‘Hyemalgeun’: A New Covered Barley Variety with Low Proanthocyanidin Content Suitable for Making Clear *Sikhye*

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ABSTRACT

▶ To develop a barley variety suitable for making clear *sikhye* (traditional Korean rice beverage) with high enzyme activity and low proanthocyanidin content, artificial crossbreeding was conducted between ‘Topgolbori(IT56909)’ which has lodging resistance and high yield, and ‘Ant17-154’, which has low proanthocyanidin content. Subsequently, in 2010, the progeny was crossed again with ‘Hyemi’. After the F_1 generation was produced in 2011, the F_2-F_3 generations were developed as a bulk from 2012 to 2013. In 2014-2015, elite lines with low proanthocyanidin content were selected from the F_4-F_5 generation through vanillin analysis. In 2016, the selected elite lines were tested as Observational yield trial(OYT), and the ‘IC10008-B-B-9-1’ line was selected. This selected line was recognized for its excellence after a two-years yield trial(2016-2017) and given the breeding line name "Jeonju518." The regional yield trials(RYT) were conducted for ‘Hyemalgeun’ as a breeding line ‘Jeonju518’ in five different regions from 2019 to 2021(RDA).

▶ The culm length of ‘Hyemalgeun’ was 84cm, which was similar to that of ‘Hyeyang’(82cm) and a weight of 34.8g for 1,000 grains which was heavier than ‘Hyeyang’(29.7g). ‘Hyemalgeun’ showed intermediate resistance to barley yellow mosaic virus (BaYMV) and susceptible to Powdery mildew which was similar to ‘Hyeyang’. The yield of ‘Hyemalgeun’ in the regional yield trial was 522kg/10a(overall average between upland and paddy field) which was similar to that of ‘Hyeyang’(516kg/10a).

▶ ‘Hyemalgeun’ showed similar levels as those of ‘Hyeyang’ with respect to protein, β-glucan(11.3%, 4.8% respectively). However, ‘Hyemalgeun’ showed lower proanthocyanidin content(0.0099mg/g) than ‘Hyeyang’(0.1401 mg/g) and higher enzyme activity(460WK) than Hye-yang(397WK). Furthermore, when making *Sikhye*, ‘Hyemalgeun’ showed higher sweetness level(11.4°Bx) than ‘Hyeyang'(11.0°Bx), and the turbidity level was 0.58, indicating a clear appearance. ‘Hyemalgeun’ has similar agricultural traits to existing varieties but has low proanthocyanidin content and high enzyme activity, making it suitable for producing clear *sikhye*. It is planned to be distributed in barley cultivation areas with a minimum average temperature above -6°C in January.

MATERIALS & METHODS

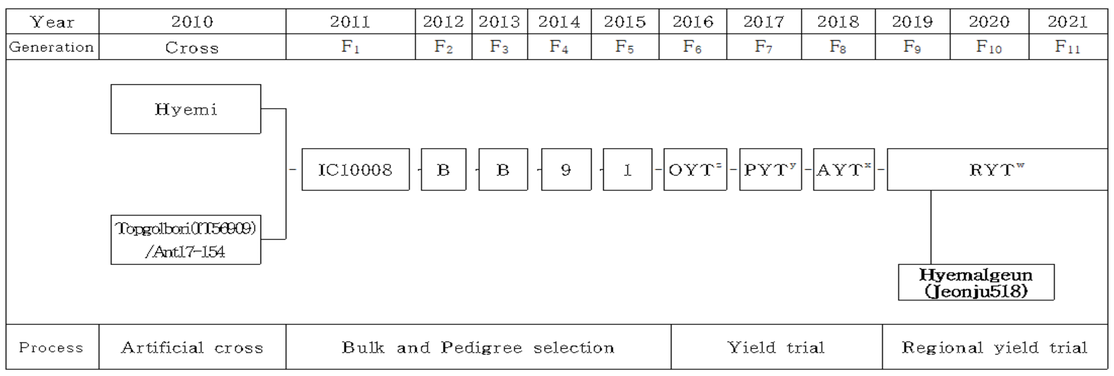

Figure 1. Pedigree diagram of covered barley cultivar, ‘Hyemalgeun’.

▶ Breeding method: Bulk(F_2-F_3) and Pedigree(F_4-F_7) breeding
▶ OYT: Observational yield trial, PYT: Preliminary yield trial, AYT: Advanced yield trial
▶ Regional yield trials (RYT) test: 3 years (from 2019 to 2021),
5 regions (Suwon, Chuncheon, Cheongju, Jeonju and Daegu)
▶ Characteristic analysis: Lodging tolerance, Powdery mildew and BaYMV resistance
▶ Quality analysis: Grain (protein, β-glucan, proanthocyanidin content)
Malt (length, enzyme activity, color)
Sikhye (sweetness and turbidity level, free sugar, color)

RESULTS

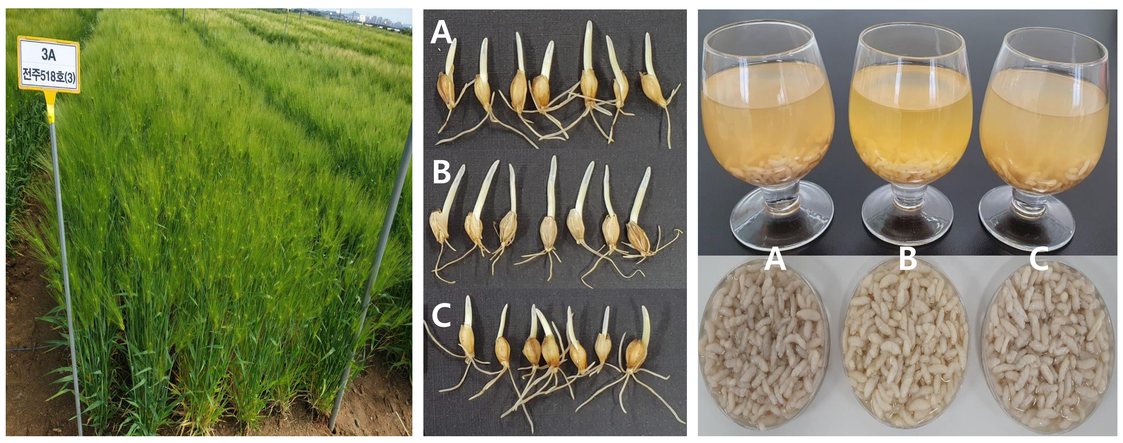

Figure 2. Heading status, malt and *sikhye* of ‘Hyemalgeun’.

A: Hyemi, B: Hyemalgeun, C: Hyeyang

Table 1. Agronomic characteristics of ‘Hyemalgeun’ cultivated in Suwon, Chuncheon, Cheongju, Jeonju and Daegu regions from 2019 to 2021.

Cultivar	Heading date (Mon. Day)	Maturity date (Mon. Day)	Culm length (cm)	Spike length (cm)	No. of spike per m^2	No. of grains per spike	1000 grain weight (g)
Hyemalgeun	Apr.23	Jun.1	84^{ns}	5.0*	638^{ns}	52*	34.8*
Hyeyang	Apr.21	May.30	82	4.5	692	55	29.7

ns and * mean no significant and significant difference at α=0.05 by t-test, respectively.

Table 2. Lodging tolerance, Powdery mildew and BaYMV resistance of cultivar ‘Hyemalgeun ’ tested in Suwon, Chuncheon, Cheongju, jeonju, Daegu, Naju, Iksan and Jinju regions from 2019 to 2021.

Cultivar	Lodging tolerance (0~9)z	Powdery mildewy	BaYMV (0~9)x		
			Naju (Ⅰ)	Iksan (Ⅲ)	Jinju (Ⅳ)
Hyemalgeun	2	Susceptible	0	3	0
Hyeyang	2	Susceptible	0	1	0

z 0: Resistance, 9: Lodging
y Disease incidence induced natural infection at plastic house at Jeonju for three years.
x Investigation at viral infested field for three years (0: Resistance, 9: Susceptible).

Table 3. Yield potential of ‘Hyemalgeun’ in the regional yield trials (RYT) tested in Suwon, Chuncheon, Cheongju, Jeonju and Daegu regions from 2019 to 2021.

Field	Region	Hyemalgeun (kg/10a)				Index (A/B) ×100	Hyeyang (kg/10a)			
		2019	2020	2021	Mean (A)		2019	2020	2021	Mean (B)
Upland	Suwon	556	721	669	649	95	589	752	716	686
	Chuncheon	340	608	827	592	112	371	701	516	529
	Cheongju	424	431	468	441	102	420	385	488	431
	Mean	440	587	655	561	102	460	613	573	549
Paddy	Jeonju	562	372	497	477	101	569	415	428	471
	Daegu	357	561	436	451	97	334	597	464	465
	Mean	460	467	467	464	99	452	506	446	468
Total Mean		448	539	579	522^{ns}	101	457	570	522	516

ns means no significant at p<0.05 by t-test.

Table 4. Grain and malt qualities of ‘Hyemalgeun’.

Cultivar	Grain			Malt				
	Protein content (%)	β-glucan content (%)	Proanthocyanidin content (mg/g)	Length (cm)	Enzyme activity (WK)	Colorx		
						L	a	b
Hyemalgeun	11.3^{ns}	4.8^{ns}	0.0099c	14.6a	460a	55.0a	5.0a	15.3a
Hyeyang	10.9	5.3	0.1401a	6.9b	397c	54.3b	4.7b	14.8b
Hyemi	-	-	0.1329b	7.7b	450b	54.6ab	4.4c	14.0c

Different letters within a column indicate significant difference between cultivars (DMRT, p<0.05)
x L: Black-White, a: Green-Red, b: Blue-Yellow

Table 5. *Sikhye* qualities of ‘Hyemalgeun’.

Cultivar	Sweetness level (°Brix)	Turbidity level	Free sugar(%)				Color(L)x	
			Total	Glucose	Maltose	Maltotriose	Solid(rice)	Liquid
Hyemalgeun	11.4a	0.58c	7.1a	1.45a	4.50a	1.18a	62a	78a
Hyeyang	11.0b	1.06a	7.0ab	1.41b	4.46a	1.13a	57b	66c
Hyemi	11.1ab	0.75b	6.8b	1.34c	4.36a	1.13a	56b	76b

Different letters within a column indicate significant difference between cultivars (DMRT, p<0.05)
x L: Black-White

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