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Full Length Article

Agricultural Safety Assessment for the Progeny of Drought-Tolerant Agb0103 GM Rice

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Abstract

The significance of environment change and genetic safety has been recently recognized by the commercialization of GM (genetically modified) crops. In this study, we evaluated the agricultural safety of drought-tolerant Agb0103 GM rice and to identify and assess environmental risks. The drought-tolerant Agb0103 GM rice including the donor plant, Ilmi and four cultivars were analysed for agronomic characters, weediness potential, survival ability in the natural environment and pollen-mediated gene flow in GM crop fields through the following experiment. First, we planted above plants Agb0103, Ilmi and four cultivars in irrigated paddy field and rainfed paddy field. And we measure agronomic characteristics. There was no statistically significant difference in agronomic characters between the drought-tolerant Agb0103 rice and the donor plant, Ilmi. There was also no statistically significant relationship between the weediness potential and survival ability in the natural environment. Especially, Viviparous germination ratio of harvest was 2.6% in irrigated paddy field lower than other varieties. These results indicate that drought-tolerant Abg0103 GM rice may be used to detect genetic safety and evaluation standards in GM rice progeny. © 2017 Friends Science Publishers

Keywords: Genetically modified; Rice; Safety assessment

Introduction

Recent global abnormal weather, desertification associated with global warming, dry land soils and salinization of ground water associated with the large-scale agricultural irrigation agriculture all demonstrate that the agricultural environment is deteriorating rapidly (Park *et al*., 2009; Long and Ort, 2010). Drought, cold weather and environmental stresses are some of the main factors that reduce crop productivity thus, the development of crops that are resistant to environmental stress are agriculturally very important (Barnabás *et al*., 2008). Agriculture is responsible for a large proportion of water usage and in arid regions, including developing countries, where the percentage of agricultural water can be as much as 90% of total water consumption.

The global drought over the past few years has led to afflation due to a decline in granary productivity. South Korea was also severely damaged by drought for several years thus, in preparation for the lack of water a systematic approach for management and agricultural sustainability of water resources, utilization of biotechnology and the need to develop drought-resistant crops is critical. Recently, Monsanto has developed drought-resistant corn for commercialization. The StMYB1 gene from potato (Im *et al*., 2012), PsAPX gene from pea (Park *et al*., 2009) AP37, AP59 genes which enhance stress tolerance (Oh *et al*., 2009; ACRE, 2004), trehalose biosynthetic gene derived from *Escherichia coli* (Jang *et al*., 2003) and PUB22, 23 from *Arabidopsis* (Cho *et al*., 2008) have been reported for drought-resistant crops in Korea. However, to develop drought-resistant transgenic rice, it is essential to establish a drought-resistant transgenic rice guide in the reproductive growth stage of GM field.

Concerns have been raised that environmental impacts have not yet been fully assessed for such GM plants (Wraight *et al*., 2000). For the cultivation of GM rice to proceed, transformed rice must be released into the agricultural environment and the potential damages must be assessed (Lee *et al*., 2011). The controversy about and stigma of transgenic agro-food products still hold like an EU (Herring, 2008). The adoption rate of genetically modified (GM) crops shows considerable disparities between different agricultural production regions worldwide (Devos *et al*., 2009). While the global cultivation area of GM soybean, maize, cotton and canola (oilseed rape) reached 114 million hectares in 2007 the total area cropped with GM crops in the European Union (EU) was approximately 110 thousand hectares (James, 2007). Commercialization of GM

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crops will also require the assessment of the risk associated with the release of GM crops. Although rice is primarily self-pollinating and the transgene expected to make a pollen-mediated gene flow close to the weeds is dispersed into the wild relatives. Because of transgenic plant is the commercialization concerns about the transgene safety of these novel foods have been raised. Prerequisite for future applications of the transgenic rice, genetically stable, phenotypically normal plants manifested that is recovered after transformation. Agricultural analysis is generally applied to detect unintended effects of GM rice.

Phenotypic traits are often analysed but the unintended effects of GM rice as concurrent sexually compatible rice species and crops can enhance certain likelihood, little and fitness enhancing transgene about how quickly it will be accumulated in these populations, it will have impact on the unwanted environment is known whether this process (Lu and Allison, 2005). Therefore, in this study, we presented the following experiments. We compared agronomic characteristics for checking the difference between GM and non-GM and a germination and shattering for finding stability in natural environment. Therefore, this result will be established as the basic material for evaluating the safety standards of GM progeny.

Materials and Methods

Comparison of Agronomic Characteristics of Agb0103 GM Rice

The field experiment was carried out in Gunwi GM field, Kyungpook Province in South Korea (4,700 m^2, 36°6′41.54″N, 128°38′26.17″E). This study used drought-resistant of Agb0103 GM rice the donor plant, inserted CaMsrB2 gene that obtained from pepper (*Capsicum annuum*) is considered as a novel defence regulator against oxidative stress and pathogen attack (Oh *et al.,* 2010). Agb0103 Ilmi, Junam, Baekjinju and Nagdong as control varieties. The total area of the experimental plot was 119×36 m and plants were spaced at 30×15 cm intervals. Fertilization of the GM field was with $N\text{-}P_2O_5\text{-}K_2O$ (9.0-4.5-5.7 $kg \cdot 10a^{-1}$) according to the Rural Development Administration rice standard cultivation method. The grain traits of length, width, thickness and the ratio of length/width were measured on 50 seeds of one line with 3 replications using a vernier caliper (MITUTOYO and CD-15CP) and an electronic scale (ARD 120). To determine the 1,000 seed weight 3 replications of filled grains were counted (Multi auto counter, WAVER, Japan) and weighed (ARD 120). The frequency of ripened grain of the panicle was calculated on a fertility and sterility by hand gripping 50 days after the heading date per line at the experimental field. Chemical properties of the grain such as amylose, protein and lipid contents were determined with near-infrared spectroscopy (NIRS, Foss 6500) in the cultivation environment.

Weather Condition

Rainfed paddy field was relied on rainfall for water and irrigated paddy field was controlled by amount of water is supplied to plants at regular intervals for agriculture.

The temperature, relative humidity, wind direction and wind speed during the flowering period were measured at intervals of 30 min using the weather instrument. According to the measured weather data 22.6% of the winds were silent in the morning (10 am to 12 pm), 64.5% of the winds of 0.1–2.0 m/s and 25% and wind direction was mainly westerly wind. And average of temperature in august was 25.76℃, average of high-temperature in august was 26.02℃ and average of low-temperature in august was 25.51℃. Monthly average amount of monthly precipitation in June to September is 132.48 mm in 2014 and monthly average amount of monthly precipitation in June to September is 92.55 mm in 2013.

Weediness Potential of Agb0103 GM Rice

Shattering character related to the primary branch in the rice panicle was investigated 50 days after transplanting by connecting a strain gauge and an amplifier. The samples were maintained with a spikelet moisture content of 12–15% before the measurement of rice grain breaking tensile strength. Among all the samples, five panicles per line were used to evaluate pulling and bending strength. The pulling strength of grain panicles was measured on 20 average grains from 3 primary branches on the uppermost part of each panicle. The pedicel of each grain was flatly fixed to the force gauge and pulled down vertically and horizontally using a digital gauge (IMADA, DS2-5W, Japan). Seeds were harvested at 50 days after the heading date and each replication of 100 grains were placed in petri dishes lined with Whatman No. 1 filter paper, wetted with 10 mL deionised water, and incubated in darkness (Incubator, DF-94F). Germination rate was investigated to change two steps each of 5 days at 50℃, 15 days after at 28℃. Germination was evaluated visually by 2 mm of the protrusion of radicle and coleoptile from the hull. Viviparous germination rate was examined 5 times at 10 day intervals. Panicles were laid on cotton in the bottom of a tray (36×26×12 cm) at 25℃ in darkness (Incubator DF-94F). A degree of germination rate was measured by percentage.

Survival Ability of Agb0103 GM Rice in the Natural Environment

Low temperature germination rate was measured as previously described at 13℃ in an incubator (Incubator, DF-94F). Germination was determined when radical length had stretched more than 2 mm and was calculated every 2 days after inoculation. Germination rate after wintering for each sample of 100 seeds was determined at 50℃ for 5 days in an incubator and were seeded in soil from the GM field (dried in the incubator) (Φ20×25 cm). Germination rate was investigated when each sample of 100 seeds was treated at 50℃ for 5 days in an incubator and seeds were inoculated for 150 days (from 1 November 2013 to 31 March 2014) with soil from 3 depths (surface, 5 cm and 10 cm) which was harvested from plots (3 × 3 m) in the GM field. All experiments were replicated at least three times and all data were analysed using the SPSS program (IBMSPSS Statistics, version22, NC). One way analysis of (ANOVA) was also practiced for statistical analysis and significant variations between means were recorded by Duncan's Multiple Range test at P<0.05% on quantitative data.

Results

Comparison of Agronomic Characteristics with the Agb0103 GM Rice

The agronomic traits of the progeny of Agb0103 GM rice, the donor plant, Ilmi, and the control varieties were compared in an irrigated rainfed paddy field (Table 1). The heading dates of the irrigated and rainfed paddy field were similar in each test of 2013 and 2014. The heading date of drought-resistant Agb0103 GM rice was also similar in the irrigated and rainfed paddy fields. The heading date of the donor plant, Ilmi, in the irrigated paddy field was 3 days later than the rainfed paddy field. The culm length was 71.8 cm in drought-resistant Agb0103 GM rice and 68.4 cm in the donor plant in the irrigated paddy field, whereas the culm length was 71.2 cm in drought-resistant Agb0103 GM rice and 69.5 cm in the donor plant in the rainfed paddy field.

Grain traits and shape did not differ among the drought-resistant Agb0103 GM rice and the donor plant, Ilmi, in 2013 and 2014, respectively (Table 2). Grain shape ranged 1.6–1.8 of length to width, 1000 grain weight ranged 20–24 g.

The ratio of ripened grain was compared between the Agb0103 GM rice, and the donor plant, Ilmi, for 2 years (2013 and 2014). Filled grain ratio of the Agb0103 GM rice ranged 86.6–89.9% and the donor plant, Ilmi ranged 88.9–91.6%. There was only a slight difference in the ratio of ripened grain (Table 3). Spikelet density, defined as the number of spikelets per unit area of crop, is a major determinant of paddy rice yield.

The amylase and protein concentrations in Agb0103 GM rice was investigated by NIR analysis in the irrigated paddy field (Table 4). Amylose and protein of Agb0103 GM rice were like those of the donor plant, Ilmi, in 2013 and 2014. There was no difference among field types in the NIR analysis in the same year. There was a difference between the varieties in the 2 years; however, it was not statistically significant. Further, the polished rice of Abg0103 GM rice was like that of Ilmi. However, the milled rice appeared more uniform in colour than that of Ilmi, was seen confidant of white core rice somewhat.

Weediness Potential of Agb0103 GM Rice

One of important agricultural traits is still seed shattering which is considered as the most subject in the breeding systems. The bending and pulling shattering of Agb0103 GM rice increased by 64.8 and 32.8, respectively (Table 5). The shattering was like bending strength, with a narrow variation range. However, the donor plant, Ilmi, decreased by 11 in the rainfed field compared to the irrigated paddy field in 2013. The pulling strength of the Agb0103 GM rice

Table 1: Comparison of agricultural characters each of GM field types

Year	Water supply	Pedigree	Heading date (day/month)	Culm length (cm) [a,b]	Panicle length (cm)[b]	No. of panicles[b]	Yield	
							Polished rice (Mg ha^{-1})	Milled rice (Mg ha^{-1})
2013	Irrigate	Agb0103	19th Aug.a	77.1±3.0a	19.9±0.9b	14.5±2.8b	9.99b	7.39b
		Ilmi	13th Aug.c	72.5±1.8b	20.6±1.5ab	12.5±2.6b	9.44c	6.99c
		Baekjinju	13th Aug.c	73.0±3.4b	20.1±3.4b	18.4±4.5a	8.23d	6.09d
		Junam	13th Aug.c	74.6±2.5b	22.4±3.3a	15.8±4.7ab	10.3a	7.64a
		Nagdong	15th Aug.bc	78.9±2.3a	18.9±1.3b	12.4±3.0b	6.50e	4.81e
	Rainfed	Agb0103	18th Aug.a	73.7±3.1b	20.5±1.0a	13.6±4.3a	7.26c	5.37c
		Ilmi	16th Aug.a	69.2±2.3c	20.6±0.8a	10.6±2.3b	7.03cd	5.20cd
		Baekjinju	12th Aug.c	69.8±2.6c	20.4±0.9a	14.9±3.3a	7.95a	5.88a
		Junam	13th Aug.c	69.8±5.0c	20.9±2.5a	13.9±3.5a	7.68b	5.68b
		Nagdong	15th Aug.bc	79.4±3.8a	20.1±1.2a	10.5±1.4b	7.81ab	5.78ab
2014	Irrigate	Agb0103	24th Aug.a	66.4±1.8c	20.0±2.0ab	13.6±2.3b	6.22e	4.60e
		Ilmi	24th Aug.a	64.2±2.7c	18.9±1.5a	15.4±3.3b	8.50a	6.29a
		Baekjinju	24th Aug.a	77.7±1.8b	20.7±1.4a	15.9±4.2b	6.85d	5.06d
		Junam	24th Aug.a	60.2±2.9c	19.8±1.6ab	14.2±2.3b	7.24c	5.36c
		Nagdong	25th Aug.a	78.7±3.1a	18.7±1.7a	22.8±7.0a	7.83b	5.79b
	Rainfed	Agb0103	24th Aug.a	68.6±3.0b	17.9±1.0b	14.4±4.2a	6.12d	4.53d
		Ilmi	24th Aug.a	69.8±2.6b	19.3±1.8b	15.0±3.1a	7.07c	5.23c
		Baekjinju	26th Aug.a	82.0±6.2a	20.4±3.2a	17.5±2.6a	8.64a	6.39a
		Junam	24th Aug.a	64.3±2.1c	20.5±1.4c	16.1±3.0a	7.88bc	5.83bc
		Nagdong	24th Aug.a	79.4±2.9a	19.0±2.5a	16.0±5.0a	7.91b	5.85b

[a]mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

Table 2: Grain traits each of GM field types

Year	Water supply	Pedigree	Polished rice (mm)			Length /width	1000 seeds (g)
			Length [a,b]	Width[b]	Thickness[b]		
2013	Irrigate	Agb0103	4.9±0.17ab	2.9±0.08a	2.7±1.54a	1.7ab	21b
		Ilmi	5.0±0.34ab	2.9±0.08a	2.0±0.05c	1.7ab	21b
		Baekjinju	5.1±0.15ac	2.9±0.08a	2.2±0.20b	1.8a	23ab
		Junam	4.9±0.18ab	2.8±0.09a	2.1±0.09b	1.8a	22bc
		Nagdong	4.9±0.17ab	2.9±0.08a	2.7±1.54a	1.7ab	23ab
	Rainfed	Agb0103	5.0±0.14ab	2.8±0.18a	2.0±0.07b	1.8a	21b
		Ilmi	5.0±0.23ab	2.9±0.12a	2.0±0.07b	1.7ab	22bc
		Baekjinju	5.1±0.16a	2.9±0.12a	2.0±0.08b	1.7ab	23ab
		Junam	5.1±0.15a	2.9±0.15a	2.2±0.13a	1.8a	24a
		Nagdong	4.9±0.17ab	2.9±0.05a	2.2±0.03a	1.7ab	23ab
2014	Irrigate	Agb0103	4.8±0.14b	2.8±0.10b	2.0±0.07ab	1.8a	20c
		Ilmi	4.8±0.13b	2.8±0.13b	2.0±0.06ab	1.7ab	21b
		Baekjinju	5.1±0.12a	2.8±0.07b	2.1±0.07a	1.8a	22bc
		Junam	4.9±0.19ab	3.0±0.09a	2.1±0.09a	1.7ab	22bc
		Nagdong	4.9±0.13ab	2.8±0.05b	2.0±0.07ab	1.7ab	20c
	Rainfed	Agb0103	4.9±0.13a	2.7±0.09ab	1.9±0.08bc	1.8a	20c
		Ilmi	4.9±0.10a	2.8±0.10b	2.5±2.23a	1.8a	21b
		Baekjinju	4.9±0.17a	2.8±0.06b	2.0±0.08c	1.7ab	23ab
		Junam	4.9±0.16a	2.9±0.04a	2.2±0.09b	1.7ab	22bc
		Nagdong	4.9±0.14a	2.8±0.10b	2.0±0.07c	1.6b	22bc

[a]Mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

was a like the donor plant, Ilmi, and also had little variation in 2014.

Comparison of germination characteristics showed that the average germination rate of the Agb0103 GM rice was 6.64 in the irrigated paddy field in 2013, and the donor plant, Ilmi, was slightly but not significantly different at 6.56. The germination characteristics showed similar traits in rainfed paddy field. The Agb0103 GM rice and the donor plant, Ilmi showed similar patterns in 2014 (Table 6). The viviparous germination of the irrigated and rainfed paddy fields showed that the Agb0103 GM rice and the donor plant, Ilmi, are similar (Table 7). The germination rate and speed of weedy rice broken dormancy was different among cultivars.

Survival Ability of Agb0103 GM Rice in the Natural Environment

Comparison of low-temperature germination showed that average germination rate of Agb0103 GM rice and the donor plant, Ilmi was 17.0 and 7.3 in the irrigated paddy rice field in 2013. The Agb0103 GM rice was slightly faster, but statistically there was no difference between irrigated paddy rice and rainfed paddy rice. However, in 2014 there were high germination rates and higher numbers of average germination days, the difference between Agb0103 GM rice and the donor plant, Ilmi (Table 8).

Discussion

The heading dates of the irrigated and rainfed paddy fields in 2014 were also similar. Yield of Agb0103 has been investigated less than the donor plant Ilmi in irrigated paddy fields; however, in this study there was no statistically significance difference between the two varieties and they showed similar trends in the rainfed and irrigated paddy fields. The result for the main parameters of plant growth in

Table 3: Comparison of ripened grain between Agb0103 and the donor plant, Ilmi

Year	Pedigree	Total spikelet/ panicle[a,b]	Fertility[b]	Sterility[b]	Ratio of ripened grain (%)[b]
2013	Agb0103	129.3±24.7	116.3±17.7	13.0±7.0	89.9±5.8ab
	Ilmi	131.3±17.1	120.3±14.5	11.0±2.6	91.6±1.5a
2014	Agb0103	100.5±11.5	87.0± 7.4	13.5±4.1	86.6±2.9b
	Ilmi	182.9±57.1	162.6±52.0	20.3±5.1	88.9±0.9ab

[a]mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

Table 4: Chemical composition of polished rice each of GM field types

Year	Water supply	Pedigree	Polished rice (%)			
			Amylose[a,b]	lipid[b]	Protein[b]	Starch[b]
2013	Irrigated paddy field	Agb0103	23.2±0.6a	1.6±0.2ab	7.7±0.3a	74.9±0.3a
		Ilmi	22.8±2.4a	1.9±0.1a	8.2±0.2a	72.5±0.3ab
		Baekjinju	19.4±1.4b	1.8±0.1a	7.5±1.4a	68.1±0.2c
		Junam	24.7±0.1a	2.0±0.3a	7.5±0.7a	76.4±0.5a
	Rainfed paddy field	Agb0103	23.8±0.4a	1.8±0.1a	7.4±0.3ab	75.2±0.3a
		Ilmi	22.7±1.8a	1.9±0.1a	8.2±0.2a	72.5±0.3ab
		Baekjinju	19.4±1.2b	1.8±0.2a	7.5±0.2ab	68.1±0.4c
		Junam	24.7±0.4a	2.0±0.1a	7.5±0.2ab	76.4±0.3a
2014	Irrigated paddy field	Agb0103	18.1±0.6a	1.6±0.2ab	6.4±0.3a	74.3±0.3a
		Ilmi	18.3±1.4a	1.8±0.1a	6.3±0.2a	73.5±0.2ab
		Baekjinju	18.2±1.4a	1.8±0.1a	6.2±0.7a	68.5±0.3c
		Junam	18.3±0.1a	1.9±0.2a	5.8±1.4ab	76.9±0.3a
	Rainfed paddy field	Agb0103	17.9±0.4a	1.7±0.2ab	6.1±0.3a	75.9±0.4a
		Ilmi	18.2±1.2a	1.7±0.1ab	6.1±0.3a	72.5±0.1ab
		Baekjinju	18.6±0.8a	1.8±0.3ab	6.3±0.2a	68.1±0.5c
		Junam	18.2±0.4a	2.0±0.1a	6.0±0.2a	76.2±0.4a

[a]Mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

Table 5: Seed shattering trait each of GM field types

Year	Water supply	Pedigree	Strength (gf)	
			Pulling[a,b]	Bending[b]
2013	Irrigated paddy field	Agb0103	170.8±41.7b	27.0±11.9c
		Ilmi	220.1±20.5a	46.1±21.4a
		Baekjinju	233.2±31.0a	36.1±17.4b
		Junam	88.9±39.5c	28.0±12.6c
		Nagdong	187.5±35.0b	25.6±11.5c
	Rainfed paddy field	Agb0103	235.6±19.2a	18.7±10.3c
		Ilmi	209.1±32.8b	29.0±13.0a
		Baekjinju	208.6±41.2b	30.3± 7.5a
		Junam	112.3±55.7d	25.1±10.3b
		Nagdong	156.8±51.3c	18.1±10.7c
2014	Irrigated paddy field	Agb0103	169.8±53.8b	18.6±11.7c
		Ilmi	150.9±58.4c	14.2±11.1c
		Baekjinju	142.4±61.3c	10.8± 6.1cd
		Junam	286.0±70.3a	51.1±11.3a
		Nagdong	178.4±45.5b	31.1± 8.5b
	Rainfed paddy field	Agb0103	171.0±56.0c	15.1± 5.4c
		Ilmi	169.6±43.1c	11.1± 6.4c
		Baekjinju	110.3±57.8d	5.5± 3.4d
		Junam	283.0±72.6a	55.8±15.4a
		Nagdong	214.9±40.3b	44.9± 9.4b

[a]mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

Table 6: Germination of character each of GM field types

Year	Water supply	Pedigree	Total seed	Average rate to germination[a,b]	Average days to germination[b]	Germination rate[b]
2013	Irrigated paddy field	Agb0103	300	6.64±0.04b	3.54±0.13b	99.7±0.58a
		Ilmi	300	6.67±0.10b	3.18±0.04b	100±0.00a
		Junam	300	6.56±0.14b	3.53±0.08b	98.3±2.01a
		Nagdong	300	6.62±0.04b	3.84±0.12b	99.3±0.58a
		Baekjinju	300	13.90±0.20a	6.80±0.10a	97.3±1.50a
	Rainfed paddy field	Agb0103	300	12.8±0.40ab	6.30±0.20a	89.3±3.10b
		Ilmi	300	10.9±4.30c	5.30±2.10b	76.3±29.90c
		Junam	300	13.6±0.80a	6.70±0.40a	95.3±5.50ab
		Nagdong	300	14.1±0.10a	6.90±0.00a	98.7±0.60a
		Baekjinju	300	14.1±0.10a	6.90±0.00a	98.7±0.60a
2014	Irrigated paddy field	Agb0103	300	6.67±0.00a	3.00±0.02a	100.0±0.00a
		Ilmi	300	6.67±0.00a	2.96±0.02a	100.0±0.00a
		Junam	300	6.58±0.04a	2.99±0.03a	98.7±0.58a
		Nagdong	300	6.62±0.04a	3.00±0.06a	99.3±0.58a
		Baekjinju	300	6.44±0.08a	2.98±0.04a	96.7±1.15ab
	Rainfed paddy field	Agb0103	300	6.64±0.04a	3.54±0.13a	100.0±0.00a
		Ilmi	300	6.67±0.10a	3.18±0.04a	100.0±0.00a
		Junam	300	6.56±0.14a	3.53±0.08a	98.7±0.58a
		Nagdong	300	6.62±0.04a	3.84±0.12a	99.3±0.58a
		Baekjinju	300	6.38±0.04b	3.79±0.06a	96.7±1.15ab

[a]Mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

this study perfectly matched the standard values (Messeguer *et al*., 2001). Development of the panicle and spikelet by the drought conditions was suppressed in rice (Asch *et al*., 2005). Development process for the drought Agb0103 decreased spikelet of filling rate indicates the drought tolerance of the reproductive stage that had been protected from drying stress. Overexpression of drought of Agb0103, in contrast, it was not effective in increasing the productivity of grain. GM rice can show differences in growth and development of fertile plants, to improve stress tolerance, it is important to evaluate the agronomic traits in transgenic crops (Oh *et al*., 2014; Asch *et al*., 2005; Bergmans *et al*., 2008; Ma *et al.*, 2016). Thus, some agronomic parameters showed a cultivars difference, there were no statistically significant differences in Agb0103 compared to the donor plant, Ilmi, between the irrigated and rainfed paddy fields each of 2013 and 2014. Abiotic stress tolerant transgenic rice plants are also found to exhibit a visible phenotype both growth inhibition (Oh *et al*., 2005). A large majority of GM rice plant performance has been found that it was inferior to the non-transgenic control (Shu *et al*., 2002). Decreased yield was considered due to the reduction of ripened grain in agricultural properties in 2014 compared with 2013. Fertility at the ratio of ripened grain stage is closely associated with spikelet density, but variation was observed in this relationship for the 2 years of the study (Table 1, 2, 3). These results demonstrate that Agb0103 GM rice in rainfed paddy fields can improve rice grain yield under drought conditions without conferring an undesirable growth phenotype.

Plant responds, and then adapt to abiotic stress in order to survive under adverse conditions (Oh *et al*., 2009). Therefore, it should be possible to successfully cultivate Agb0103 GM rice in rainfed paddy field environments such as the west coast area of South Korea. The Agb0103 GM rice was even stably cultivated under organic farming techniques and therefore similar quantities can be expected regardless of the characteristics of the specific cultivation field. Shattering showed similar values over the 2 years. This result means that seeds are prevented from being inadvertently released into the environment. If we reduce the shattering of rice, seeds will be domesticated and will not spread out to environment (Li *et al*., 2006). Germination experiments are most commonly used to determine seed viability. Seed viability denotes the degree to which a seed is alive, metabolically active, and depends on the environmental conditions to which they are exposed. The ability of seeds to germinate at low temperatures is an important agricultural trait for direct seeding of rice in the natural environment. And average of low temperature germination per cent is lower than germination in general temperature per cent. This means that seeds very difficult to germinate in frozen-soil when they are spread out to environment in harvest (Roberts, 1965).

Conclusion

Concerns about transgenic crops still strongly remain in the world. So, we already did a few experiments about safety assessment to ease the recognition about problems. Whether data are needed at all for risk assessment of GM stacked events has been argued. Commercial cultivation of transgenic crops started in the early 1990 and development of commercial GM rice cultivated genetically modified (GM) crops and the country has been increasing continuously. GM crops are now commercially planted on

Table 7: Viviparous germination ratio of harvest each of GM field types

Water supply	Pedigree	Average spiklet/panicle[a,b]	Viviparous germination (%)[b]
Irrigated paddy field	Agb0103	128.3±6.1c	2.6d
	Ilmi	162.0±18.0a	7.2c
	Baekjinju	140.3±11.6b	37.5b
	Junam	102.7±26.8d	6.5c
	Nagdong	110.0± 2.6d	56.1a
Rainfed paddy field	Agb0103	134.0±21.4a	0.5c
	Ilmi	131.0± 3.0ab	2.5c
	Baekjinju	105.0±11.5d	39.4a
	Junam	128.3± 2.5c	1.8c
	Nagdong	133.3± 5.1a	12.8b

[a]Mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

Table 8: Germination ratio of low temperature each of GM field types

Year	Field type	Pedigree	No. total seeds	Average rate of germination[b]	Average Days of germination[b]	Germination (%)[a,b]
2013	Irrigated paddy field	Agb0103	300	2.4±1.5c	1.2±0.7b	17.0±10.6c
		Ilmi	300	1.0±0.2d	0.5±0.1c	7.3± 1.5d
		Junam	300	0.9±0.7d	0.4±0.3c	6.3± 4.9d
		Nagdong	300	5.6±1.6b	2.8±0.8ab	39.3±11.0b
		Baekjinju	300	7.3±2.8a	3.6±1.4a	51.0±19.9a
	Rainfed paddy field	Agb0103	300	0.2±0.1c	0.1±0.0c	1.3±0.6c
		Ilmi	300	0.4±0.3c	0.2±0.1c	2.7±2.1c
		Junam	300	0.2±0.1c	0.1±0.0c	1.7±0.6c
		Nagdong	300	3.2±1.2a	1.6±0.6ab	22.3±8.4b
		Baekjinju	300	4.3±0.9a	2.1±0.4a	30.3±6.1a
2014	Irrigated paddy field	Agb0103	300	5.4±0.21a	3.6±0.18a	80.3±3.21ab
		Ilmi	300	5.5±0.34a	3.5±0.31a	82.7±5.13a
		Junam	300	1.2±0.13c	1.3±0.15c	18.0±2.00d
		Nagdong	300	2.0±1.13b	1.5±0.25c	30.0±4.58c
		Baekjinju	300	1.4±0.59c	1.7±0.28c	21.0±8.89cd
	Rainfed paddy field	Agb0103	300	6.1±0.40a	10.6±0.38ab	91.0±3.61ab
		Ilmi	300	6.3±0.42a	11.3±0.74a	94.7±2.52a
		Junam	300	6.1±0.41a	11.4±0.48a	91.3±3.21ab
		Nagdong	300	6.4±0.42a	11.8±0.09a	95.3±1.53a
		Baekjinju	300	5.6±0.38ab	10.7±0.74ab	84.7±5.51c

[a]Mean±SD, [b]Mean followed by same letter within a row are not significantly different at the 5% level

about 100 million hectares in some 22 developed and developing countries (FAO, 2011). Based on this fact, the needs for GM crops are increasing. But unintended effects might be caused by the method of genetic engineering for GM plants. To solve this problem the agricultural safety assessment can increase the likelihoods of identifying unintended effects in the GM crops as comparison of agronomic characteristics, weedy potential, survival ability and the hybridization in control rice by pollen-mediated gene flow. Although data measured different among cultivars and years there was no statistically significance difference and they showed similar trends each of the treatment GM field. Rice, most of outcrossing is closely a small amount of pollen to occur between the adjacent plants to reproduce almost completely by self-fertilization. There are no records of naturally occurring hybrids between rice and any wild relatives in South Korea. Experimental monitoring of commercial release of GM rice is done based on good scientific knowledge of wild relatives and ecology GM rice of wild relatives and ecology GM rice. In this study, we discussed agricultural safety. As such, it remains to be seen whether the coexistence policy will ever succeed in appeasing the contending normative positions raised on agricultural futures and the role agro-food biotechnology might play therein not to mention letting different cropping systems exist 'peacefully' together in practice.

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