas and at high altitudes in Asian cultivated rice (Oryza sativa). Difference of cold tolerance traits at booting stage and the similarity of japonica varieties between different countries were studied, by using 11 japonica rice varieties from three countries. The results showed that the cold tolerance at the booting stage among japonica rice under natural temperature and cold water irrigation were significantly different and japonica rice varieties from Korea showed stronger cold tolerance than that from Russia and China. Five japonica rice varieties with stronger cold tolerance at the booting stage were selected. Among them, Jinbubyeo, Junganbyeo and SR30084-F8-156 from Korea showed stronger cold tolerance both under constant cold water irrigation and 7-days cold water treatment at booting stage. This study also funded that the main panicle length of all test materials becomes shorter than the control.

Keywords: Booting stage, cold tolerance, cold water stress, natural low temperature, rice

INTRODUCTION

Low temperature or cold stress is one of the major constraints of rice production and productivity in temperate rice-growing countries and high-altitude areas in the tropics. Cold stress cause seedling mortality and spikelet sterility and, eventually, significant yield losses (Shimono *et al*., 2002). Identification of new genetic sources of cold tolerance is very important to enable rice breeders to develop and grow cold-tolerant rice cultivars in temperate regions.

The booting stage is a critical and cold-sensitive stage to rice grows. On cold damage at the booting stage, many evaluated methods were proposed, such as a long cold water irrigation (Han and Koh, 2000), constant temperature deep cold water irrigation (Futsuhara and Toriyama, 1964), short-term low temperature management (Tsumoda *et al*., 1968), natural low temperature treatment (Dai *et al.*, 2002) and identification of artificial climate chamber (Farrell *et al*., 2006), etc. Fetility as the main index of cold tolerance, addition to morphological and physiological evaluation, has made great results in rice cold tolerance germplasm screening and breeding. However, Identification and evaluation of japonica rice varieties from different country at booting stage has not been reported.

This study evaluated the japonica rice varieties of cold tolerance from different countries in order to screening strong cold-tolerance germplasm and analyzed the difference between 7-days cold stress at the booting stage and cold stress which provide a reference to evaluation and breeding.

MATERIALS AND METHODS

Plant materials: The present investigation was carried out at the Gongzhuling Rice Research Institute (RRI), Jilin Academy of Agricultural Science (JAAS), China (430N and 1240E).

Nine elite rice cultivars from three temperate rice-growing countries and two Recombinant Inbred Lines (RILs) from the IRRI-Korea Office (IKO) Project were evaluated (Table 1). Three genotypes (Sobaegbyeo, Liman and Changbai 9) belonged to the cold-sensitive varieties and the other eight belonged to the cold-tolerant.

Cold tolerance evaluation: The materials were planted in the cold screening nursery from the vegetative stage to grain maturity and also in pots with two replications for 7 days under 19°C water temperature during booting. We used artificial cold water from a 200-m bore well to evaluate genotypes in the greenhouse plot at 19°C. Cold water treatment was given in two phases.

One was given from the vegetative stage to grain maturity in a greenhouse plot for 40 days (June 28 to August 6). The materials were seeded on April 15 and transplanted on May 25. Planting space was 25*12.5

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Table 1: The japonica rice varieties used for cold-tolerance evaluation

Cultivar	Original	Relative tolerance	Cultivar	Original	Relative tolerance	Cultivar	Original	Relative tolerance
Jinbubyeo	Korea	T	Severny	Russian	T	Tongjing 29	China	T
Junganbyeo	Korea	T	Kuban-3	Russian	T	Jisheng 202	China	T
Sobaegbyeo	Korea	S	Liman	Russian	S	Changbai 9	China	S
SR30084-F8-156	IKO	T						
SR30084-F8-14	IKO	T						

T: Cold tolerance; S: Cold sensitive

Table 2: Results of cold stress under artificial environment having modern cold water irrigation facilities (19°C cold water treatment) at Gongzhuling, RRI, JAAS, China (2008)

		Days to heading (days)					Fertility (%)	
Cultivar	Original	Treatment#	Control	Culm length (cm)	PACP at maturity (1-9)	Cold tolerance (1-9)	Treatment	Control
Jinbubyeo	Korea-T	134	121	61.60	9*	5	50.4	88.8
Junganbyeo	Korea-T	148	148	61.60	9*	5	60	94.3
Sobaegbyeo	Korea-S	130	114	66.90	9*	9	0	79.3
SR30084-F8-156	IKO-T	136	125	58.10	9*	5	50.6	83.2
SR30084-F8-14	IKO-T	152	150	63.00	9*	5	59.9	78.8
Severny	Russian-T	140	111	115.0	5	5	45.9	93.2
Kuban-3	Russian-T	140	100	113.0	5	7	25.9	93.5
Liman	Russian-S	108	104	100.0	5	9	0.10	87.6
Tongjing 29	China-T	115	103	105.0	3	9	2.30	93.6
Jisheng 202	China-T	111	105	103.0	3	9	0	94.3
Changbai 9	China-S	111	105	100.0	3	9	2.40	95.6

*: It cannot maturity normally; #: Plants were covered by plastic film on August 10

Table 3: Results of cold stress for 7 days during booting stage (19°C cold water treatment) at Gongzhuling, RRI, JAAS, China (2008)

			Fertility %		
Cultivar	Original	Cold tolerance (1-9)	Treatment	Control	Initial date of treatment
Jinbubyeo	Korea-T	1	88.8#	97.9	July 25
Junganbyeo	Korea-T	1	89.6#	87.3	August 4
Sobaegbyeo	Korea-S	1	86.7#	94.8	July 15
SR30084-F8-156	IKO-T	1	84.5#	95.7	July 26
SR30084-F8-14	IKO-T	7	32.1	74.7	July 26
Severny	Russian-T	5	52.5	87.6	July 14
Kuban-3	Russian-T	7	21.6	92.9	July 8
Liman	Russian-S	7	37.6	83.4	July 21
Tongjing 29	China-T	5	46	88.7	July 9
Jisheng 202	China-T	7	24.9	86.7	July 8
Changbai 9	China-S	7	26.8	92.8	July 8

#: It is not good stage of treatment according to heading date in the field

Table 4: Difference on main panicle length through a long cold water irrigation

		Main panicle length				Main panicle length	
Cultivar	Origin	Treatment	Control	Cultivar	Origin	Treatment	Control
Jinbubyeo	Korea-T	15	18.9	Severny	Russia-T	17	17.4
Junganbyeo	Korea-T	18	15.9	Kuban 3	Russia-T	16	19.1
Sobaegbyeo	Korea-S	16	20.3	Liman	Russia-S	15	16.2
SR30084-F8-14	IKO-R	18	20.8	Ji sheng 202	China-T	17	19.9
SR30084-F8-156	IKO-R	16	21.8	Tong jing 29	China-T	19	20.6
				Chang bai 9	China-S	18	19.5

cm for the control plot and 20*10 cm for the cold water (19°C) treated plot.

The other was given for 7 days on potted plants at the start of the first node, keeping them inside the greenhouse plot during booting stage. The potted plants were evaluated with two replications.

RESULTS AND DISCUSSION

We observed differences in cold tolerance and cold sensitivity among the tested genotypes. The materials from Russia and China showed earlier days to heading and had longer culms than those from Korea and IKO. Phenotypic Acceptability (PA) at maturity was not good for materials from Korea and IKO. With respect to grain fertility, Jinbubyeo and Junganbyeo from Korea, IR83222-f8-156 and IR83222-f8-14 from IKO and Severny from Russia showed cold tolerance. However, cultivars from China were sensitive to low temperature stress (Table 2).

With the cold water treatment for 7 days at 19°C on potted plants during booting, three cultivars from

Korea and one breeding line from IKO showed cold tolerance based on grain fertility. As per heading date in the screening nursery, materials from Korea and IKO were treated at an unsuitable stage. This means that treatment was given at the advanced booting stage. Other test cultivars were highly susceptible to cold stress for seed fertility (Table 3). We also funded that the main panicle length of all test materials becomes shorter than the control (Table 4).

CONCLUSION

From this study, we can find that fertility showed significantly decrease under long cold water irrigation, especially to cold-sensitive japonica rice varieties. Sobaegbyeo from Korea, LIMAN from Russia and three China japonica rice varieties' fertility is almost zero. However, under 7-days cold water stress at the booting stage, the decline of fertility is not significant than under long cold water irrigation. Four japonica rice genetypes from Korea show high fertility may be not good stage of treatment according heading date in the field. Nevertheless, the 7-days cold treatment is a reference to the treatment of the reproductive growth. It is important of good stage of treatment.

Compared to cultivars from Korea and Russia, cultivars from China were sensitive to low temperature stress. This shows that this type of treatment conditions is too strict to Chinese japonica cultivars and is more appropriate to Korea and Russia's.

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