

한국 육성 벼 품종의 DNA profiling에 의한 유전적 다양성 분석 및 품종 판별

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Discrimination of Korean rice varieties as revealed by DNA profiling and its relationship with genetic diversity

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Abstract This study is to establish the varietal discrimination based on DNA profiling of different varieties of rice. We examined the genetic distance among Korean rice varieties using allele frequencies and a genetic diversity analysis with Simple Sequence Repeats (SSRs) markers. The analysis of the genetic diversity and genetic relationships of 243 Korean rice varieties was varied out using 20 SSRs markers. A total of 268 alleles were detected, ranging from 6 to 32, with an average of 13.45 alleles per locus, and an average of gene diversity (GD) of 0.556. Seven SSR markers were selected as key markers for discrimination among the Korean rice varieties. Concerning the results, 243 varieties (100%) were discriminated among by using acrylamide gel and fragment analyzer-based markers. In conclusion, this study provides useful basic data that can be utilized concerning Korean rice varieties breeding and development. In addition, we will have to manage and conserve as a valuable genetic resource, without losing the diversity of Korean rice varieties.

Keywords Discrimination, Korean rice variety, Genetic diversity, Simple sequence repeats (SSRs)

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서 언

벼(*Oryza sativa* L.)는 밀, 옥수수과 함께 세계 3대 식량 작물 중 하나로서 전 세계 60억 인구가 주식으로 이용하고 있다. 또한 벼 염색체 완전해독연구(<http://rgp.dna.affrc.go.jp/IRGSP/>)가 2004년 완료된 이후 전세계적으로 벼 유전자 3만여 개의 기능을 밝히고 유용 형질 유전자 분리 및 타 작물 유전자와의 비교 분석 연구를 통한 실용화 연구에 박차를 가하고 있다(Park et al. 2011; Yoon et al. 2011).

최근, 종자산업법에서는 육종가, 발명자의 권리를 보호하고 자 신품종 개발 시 기존 품종과의 차별성을 제시하도록 하고 있으며, 국제신품종보호동맹(International Union for the Protection of New Varieties of Plants, UPOV)에서도 신품종의 구별성 검정에 DNA 마커의 활용을 적극 검토하고 있다(Kim et al. 2011).

1970년대 초반부터 여러 종류의 분자 마커가 개발되어 왔으며, 지금까지 개발된 DNA 마커로는 RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphic DNA), SSRs (Simple Sequence Repeats), STS (Sequence Tagged Sites), SNP (Single Nucleotide Polymorphism) 등이 널리 사용되고 있다. 이러한 마커는 비용이 적게 들며, 간편하고, 시발체에 대한 정보가 불필요하며, 많은 정보를 제공하여 다형성 탐지, 중간 구분, 진화계통도 정립 등에 크게 기여하였다(Kim et al. 2006; Hwang et al. 2008; Jang et al. 2009; Hwang et al. 2012).

Simple sequence repeats (SSRs)는 대부분 2~9 bp의 단일염기의 반복으로 이루어진 DNA 염기서열로 DNA 복제 과정에서 DNA polymerase의 미끄러짐 현상이나 불공평한 교차로 인하여 품종 또는 개체 간의 다형성이 생긴다. SSR 마커는 PCR을 기반으로 다형성과 재현성이 높아 품종판별 및 유전적 다양성 분석에 특히 많이 이용되고 있다(He et al. 2003;

Hwang et al. 2012). 그러나 국내에서는 여러 작물에 대한 DNA Profile의 데이터베이스를 구축하여 다방면에 활용하고 있으나(Hong et al. 2013a; Hong et al. 2013b; Kwon and Choi 2013), 국제신품종보호동맹(UPOV)의 사례와 같이 국가적이고 표준화된 데이터베이스의 구축은 미흡한 실정으로 차후에 분석결과에 신뢰도 및 공정성에 대한 문제점이 발생할 수 있을 것으로 예상된다.

따라서, 본 연구는 벼 품종의 DNA profiling을 위하여 SSR 마커 20종을 국내 육성 벼 243개 품종에 적용하여 이들의 유전자좌의 다양성을 이용하여 품종 판별 여부를 확인하였다. 또한, 향후 국내 육성 품종, 육성계통 및 다양한 유전자원을 대상으로 이들의 유전적 다형성 분석, 구별성 및 균일성 검증 등에 활용하고자 수행하였다.

재료 및 방법

시험재료 및 재배법

시험재료는 국내에서 육성된 벼 품종 중 Japonica 벼 품종의 육성이 본격화 되었던 1982년부터 2013년까지 국립종자원을 통하여 보급된 243개 벼 품종이 사용되었다(Table 1). 벼 품종은 2015년과 2016년에 충북대학교 시험포장에 이양하여 재배하였다. 품종 당 1주 1본씩, 16주/열, 3열로 이양하였으며 물 관리와 비료의 시용 및 병, 해충의 방제는 농촌진흥청 벼 표준재배법에 준하여 수행하였다(RDA 2003).

DNA 추출

벼 품종의 DNA 추출은 CTAB (Cetyltrimethyl ammonium bromide) 법을 이용하였다. 품종 별로 이양 후 15일된 어린잎으로부터 0.5 g의 조직을 채취하여 액체 질소를 이용하여 미세하게 분쇄하였고, DNA 추출 완충액 400 μ l가 담긴 1.5 ml 원심분리용 튜브에 분쇄한 조직을 넣고 상하로 20회 흔들어 혼합하였다. 그 후 2X CTAB 완충액 200 μ l를 첨가하여 같은 방법으로 혼합하고 10% SDS를 넣고 10회 정도 상하로 흔들어 혼합한 후, 65°C 항온수조에서 20분간 반응시켰다. 5M potassium acetate (pH 7.5) 200 μ l를 첨가하고 50회 정도로 상하로 흔들어 섞어 준 후, Phenol/Chloroform/Isoamylalcohol (25:24:1)를 700 μ l 넣고 30회 정도 상하로 섞어 실온에서 12,000 rpm, 10 분간 원심분리하여 단백질을 분리해냈다. 상층액 400 μ l 정도를 새로운 1.5 ml 튜브로 옮긴 후 동량의 isopropanol을 첨가하여 -20°C 냉동고에 20분간 보관하였다가 4°C의 12,000 rpm에서 15분간 원심분리하여 DNA를 침전시켰다. 침전된 DNA를 70% ethanol 1 ml를 넣고 세척한 다음 실온에서 완전히 건조시키고 RNase (1 mg/ml) 2 μ l가 첨가된 TE 완충액 50 μ l에 충분히 녹인 후 37°C에서 1시간 방치한 후 사용하였다. 추출한 DNA는

λ DNA (100 ng/ μ l)와 함께 1% agarose gel에서 확인하였고 20 ng/ μ l로 정량하여 실험에 사용하였다.

SSR 마커 분석

DNA profiling을 위하여 SSR 마커의 PCR 분석은 반응액으로 20 ng의 genomic DNA, 10X PCR buffer, 0.25 μ mol의 primer, 250 μ mol의 dNTP, 50 mM의 KCl, 10 mM Tris-HCl pH8.3 0.01% gelatin, 1.5 mM MgCl₂와 2.5 unit의 Taq DNA polymerase를 혼합하였다. DNA 증폭은 Thermal Cycler (Bio-Rad, T100)를 사용하여, Hot step을 94°C에서 5 분간 실시하고, 94°C에서 40 초간 denaturation, SSR 마커에 따라 52~60°C로 30 초간 annealing, 72°C에서 30초간 extension의 과정을 35회 반복하고, 10분 동안 최종 extension을 수행하였다(Table 2).

PCR 증폭산물은 4% polyacrylamide gel을 이용하여 전기영동한 다음 silver sequenceTM staining reagents (Promega, USA)으로 염색하였고 각 품종별 대립유전자의 차이를 분석하여 다형성을 보이는 마커를 선발하였다. 또한, 일부 마커에 대한 PCR 증폭산물은 Fragment capillary gel electrophoresis system (Fragment analyzer, USA)을 이용하여 전기영동하였으며, 각 마커에 대한 fragment의 사이즈 및 scoring은 PROSize 2.0 software (Fragment analyzer, USA)를 이용하여 실시하였다.

데이터 분석 및 품종판별

통계프로그램 SAS version 9.2 (SAS Institute Inc. 2004)과 Multibase program (<http://www.numericaldynamics.com>)을 이용하였으며 2015년도와 2016년도에 243개 품종으로부터 얻어진 데이터를 분산분석을 통해 유의성을 검증하고 주성분 분석과 군집 분석을 수행하였다.

벼의 품종판별을 위해 20개의 SSR 마커 중 다양성이 높은 4개의 마커를 먼저 선발하였고, 판별되지 않은 품종들을 확인하여 효율적으로 판별할 수 있는 마커 3개를 추가로 선발하였다. 1단계에서 가장 다양성이 높은 마커를 이용하여 품종판별을 하였고, 2단계에서 그 다음으로 다양성이 높은 마커를 이용하여 품종을 판별하는 방법으로 6단계까지 7개의 SSR 마커를 이용하여 품종을 판별하였다.

결과 및 고찰

SSR 마커 분석

본 연구는 국내 육성 벼 243개 품종에 대한 SSR 마커를 이용하여 품종간 다형성 정도를 분석하고자 수행하였다. Polyacrylamide gel 및 fragment analyzer에서 다형성을 보이는 SSR 마커 중 PCR 증폭이 약한 밴드는 제외하고, 밴드 패턴이 선

Table 1 List of 243 Korean rice varieties used in this study

Code	Variety name	Type (J/T)	Registrati on year	Cross Combination	Code	Variety name	Type (J/T)	Registrati on year	Cross Combination
1	Keumyeong	J	2009	Sanbaek/Iksan423//Sangju22	131	Onnuri	J	2005	Milyang165/HR14732-B-67-2-3
2	Durujinmi	J	2010	Suwon478/Odae	132	Wonkwang	J	2000	Seomjin Mutant
3	Manho	J	2002	Singeumo/Iksan423	133	Wonmi	J	2000	Seomjin Mutant
4	Sandeuljinmi	J	2006	Sambaek/Yongseong12	134	Wonhwang	J	1998	Milyang96/Iri390/Milyang5
5	Samcheonbyeo	J	1995	Unbong/Fukei126	135	Yunnongchamssal	J	2008	Dong poor rice/Glutinous rice
6	Unjangbyeo	J	1994	Unbong//Suwon244/Hwasetoramoji//Sangnam	136	Joryeongbyeo	J	1992	Gosihikari/Seonam//Milyang79
7	Wonpyeong	J	1999	Hwaseong Mutant	137	Jongnam	J	2001	Milyang96/YR12734-B-B-22-2
8	Jeokjinju	J	2000	Obong//Obong/Syare	138	Juan1	J	2005	Ilpum/SR18392-HB683-104
9	Josaengheukchal	J	2004	Dongbukna149/Sx864	139	Jungmo1001	J	2004	Cheolwon52/SR21049
10	Joan	J	2003	Jinmi/jinbu10	140	Jungmo1012	J	2007	Sambaek/Ou329
11	Jungmo1011	J	2010	Suwon478/Unbong33	141	Jungmo1014	J	2010	Milyang207/Samgwang
12	Jinbong	J	2000	Jinmi/Unbong	142	Jungmo1009	J	2009	YR22207//Iksan2443/Milyang165
13	Taebong	J	2000	SR13330-13-3-5-2-1/Jinbu10	143	Jungsan	J	2000	Sambaek/Milyang107
14	Taeseong	J	2002	Cheolwon49/Jinbu10	144	Cheongdam	J	2006	SR19200-HB826-34/Juan
15	Hwanggeumbora	J	2006	Jinbu/Odae//Fukei126	145	Cheongho	J	2004	Iri407/Iri417
16	Heukseonchal	J	1999	Sanghaehyanghyeolra Mutant	146	Pungmi	J	2004	Milyang165//YR16365Acp13/Iksan438
17	Geurubyeo	J	1997	Suwon313/Cheolwon42	147	Pungmi1	J	2005	YR13616Acp1/Milyang122
18	Geumseong	J	2003	Hajjebosi/Hyangmi	148	Hangangchal1	T	2006	Hangangchal/YR8208-20
19	Dunnaebyeo	J	1992	SR11139-48-1/Suwon320	149	Hanmaeum	J	2004	Milyang165//YR16365Acp13/Iksan438
20	Manna	J	2005	Iksan438/Imi	150	Hanareum2	T	2010	Milyang181/Milyang154
21	Manchu	J	2001	Jinmi/Unbong12	151	Haepyeong	J	2000	Milyang101/Akichikara
22	Sambaekbyeo	J	1993	Gosihikkari/TR2406-2-1-1//Hukkurikkul15/Cheolwon29	152	Haepyeongchal	J	2004	Haepyeong Natural Mutant
23	Sangsanyeo	J	1993	Sobaek/Daeseong	153	Hyangnambyeo	J	1995	Iri389/Dohoku144
24	Sangjuchalbyeo	J	1997	YR4117-99-1-1-2-4/YR4200-2-3-2-2	154	Hongjinju	J	2006	SR18164F2/Suwon383
25	Seolbaek	J	2010	Suwon360/Geuru	155	Hwanambyeo	J	1993	Milyang95/Tamjin
26	Sinunbong1	J	2005	Sangju/Unbong17	156	Hwadongbyeo	J	1997	Daejin/SR13345-20-1
27	Ansanyeo	J	1995	Rax102-123/Seonam	157	Hwabong	J	1998	Milyang95/Iri390//Milyang101/Iri390
28	Wonhae	J	2007	Dongjin Mutant	158	Hwasambyeo	J	1996	Milyang101/Iri389
29	Wolbaek	J	2010	Milkikwin/Geuru	159	Hwaseonchalbyeo	J	1992	Inabawase/Dongjin
30	Inwol	J	1998	Fukei127/Unbong	160	Hwasinbyeo	J	1995	Iri390/Milyang110
31	Joun	J	2009	SR14880-173-3-3-2-2-2/Unbong20	161	Hwaan	J	2000	Suwon362/SR10778-2-2
32	Jungmo1007	J	2009	Sanbaek/Unbong19	162	Hwajungbyeo	J	1993	SaSanisiki/Cheonma
33	Junghwabyeo	J	1995	Etnan126/Bokgang//Daeseong	163	Heukgawichal	J	2008	Iksan427/Gawichal
34	Cheongbaekchal	J	2010	SR20261-5-4-10/Jinbuchal	164	Geonganghongmi	J	2010	Sugary*2/Milyang152
35	Hyangmibyeo	T	1996	IR841-76-1/Suwon334	165	Goami	J	2000	Milyang95//Kimcheon poor rice/Ilpum
36	Goun	J	2004	Jinbu10/Jinbu17	166	Geuman	J	2002	SR11878-14-4-1/Suwon345
37	Namil	J	2002	Ilpum/Namyang7	167	Geumobyeo2	J	1996	Milyang96//YR6419Acp13/Palgong
38	Manan	J	1998	Milyang110/Milyang110/Yeongdeok7	168	Namgangbyeo	J	1997	.Milyang95/Milyang96
39	Munjang	J	1999	Sangsang/Suwon397	169	Nogyang	T	2006	Yongmun/IR67396-16-3-3-1
40	Sangmi	J	1998	Sambaek/Ou316	170	Daeripbyeo1	J	1993	Niheunmasari ms/BG29
41	Saasangju	J	2001	Junghwa/Sambaek	171	Daepyeong	J	2002	HR14028-AC-5/Milyang122
42	Odae1	J	2005	Ilpum/Jinbu10	172	Dongwon	J	2011	-
43	Undu	J	1998	Odae/Jinbu13	173	Manmi	J	2002	Milyang95//Bukryukbanna/Milyang95
44	Wonpum	J	2004	Ilpum Mutant	174	Mogyang	J	2010	SR24592-HB2319/IR3165-B-6-1-1
45	Jeokjinjuchal	J	2010	Sangnambat/Jeokjinju	175	Milkikwin	J	2007	Gosihikari Mutant
46	Jopyeong	J	2010	HR16683-46-3/HR18129-B-16	176	Sampyeong	J	2000	Suwon345/SR11340-46-5-4-1
47	Daechan	J	2009	Nongan/2*Suwon403	177	Saechucheong	J	1999	Daeseong/5*Chucheong//Bonggwang/5*C hucheong
48	Jungmo1010	J	2009	SR18390-9-7-2-5/IR66160-5-2-3-2	178	Seonong15	J	2010	Heukjinju/Floury rice
49	Heukjinjubyeo	J	1997	Yongjeong4/Segeum	179	Seolhyangchal	J	1999	Miyagaori/2*Suwon357
50	Jakwangchal	J	2007	Jinbuchal/Jagwangdo	180	Seongjochal	J	2008	Wangchal Mutant
51	Hwanggeumchal	J	2007	Sakita/Jinbuchal	181	Suan	J	2010	HR20017-B-19-3-1/Iksan467
52	Daeanbyeo	J	1994	Oseto/Seomjin	182	Sindongjin	J	1999	Hwayeong/YR13604ACP22
53	Seomyeong	J	2009	Kyehwa21/Milyang165	183	Aranghyangchalbyeo	J	1997	Sinseonchal/Tohoku144

Table 1 Continued

Code	Variety name	Type (J/T) ^z	Registrati on year	Cross Combination	Code	Variety name	Type (J/T)	Registrati on year	Cross Combination
54	Seojin	J	1996	Aijji37/Sangpung	184	Onojjinoijji	J	-	
55	Juanbyeo	J	1994	Seolak/Gosihikkari//Samnam	185	Wonchu	J	2001	Chucheong Mutant
56	Hojin	J	2000	Hwayeong//Dongjin/Milyang95	186	Jungan	J	1999	Namyang7/2*Hapcheon1
57	Hwarang	J	2003	Iksan420/YR13616Acp1	187	Jimbo	J	2009	Yeongdeok26/Gosihikari
58	Hwamyongbyeo	J	1997	Hwayeong/SR14779-HB234-32	188	Jinsang	J	2008	Yumetsukushi/Milkykwin
59	Nampyeongbyeo	J	1997	HR11735-82-1-5-5/Milyang95	189	Garak	J	2009	Chucheong/Sinseonchal
60	Naepungbyeo	J	1995	Milyang97//OU316/Iri373	190	Kwangan	J	1998	Namyang7/SR14779-HB234-31
61	Dasan	T	1995	Suwon332/Suwon333	191	Geumtap	J	2008	Sinseonchal//Juan/쌀사레
62	Dasan1	T	2006	Bangal//Yongju/Dasan	192	Noreunjachal	J	2008	Sinseonchal//Juan/쌀사레
63	Daesanbyeo	J	1996	Milyang95/Suwon366	193	Nunbora	J	2006	Iksan433/Miyadanamoggi
64	Dongbo	J	2010	Yeongdeok19/Gosihikkari	194	Daeripjami	J	2009	C3GHi/Daerip1
65	Dongan	J	1996	Milyang95/HR5119-12-1-5	195	Dongjin1	J	2001	Hwayeong/HR12800-AC21
66	Dongjin2	J	2005	Milyang165/Iksan438//HR14018-B-1-1/Iksan435	196	Manwol	J	2001	Milyang120/Hwayeong
67	Dongjinchal	J	1998	SR11155-4-2/Doyonisiki//Milyang95	197	Manjong	J	2009	Yeongdeok34/Nampeong
68	Donghaejinmi	J	2006	Milyang64/4*Milyang165	198	Seonong14	J	2008	Heukjinju/Geodae
69	Malgeumi	J	2006	Hwayeong/Aichi 76	199	Sobi	J	1999	Hwayeong/YR13604ACP22
70	Mikwang	J	2009	SR15926-10-2-3-3/Iksan431	200	Yeongan	J	2001	Milyang122/YR13616 Acp1
71	Mihyang	J	1999	Seomjin/Dongbuk144//IR392	201	Jinpum	J	1999	SR14703-60-5-GH1/Suwon353
72	Baekjinju	J	2001	Ilpum Mutant	202	Keunnun	J	2005	Ilpum Mutant
73	Boramchan	J	2009	HR21124-B-59/Kyehwa24	203	Keunnunjami	J	2007	Heukjinju/Suwon425
74	Saekyehwa	J	2001	Ilpum//Mangeum/Jyukeoi830	204	Hopyeong	J	2003	Hitobebore/Hwajin
75	Seonong10	J	2005	Hwacheong Mutant	205	Heukkwan	J	2003	Hwajin//Gilrimheukmi/Ilpum
76	Seonong16	J	2010	Seonong8/Saengdongchal	206	Nongho	J	1998	Chukei1016/Milyang79
77	Segyejinmi	T	2009	Milyang160/Yongju	207	Mipum	J	2010	Gosihikari//Kyehwa21/Junam
78	Sujin	J	1999	Milyang95//Milyang96/Milyang106	208	Syuepojami	J	2009	C3GHi/EM76
79	Woncheong	J	2003	Chucheong Mutant	209	Suryeojinmi	J	2010	Milyang182/SR21144-17-3-2
80	Junam	J	2000	Hwayeong//Sangju/Ilpum	210	Heukhyang	J	2000	Mangeum/SX864
81	Jungmo1013	J	2010	Iksan469//Dongjin1/Iksan474	211	Baekjinju1	J	2005	Ilpum(MNU)-10-2-GH1-3/Seoan
82	Cheonga	J	2006	Ginuhikari/Yangju	212	Jungmo1015	J	2010	Sindongjin/Milkikwin
83	Cheonghaejinmi	J	2009	Sanjiyeon/SR14694-57-4-2-1-3-2-2//Iri402	213	Saenuri	J	2007	Kyehwa/HR14026-B-68- 6-1-5
84	Chinnong	J	2010	Iksan450/YR21258-GH3	214	Yeonghojinmi	J	2009	Hiddeumeaborea/Junam
85	Keunseom	T	2006	Milyang165*3/Gosihikari	215	Hiami	J	2009	Jinmi Mutant
86	Pyeongan	J	2003	Iksan438/HR15003-69-B-3	216	Dacheong	J	2008	Iksan450/YR21258-GH3
87	Hyangmibyoe1	T	1993	IR841-76-1/Suwon334	217	Daeyabyeo	J	1992	Gwandong PL5/Gwandong PL3//Daecheong
88	Hoan	J	1998	Kanto149/Milyang95	218	Deuraechan	J	2008	Milyang165//Sindongjin/YR19105Acp222
89	Hwasin1	J	2005	HR13185-B-B-100//Iri407/HR14732-B	219	Boseok	J	2008	Ginuhikari//HR19621AC6/Sobi
90	Heuknam	J	1997	Tamjin/Sanghaehyanghyeolna	220	Seogan	J	2002	HR1752-11-14-4/HR10213 -11-3-5
91	Gancheokbyeo	J	1992	Aichi37/Seomjin	221	Unmi	J	2007	Samcheon/HR17870
92	Gangbaek	J	2006	Suwon345/DV85	222	Jungmo1008	J	2010	Iksan451/Sangju21
93	Gangchan	J	2010	Iksan421/Suwon438	223	Jinbaek	J	2008	HR15204-38-3//Milyang165/Iksan438
94	Goami2	J	2002	Ilpum Mutant	224	Honong	J	2009	Unbong31 Mutant
95	Goami4	J	2009	Suwon464/Daeon	225	Hwanggeumnodeul	J	2007	Milyang165/HR15151-B-21-3
96	Gopumbyeo	J	2004	SR15225-B-22-1-2//54BC-68/Iri369	226	Honggwang	J	2009	Chucheong/Sinseonchal
97	Geumnambyeo	J	1994	Jinju/Suwon346	227	Goami3	J	2008	Suwon464/Daeon
98	Geumobyoe1	J	1995	Chukri830//KantoPL5//Milyang79/Aichi65	228	Danmi	J	2009	Sugary/Seomjin
99	Namcheonbyeo	T	1995	YR3299-34-2-2//Suwon318	229	Mogwoo	J	2009	Dasan//Suwon431/IR71190-45-2-1
100	Nokwonchalbyeo	J	2007	Nokmi Mutant	230	Baekokchal	J	2009	Dongjinchal/YR19700
101	Nongan	J	1993	SR5204-30-2/Pungsan	231	Boseokheukchal	J	2008	SR18638-B-B-18-2/H31
102	Dami	J	2006	Iksan438/Iksan426	232	Joami	J	2008	Yukara/Tonggae112//Sambaek
103	Dasan2	T	2009	Suwon450/SR21356	233	Jungmo1004	J	2007	Sugary/HwayeongAcp33
104	Daejin	J	1996	Daeseong/Seomjin	234	Jungmo1005	J	2009	Milyang165//Seomjin//Iksan438/Sangju13
105	Deurimi2	J	2009	SNDH-39/Junam	235	Jungmo1006	J	2009	Samgwang/Nakdong
106	Manpung	J	2000	Nakdong//Iri390/Milyang111	236	Jinsumi	J	2008	Milyang165//YR16195-B-B-B-21//Milyang169

Table 1 Continued

Code	Variety name	Type (J/T) ^z	Registrati on year	Cross Combination	Code	Variety name	Type (J/T)	Registrati on year	Cross Combination
107	Boseokchal	J	2004	Hwayeong//Tamjin/2*Sinseonchal	237	Cheongcheongjinmi	T	2009	IR401/Ilpum
108	Samkwang	J	2003	Suwon361/Milyang101	238	Cheongpungheukchal	J	2009	Sindongjin/Heukseonchal
109	Samdeok	J	2002	YR/12733-B-B-5-1/Milyang101	239	Pyeongwon	J	2007	Jinbu19/Sanjijeon4
110	Sanggal	J	2007	Ilpum Mutant	240	Handeul	J	2007	Sangju/Tomoemasari//Geuru
111	Sangok	J	2003	Milyang101/YR8697 Acp 19	241	Haoreumi	J	2008	Milyang165/Haepyeong
112	Seonong12	J	2006	Nampung//EM40/Nampung*2	242	Hoban	J	2007	Hidomebore/Jinbu
113	Seonong6	J	2002	Hwacheong Mutant	243	Cheongnam	J	2009	Ginuhikari/Milyang189
114	Seonong8	J	2005	Hwacheong Mutant					
115	Seonong9	J	2006	Hwacheong Mutant					
116	Seoan1	J	2005	Namyang9/Kyehwa7					
117	Seoeun	J	2008	Hwacheong Mutant					
118	Seopyeong	J	2003	Hwayeong/HR11752					
119	Seokjeong	J	2001	Namyang7/SR11340-30-4-1-3-2					
120	Seolgaeng	J	2001	Ilpum Mutant					
121	Sura	J	1998	Suwon345/KantoPL 4//Suwon345					
122	Sinmyeongheukchal	J	2006	Heuknam/Milyang153					
123	Sinbaek	J	2010	Iksan469/HR23966-22-1-2					
124	Sintoheukmi	J	2008	Heuknam/Milyang153					
125	Areum	T	1999	YR3299-34-2-2//Suwon318					
126	Anda	T	1998	SR11532-4/SR14502F2					
127	Anmi	J	2010	Junam/IR65482-7-216-1-2//3*Junam					
128	Yangjogyeyo	J	1994	HR7874-AC77/HR8140/AC59					
129	Yeonghaebyeoye	J	1997	Milyang101/Chucheong					
130	Orae	J	2007	Ilpum Mutant					

^zJ: Japonica type, T: Tongil type

Table 2 Information of SSR markers used for discrimination of Korean rice varieties

No.	SSR marker	Linkage group	Repeat motif	Allele No.	PIC	Size range(bp)	Forward primer(5'-3')	Reverse primer(5'-3')	Annealing Temperature (°C)
1	RM493	1	(CTT)9	12	0.87	210-248	TAGCTCCAACAGGATCGACC	GTACGTAACCGGGAAGGTG	57
2	HsSSR01-52	1	(TTA)	14	0.68	279-306	ACACCATACCAATACGAAGG	ACACCGTACTGTTTATTGGG	55
3	RM580	1	(CTT)19	11	0.82	206-234	GATGAACTCGAATTTCATCC	CACTCCCATGTTTGGCTCC	52
4	RM48	2	(GA)17	25	0.82	202-216	TGTCCTACTGCTTCAAGC	CGAGAATGAGGGACAAATAACC	55
5	RM157	3	(CT)11(TC)10	6	0.72	112-134	CCTCCTCTCACGAATCCCGCC	GGGCTTCTTCCGCCGGCTTC	55
6	RM307	4	(AT)14(GT)21	7	0.83	124-176	GTACTACCGACCTACCGTTCAC	CTGCTATGCATGAACTGCTC	55
7	RM241	4	(CT)31	12	0.68	126-196	GAGCCAAATAAGATCGCTGA	TGCAAGCAGCAGATTTAGTG	52
8	RM334	5	(CTT)20	7	0.83	146-197	GTTCAAGTTCAGTGCCACC	GACTTTGATCTTTGGTGGACG	52
9	RM249	5	(AG)5NN(AG)14	13	0.78	125-144	GGCGTAAAGGTTTTGCATGT	GCTGACCTTCATGGCATCAT	55
10	RM204	6	(CT)44	14	0.87	150-185	GTGACTGACTTGGTCATAGGG	GGTACGAGAGCATGGCTAGC	55
11	RM253	6	(GA)25	4	0.48	121-125	TCCTTCAAGAGTGCAAAACC	GCATTGTCATGTCGAAGCC	55
12	RM276	6	(AT)8A3(GA)33	7	0.84	85-153	CTCAACGTTGACACCTCGTG	TCCTCCATCGAGCAGTATCA	55
13	RM1306	7	(AG)18	21	0.84	97-140	TGCCAATTACCTTCCCGTAC	TGCTCCGTATTGCTGCTATG	55
14	RM264	8	(GA)27	5	0.48	155-165	GTTGCGTCTACTGCTACTTCT	GCTAATCATCGACACGGATC	55
15	RM257	9	(CT)24	11	0.80	147-196	CAGTTCGAGCAAGAGTACTC	CATATGCCACGTCGGATCC	55
16	RM333	10	(TAT)19(CTT)19	8	0.83	164-215	GTACGACTACGAGTGTACCAA	GTCTTCGCGTACTCGC	55
17	RM21	11	(GA)18	9	0.83	124-135	ACAGTATCCGTAGGCACGG	GCTCCATGAGGGTGGTAGAG	55
18	RM224	11	(AAG)8(AG)13	11	0.79	117-155	ATCGATCGATCTTCAGAGG	CCCGAATGCCTTTTATAGCA	55
19	RM286	11	(GA)16	6	0.72	99-128	GGCTTCACTTTGGCGAC	CCGGATTACAGAGATAAACTC	50
20	RM117	12	(AG)7	3	0.70	203-307	CGATCCATTCTGCTGCTCGCG	CGCCCCATGCATGAGAAGACG	52

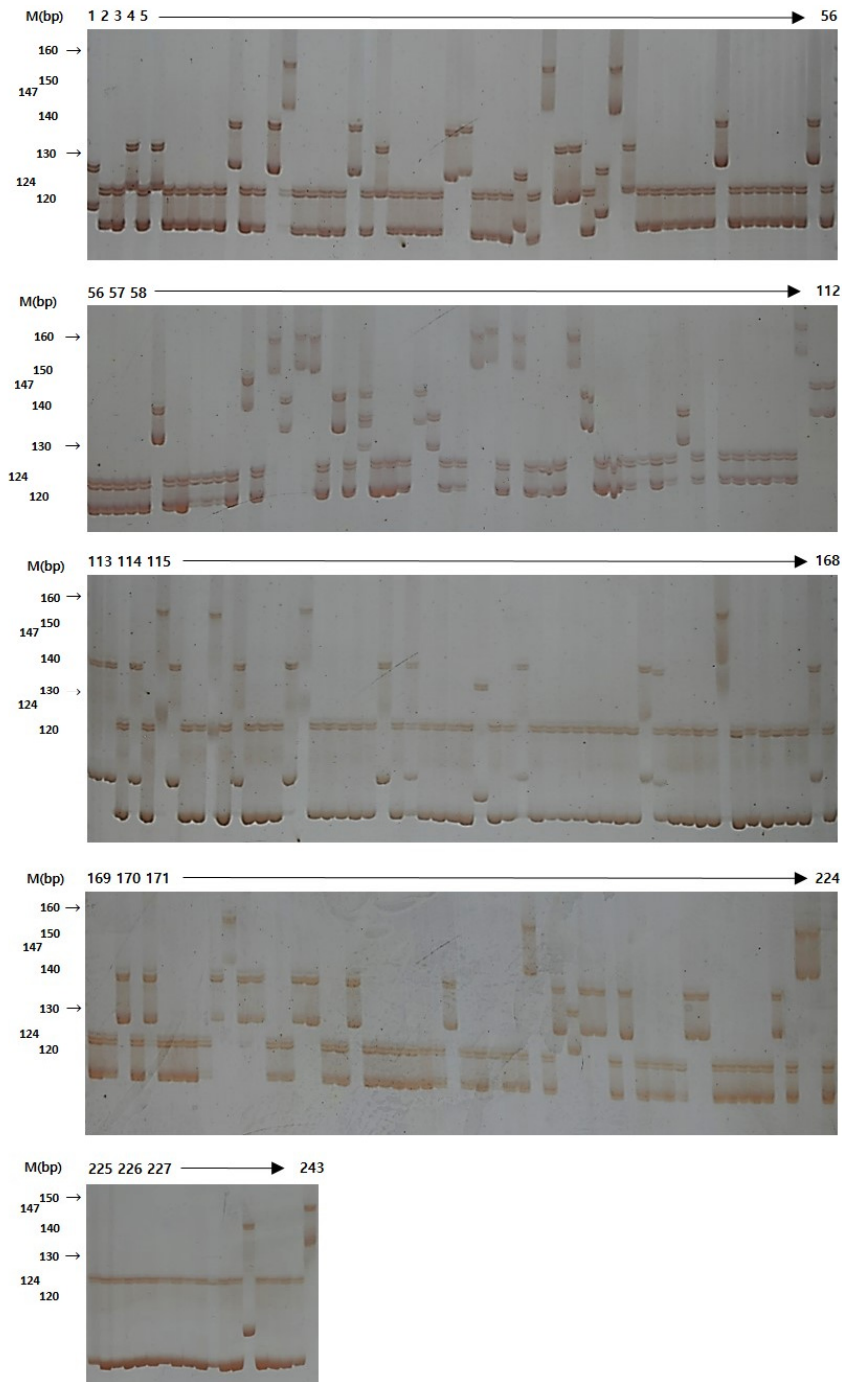


Fig. 1 Segregation of alleles of an SSR marker observed on 4% polyacrylamide gel in 243 Korean rice varieties. Numbers 1 → 243 refer to the list of varieties in Table 1. The numbers indicate the size of the molecular weight ladder (bp)

명하고, 반복 실험간 뚜렷한 재현성을 보이는 20개의 마커를 최종 선발하였다(Fig. 1, Fig. 2).

총 20개 SSR 마커에 의해 분석된 대립유전자의 수는 6~32 개였고, 총 269개의 대립유전자가 분석되었으며 마커 당 평균 대립유전자의 수는 13.45개로 나타났다(Table 3). SSR 마커를 이용한 다른 연구자의 분석결과를 살펴보면 자포니카 벼 21개 품종을 50개의 SSR 마커로 분석하였을 때 발생된 대립유전자의 수는 2~9개였고, 총 68개의 대립유전자가 분석

되었으며, 마커당 평균 대립유전자의 수는 3.00개로 보고되었다(Kwon et al. 2006). 본 연구의 결과와 대립유전자의 수가 다소 다르게 나타났는데 이는 본 연구에서 활용된 분자마커가 다르고 공시품종들의 유전적인 다양성 정도가 다르기 때문인 것으로 사료된다.

총 20개 마커별 품종식별력 정도를 나타내주는 PIC 값은 0.147~0.865의 분포를 나타내었고, 평균값은 0.532로 조사되었다. 본 연구에서 최종 선발된 20개 SSR 마커 중에서 RM21,

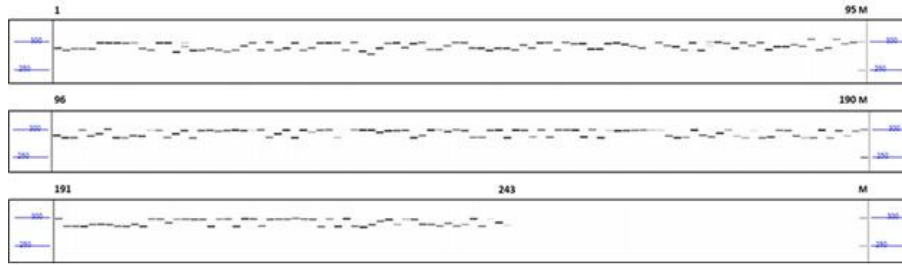


Fig. 2 PCR amplification patterns of the HsSSR01-52 marker in 243 Korean rice varieties. Band patterns indicate the size differentiation by fragment analyzer gel electrophoresis

Table 3 PowerMarker® Summary statistics output for the selected 20 SSR markers across 243 Korean rice varieties

Marker	Major Allele Frequency	No. of Allele	Gene Diversity	PIC
RM21	0.333	10.0	0.811	0.789
RM249	0.473	9.0	0.727	0.703
RM257	0.259	17.0	0.870	0.858
RM253	0.576	8.0	0.596	0.546
RM224	0.683	7.0	0.496	0.460
RM264	0.288	11.0	0.779	0.746
RM204	0.893	20.0	0.202	0.200
RM493	0.922	9.0	0.149	0.147
HsSSR01-52	0.441	14.0	0.717	0.679
RM307	0.885	12.0	0.215	0.212
RM276	0.901	6.0	0.182	0.172
RM333	0.222	32.0	0.876	0.865
RM117	0.486	7.0	0.577	0.486
RM580	0.338	18.0	0.816	0.797
RM241	0.659	11.0	0.528	0.493
RM334	0.877	13.0	0.230	0.228
RM48	0.724	11.0	0.450	0.423
RM1306	0.510	23.0	0.704	0.684
RM157	0.292	16.	0.781	0.748
RM286	0.766	15.0	0.407	0.399
Mean	0.576	13.5	0.556	0.532

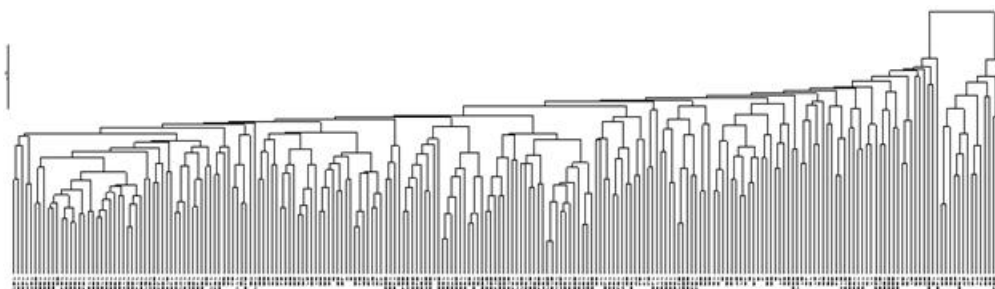


Fig. 3 UPGMA dendrogram showing the relationship among 243 Korean rice varieties based on 20 SSR markers (See Table 5 for variety information)

RM580, RM2570 및 RM333은 PIC 값이 0.75 이상으로 공시품종 내에서 높은 다형성을 나타내었다. PIC 값은 유전적 연관관계에 근거하여 유전자형간 차이를 알아내는데 있어서 마커의 이용 가능성과 SSR loci의 정보를 보여준다. RM333의 경우 많은 대립유전자의 수와 높은 PIC 값을 나타내었는데, 이 SSR loci는 국내 육성 벼 품종의 유전연구에 매우 유용하

게 이용될 것으로 사료된다.

유전적 다양성과 유연관계

벼 품종판별을 위해 선발된 20개의 마커를 이용하여 243개 품종에 대한 유전적 유연관계를 분석하였다(Fig. 3). 공시품

Table 4 Varietal composition of each group classified by the cluster analysis using the principal component scores

Group	No.	Maturity	Variety name
I	17	Medium ² (17)	Baekokchal, Hwanggeumnodel, Dongjinchal, Jinbaek, Garak, Goami, Cheonghaejinmi, Wonchal, Seonong8, Geonganghongmi, Hoan, Dongjin1, Seooun, Daesanbyeol, Malgeumi, Dami, Geumtap
		Early(8)	Joan, Taebong, Jungmo1007, Taeseong, Heukjinjubyel, Cheongbaekchal, Namil, Manan Suan, Haepyeong, Heukgwang, Samdeok, Jongnam, Hwabong, Mihyeong, Seogan, Dongbo, Haeoreumi, Dongan, Donghaejinmi, Seojin, Samgwang, Keunnunjami, Seonong15, Manmi, Jinsumi, Dongjin2, Suryeojinmi, Boseokchal, Goami3, Boramchan, Chinnong, Daepyeong, Jungsan, Cheongnam, Deurimi2, Onnuri, Jinpum, Mokyang, Daeyabyel, Manwol, Geuman, Seonong10, Hwanambyeol, Sujin, Geumobyel2, Sobi, Aranghyangchalbyeol, Wongwang, Pungmil, Hopyeong, Hwasambyeol, Junam, Seoan1, Anmi, Jungmo1009, Jungmo1014, Yeonghaebyeol, Seonong14, Sura, Mipung, Jinsang, Haepyeongchal, Hwamyeyongbyeol, Boseokheukchal, Wonhwang, Geumobyel1, Gancheokbyeol, Sangok, Sampyeong, Gangchan, Hwaan, Namgangbyeol, Geumnambyeol, Gopum, Daeanbyeol, Seolhyangchal, Hwaseonchalbyeol, Seokjeong, Nokyang
II	82	Medium(72)	Goun, Undu, Odae1, Pyeongwon, Hoban, Unmi, Wolbaek, Sambaekbyeol, Joryeongbyeol, Sangsanbyeol, Munjang, Geumyeong, Sangjuchalbyeol, Manchu, Samcheonbyeol, Jinbong, Jopyeong, Jungmo1012, Saesangju, Geumseong, Sangmi, jungmo1010, Handeul, Joami
		Late(2)	Syupeojami, Dacheong
III	33	Early(24)	Honggwang, Joun, Seolbaek, Sinunbong1, Dunnaebyeol, Unjangbyeol, Hwanggeumchal, Boseok, Inwol, Naepungbyeol, Sandeuljinmi, Geurubyel, Manna, Daejin, Jungmo1011, Wonpyeong, Hwadongbyeol, Wonhae, Jeokjinju, Daechan, Jungmo1001, Hwanggeumbora, Wonpung, Jeokjinjuchal
		Medium(9)	Orae, Juanbyeol, Gangbaek, Wonmi, Sanggol, Sinbaek, Jinbo, Hanmaeum, Migwang, Yeongan, Daeripbyeol1, Dongwon, Hongjinju, Gwangan, Manjong, Nunbora, Haiami, Goami2, Juan1, Goami4, Woncheong, Baekjinju, Seolgaeng, Deuraechan
IV	49	Medium(24)	Baekjinju1
		Late(1)	Jungmo1008, Wolbaek, Heukseonchal, Ansanbyeol, Heukgawichal, Junghwabyel, Josaengheukchal, Manho, Pungmi, Honong
V	44	Medium(29)	Manpung, Seomyeong, Saegyeohwa, Cheongho, Hwajungbyeol, Keunnun, Noreunjachal, Jungmo1005, Cheongcheongjinmi, Jungmo1006, Hojin, Yangjobyel, Jungmo1013, Hwarang, Nongho, Seonong6, Sinmyeongheukchal, Seopyeong, Nampyeongbyeol, Seonong9, Heuknam, Pyeongan, Sindongjin, Saechucheong BIL-3, Hwasin1, Hwasinbyeol, Daeripjami, Saenuri, Cheongpungheukchal
		Late(5)	Heukhyang, Sintoheukmi, Seonong16, Jungmo1015, Yeonghojinmi
VI	18	Medium(15)	Jagwangchal, Hyangmibyeol2
		Late(1)	Namcheonbyeol, Dasan1, Areum, Dasan2, Seonong12, Yoonnongchamssal, Hyangmibyeol1, Seongjochal, Nongan, Hangangchal1, Dasan, Hanareum2, Segyejinmi, Keunseom, Anda
		Late(1)	Moku

²Early = Early flowering rice varieties; Medium = Medium flowering rice varieties; Late = Late flowering rice varieties

종의 전체 유사도 지수는 0.1~0.4의 범위로 나타났으며, 유사도 지수 약 0.15를 기준으로 할 때 6개의 그룹으로 구분되었다(Table 4).

제 I군은 ‘백옥찰’, ‘황금노들’, ‘동진찰’ 등 17개 품종이 속하였으며, 제 II군은 ‘조안’, ‘태봉’, ‘흑진주’와 같은 조생종 품종과 ‘밀양95호’를 교배모본으로 육성된 ‘만미’, ‘남강벼’, ‘화봉’ 등 중생종 품종 72개, 만생종 품종 ‘슈퍼자미’ 및 ‘다청’ 총 82개 품종이 속하였다. 제 III군과 제 IV군은 다른 군에 비하여 조생종 품종이 큰 비율을 차지하고 있으며 제 V군은 조생종 10개 품종, 중생종 29개 품종 및 만생종 5개 품종이 속하였고 제 VI군은 벼 18개 품종이 속하였는데, 그 중 조생종 품종 2개, 중생종 품종 15개, 만생종 품종 1개로 나타났다.

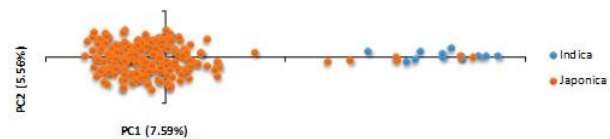


Fig. 4 Principal component analysis (PCA) on two main subspecies of Asian cultivated rice (*Oryza sativa* L.) of the 243 Korean rice varieties. PC1 and PC2 refer to the first and second principal components, respectively

또한, Multibase program을 이용하여 시각적으로 분류한 집단의 경향을 알아보기 위해 주성분분석을 수행하였다. 최종 선별한 20개 SSR 마커를 이용하여 품종들의 구조적 관계를 확인한 결과는 Figure 4와 같다. 제1주성분은 7.59%, 제2주성

Table 5 PowerMarker® Summary statistics output for the selected 7 SSR markers across 243 Korean rice varieties

Marker	Major Allele Frequency	No. of Alleles	Gene Diversity	PIC
RM21	0.333	10.0	0.811	0.790
RM257	0.259	17.0	0.870	0.859
HsSSR01-52	0.440	14.0	0.717	0.679
RM333	0.222	32.0	0.876	0.865
RM580	0.338	18.0	0.816	0.797
RM1306	0.510	23.0	0.704	0.684
RM157	0.292	16.0	0.781	0.748



Fig. 5 Diagrammatic display of variety identification at each step by a UPGMA dendrogram using seven SSR markers in 243 Korean rice varieties (See Table 6 for variety information)

분은 5.56%를 설명할 수 있었다. 주성분분석 결과 얻어진 243개 품종의 분류적 관계는 품종간의 뚜렷한 집구현상은 관찰되지 않았지만, 자포니카 계통(Orange)과 인디카 계통(Blue)으로 크게 2개의 집단으로 구분되었다.

따라서 본 연구에서 SSR 마커의 genotype에 의해 작성된 dendrogram을 분석해 볼 때 벼 품종의 생태형이 비슷하거나 품종육성에 이용된 교배모본의 계보가 유사한 품종이 동일한 그룹 내에 위치하는 것으로 분석되었다.

SSR 마커 조합에 의한 품종 판별

벼 243개 품종에 대한 품종판별을 위한 최소 SSR 마커를 설정하기 위하여, 품종간 유전적 유연관계 분석에서 다형성을 보인 20개의 마커 중에서 밴드가 선명하고 PIC 값이 높은 7개 마커를 선정하였다. 총 대립인자 수는 130개였으며, 대립인자 수의 범위는 10~32개이었고, 평균 대립인자 수는 18.57이었다(Table 5). 분자마커를 이용한 유전적 다양성 및

유전적 거리를 분석할 경우 대립인자의 수 및 PIC값이 높은 마커를 활용하여 분석하는 것이 신뢰성을 높이는 중요한 요소이나 본 연구에서와 같이 품종판별을 목적으로 하는 경우에는 효율성을 감안하여 사용 가능한 마커의 수를 최소화 할 필요가 있다(Singh et al. 2004; Sun et al. 2009).

벼 243개 품종을 대상으로 단계별(6단계)로 품종을 판별한 결과는 Figure 5 및 Table 4에 나타내었으며, 각 단계별로 다양성이 높은 마커를 하나씩 추가로 조합하여 품종판별을 진행하였다. 1단계로 대립인자수가 가장 많고, 다양성지수가 가장 높았던 RM333과 RM257을 사용하여 판별한 결과 전체 품종의 29%의 비율을 나타내는 둔내벼, 흑진주벼, 황금찰 등 68개의 품종이 판별되었다. 2단계에서 다음으로 다양성이 높았던 RM157을 조합하여 판별한 결과 판별되지 않았던 175개 품종 중에서 운장벼, 청백찰, 태봉 등 67개(28%)의 품종이 판별되었고, 3단계에서는 RM580을 조합하여 판별한 결과 설백, 조안, 보석 등 61개(25%)의 품종이 판별되었다. 4단계에서 RM1306을 조합하여 판별한 결과 판별되지 않

Table 6 Varieties identified at each step using seven SSR markers in 243 Korean rice varieties

Step	Marker	Identified varieties	No. of identified varieties	Percentage of identified varieties
Step 1	RM333 +RM257	Honggwang, Dunnaebyeo, Heukjinjubyeo, Hwanggeumchal, Heukseonchal, Sangjuchalbyeo, Ansanbyeo, Manchu, Manan, Saesangju, Hwanggeumbora, Namil, Jeokjinjuchal, Honong, Namcheonbyeo, Seolhyangchal, Geumobyeo1, Seonong12, Yoonnongchamssal, Seongjochal, Hangangchal1, Suan, Sanggol, Seonong15, Hanmaeum, Gangchan, Hanareum2, Daeanybyeo, Boseokchal, Seoan1, Sura, Hwabong, Jinsang, Cheongho, Haepyeongchal, Dongwon, Jinpum, Hongjinju, Sampyeong, Keunnun, Geuman, Jungmo1005, Haeoreumi, Cheongcheongjinmi, Cheongnam, Goami3, Mipung, Wonhwang, Mihyeong, Seopyeong, Heuknam, SaechucheongBIL-3, Hwasin1, Seonong8, Hyangnambyeo, Hwasinbyeo, Daeripjami, Goami, Geonganghongmi, Jinbaek, Cheongpungheukchal, Jungmo1004, Danmi, Jinsumi, Baekjinju1, Sintoheukmi, Jungmo1015, Dacheong	68	29%
Step 2	Step1 +RM157	Unjangbyeo, Cheongbaekchal, Taebong, Odae1, Durujinmi, Jagwangchal, Pyeongwon, Wolbaek, Sandeuljinmi, Geumyeong, Jungmo1007, Heukgawichal, Hwadongbyeo, Hyangmibyeo2, Jungmo1012, Wonhae, Josaengheukchal, Geumseong, Taeseong, Pungmi, Wonpum, Dasan1, Juanbyeo, Gancheokbyeo, Wonchu, Cheongdam, Manpung, Hyangmibyeo1, Jungan, Nongan, Wonmi, Hwaseonchalbyeo, Nokyang, Sinbaek, Yeongan, Samgwang, Daepyeong, Gwangan, Neongeongbyeo, Noreunjachal, Seonong14, Haiami, Daeyabyeo, Seogan, Boseokheukchal, Hojin, Yangjobyeo, Goami2, Jungmo1013, Jongnam, Deurimi2, Seonong6, Yeonghaebyeo, Woncheong, Sinmyeongheukchal, Baekjinju, Nampyeongbyeo, Hoan, Seooun, Daesanbyeo, Dongjinchal, Pyeongan, Pungmi1, Geumtap, Mokyang, Syupeojami	67	28%
Step 3	Step 2 +RM580	Seolbaek, Goun, Joan, Boseok, Hoban, Inwol, Sangsanbyeo, Geurubyeo, Manna, Jungmo1011, Samcheonbyeo, Junghwabyeo, Jinbong, Jopyeong, Wonpyeong, Daechan, Jungmo1010, Handeul, Orae, Areum, Dasan2, Jungsan, Manwol, Milkikwin, Onojjinoijji, Seomyeong, Gopum, Dasan, Saegyehwa, Jinbo, Samdeok, Haepyeong, Geumnambyeo, Hwamyongbyeo, Migwang, Dongbo, Segyejinmi, Seojin, Daeripbyeo1, Sangok, Keunnunjami, Manmi, Hwaan, Nunbora, Hwajungbyeo, Dongjin2, Onnuri, Boramchan, Hwaranag, Nongho, Keunseom, Dami, Anmi, Malgeumi, Sindongjin, Nokwonchal, Anda, Seonong10, Seokjeong, Garak, Heukhyang, Seonong16, Moku	61	25%
Step 4	Step 3 +RM1306	Joun, Sinunbong1, Undu, Unmi, Jungmo1008, Naepungbyeo, Daejin, Jeokjinju, Manho, Jungmo1001, Joami, Gangbaek, Cheonga, Suryeojinmi, Heukgwang, Manjong, Dongjin1, Jungmo1006, Chinnong, Junam, Seonong9, Seolgaeng, Cheonghaejinmi, Jungmo1014, Wongwang, Arangyangchalbyeo, Sujin, Jungmo1009, Sobi, Saenuri, Hwanggeumnodeul, Baekokchal, Yeonghojinmi	35	14%
Step 5	Step 4 +RM21	Joryeongbyeo, Munjang, Donghaejinmi, Dongan, Hwanambyeo, Geumobyeo2	6	2%
Step 6	Step 5 +HsSSR01-52	Sambaekbyeo, Sangmi, Juan1, Goami4, Hwasambyeo, Hopyeong	6	2%

은 47개의 품종 중에서 조운, 신운봉1호, 운두 등 35개(14%)의 품종이 판별되었고, 5단계 RM21을 포함한 조합에서는 조령벼, 문장 등 6개(2%)의 품종이 판별되었다. 마지막으로 6단계에서는 HsSSR01-52를 조합하여 삼백벼, 상미 등 6개(2%)의 품종이 판별되어 벼 243개의 모든 품종이 판별되었다.

이상의 결과와 같이 SSR 마커 7개로 국내에서 육성된 벼 품종 243개 중 243개(100%) 모든 품종의 판별이 가능함을 확인하였다. 따라서 본 연구에서 이용된 SSR 7개 마커는 한국 벼 품종에 대한 유전적 거리의 사전 예측, 품종보호 출원품종의 대조품종 선정과 구별성, 균일성, 안전성의 확인, 품종

보호등록 품종의 특성 유지 확인에 매우 효율적으로 이용될 수 있을 것으로 여겨진다.

품종 육종가의 권리보호와 품질 안정화의 필요성에 따라 품종 판별 기술의 확립이 시급히 요구되는 실정이다. 최근 주요 작물에 대한 유전체 연구가 활발히 진행되고 있는데, 염색체 내의 단일염기서열 변이(SNP)를 탐색하고 이를 품종판별용 마커로 개발하여 품종별로 바코드화한 연구가 보고되고 있다(Tian et al. 2015; Gao et al. 2016). 향후 SNP 기반의 벼 품종판별 체계와 본 연구에서 SSR 마커에 의해 구축된 품종별 DNA database와의 효율성이 비교, 분석된다면 벼 품종

의 식별 정확도는 한층 더 높아질 것으로 사료된다.

적 요

벼 품종의 DNA profiling을 위하여 SSR 마커를 활용하여 한국 벼의 품종판별 기술 확립을 위하여 국내에서 육성된 벼 243개 품종에 대하여 최종 선발된 7개의 SSR 마커(RM21, RM257, HsSSR01-52, RM333, RM580, RM1306, RM157)를 이용하여 판별하였다. 판별용으로 이용된 SSR 마커 7개의 총 대립인자 수는 130개였으며, 대립인자 수의 범위는 10~32개이었고, 평균 대립인자 수는 18.57이었다. PIC 값은 0.679 (HsSSR01-52)~0.895 (RM333)의 범위이었으며, 평균 PIC 값은 0.774이었다. SSR 마커 7개의 조합으로 6단계의 판별을 통해 총 243개 품종 중 243개 모든 품종의 구별이 가능하였다. 이와 같은 결과, 본 연구에 이용된 SSR 7개 마커는 한국 벼 품종의 판별과 순도유지에 매우 효율적으로 이용할 수 있을 것으로 여겨진다.

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Supplementary Table 1 Number and frequency of simple sequence repeat (SSR) alleles observed in 243 Korean rice varieties using 10 SSR markers

Variety	RM21	RM249	RM257	RM253	RM224	RM264	RM204	RM493	HsSSR01-52	RM307
Honggwang	138/138	128/128	154/154	136/136	128/128	160/160	147/147	214/214	289/289	137/137
Joun	138/138	128/128	170/170	132/132	122/122	168/168	165/165	212/212	285/285	136/136
Seolbaek	138/138	146/146	170/170	136/136	122/122	160/160	147/147	210/210	289/289	137/137
Sinunbong1	138/138	146/146	170/170	132/132	132/132	168/168	147/147	212/212	289/289	137/137
Dunnaebyeo	138/138	128/128	172/172	132/132	122/122	160/160	147/147	212/212	289/289	139/139
Unjangbyeo	138/138	128/128	168/168	132/132	132/132	160/160	147/147	212/212	299/299	137/137
Cheongbaekchal	138/138	146/146	172/172	136/136	122/122	160/160	147/147	212/212	299/299	137/137
Goun	142/142	128/128	170/170	130/130	122/122	168/168	169/169	212/212	299/299	139/139
Undu	142/142	128/128	170/170	136/136	122/122	160/160	147/147	212/212	299/299	137/137
Taebong	138/138	128/128	170/170	130/130	122/122	160/160	165/165	214/214	299/299	137/137
Odae1	142/142	128/128	170/170	134/134	122/122	160/160	147/147	214/214	289/289	137/137
Durujinmi	142/142	128/128	174/174	132/132	137/137	160/160	145/145	214/214	287/287	142/142
Joan	138/138	128/128	170/170	130/130	122/122	168/168	165/165	212/212	299/299	137/137
Heukjinjubyeo	138/138	128/128	164/164	132/132	122/122	192/192	145/145	212/212	299/299	137/137
Hwanggeumchal	134/134	146/146	172/172	134/134	137/137	160/160	147/147	212/212	283/283	137/137
Jagwangchal	140/140	146/146	172/172	136/136	155/155	174/174	147/147	246/248	293/299	139/139
Boeok	138/138	128/128	172/172	132/132	122/122	160/160	147/147	212/212	285/285	137/137
Pyeongwon	150/150	124/124	164/164	132/132	122/122	160/160	169/169	212/212	285/285	137/137
Hoban	142/142	128/128	170/170	136/136	122/122	160/160	157/157	212/212	289/289	139/139
Unmi	142/142	128/128	164/164	132/132	122/122	160/160	139/139	212/212	287/287	137/137
Jungmo1008	138/138	128/128	176/176	132/132	137/137	162/162	147/147	212/212	283/283	139/139
Wolbaek	142/142	128/128	170/170	136/136	122/122	168/168	145/145	214/214	287/287	137/137
Inwol	138/138	146/146	170/170	132/132	132/132	160/160	145/145	214/214	293/293	137/137
Sambaekbyeo	142/142	136/136	164/164	136/136	122/122	168/168	145/145	214/214	299/299	137/137
Joryeongbyeo	134/134	128/128	154/154	132/132	122/122	168/168	145/145	214/214	287/287	137/137
Sangsanyeo	142/142	136/136	164/164	136/136	122/122	168/168	147/147	212/212	299/299	139/139
Naepungbyeo	138/138	146/146	168/168	132/132	122/122	168/168	147/147	212/212	287/287	137/137
Heukseonchal	134/134	146/146	180/180	136/136	136/136	160/160	141/141	212/212	289/289	137/137
Munjang	142/142	128/128	154/154	132/132	137/137	168/168	145/145	214/214	299/299	137/137
Sanduljinmi	138/138	146/146	174/174	132/132	122/122	168/168	145/145	212/212	285/285	137/137
Geurubyeo	138/138	128/128	170/170	136/136	122/122	168/168	147/147	214/214	289/289	137/137
Geumyeong	142/142	128/128	164/164	136/136	122/122	168/168	147/147	212/212	299/299	137/137
Sangjuchalbyeo	142/142	146/146	180/180	130/130	128/128	160/160	145/145	212/212	299/299	137/137
Jungmo1007	138/138	146/146	170/170	136/136	122/122	168/168	145/145	214/214	299/299	137/137
Manna	138/138	146/146	172/172	136/136	155/155	168/168	171/171	214/214	287/287	137/137
Daejin	138/138	128/128	174/174	130/130	132/132	160/160	158/158	212/212	299/299	139/139
Ansanbyeo	132/132	128/128	170/170	136/136	132/132	168/168	147/147	214/214	285/285	137/137
Heukgawichal	156/156	146/146	164/164	137/137	122/122	170/170	147/147	232/232	279/279	139/139
Jungmo1011	138/138	136/136	170/170	136/136	128/128	168/168	122/122	212/212	289/289	137/137
Manchu	142/142	146/146	164/164	136/136	155/155	168/168	147/147	212/212	299/299	137/137
Samcheonbyeo	142/142	128/128	170/170	130/130	132/132	160/160	147/147	212/212	299/299	137/137
Junghwabyeo	136/136	124/124	176/176	136/136	122/122	168/168	147/147	212/212	291/291	137/137
Jinbong	142/142	128/128	170/170	130/130	122/122	168/168	147/147	212/212	298/298	137/137
Jopyeong	142/142	146/146	170/170	136/136	122/122	160/160	147/147	214/214	299/299	137/137
Wonpyeong	138/138	128/128	170/170	136/136	122/122	160/160	147/147	212/212	287/287	137/137
Hwadongbyeo	138/138	128/128	172/172	136/136	122/122	168/168	147/147	214/214	287/287	137/137
Hyangmibyeo2	132/132	124/124	148/148	141/141	122/122	170/170	165/165	241/241	293/293	180/187
Manan	134/134	124/124	168/168	136/136	137/137	160/160	147/147	214/214	299/299	137/137
Jungmo1012	142/142	146/146	172/172	136/136	122/122	168/168	147/147	214/214	299/299	137/137
Wonhae	138/138	146/146	172/172	136/136	122/122	160/160	147/147	212/212	289/289	137/137
Jeokjinju	138/138	128/128	168/168	130/130	122/122	168/168	147/147	212/212	289/289	137/137
Josaengheukchal	156/156	136/136	176/176	130/130	122/122	192/192	147/147	214/214	285/285	137/137
Saasangju	142/142	136/136	176/176	136/136	122/122	160/160	147/147	212/212	289/289	137/137
Geumseong	138/138	128/128	164/164	136/136	122/122	168/168	149/149	212/212	289/289	139/139
Manho	142/142	128/128	176/176	130/130	137/137	160/160	147/147	214/214	287/287	142/142
Sangmi	142/142	136/136	164/164	136/136	122/122	168/168	147/147	212/212	295/295	137/137
Daechan	138/138	148/148	176/176	130/130	122/122	162/162	145/145	214/214	289/289	137/137

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Variety	RM21	RM249	RM257	RM253	RM224	RM264	RM204	RM493	HsSSR01-52	RM307
Jungmo1001	138/138	128/128	164/164	130/130	122/122	168/168	145/145	214/214	299/299	137/137
Taeseong	138/138	142/142	170/170	128/128	122/122	162/162	147/147	214/214	299/299	137/137
Hwangeumbora	138/138	128/128	170/170	130/130	122/122	162/162	145/145	214/214	287/287	137/137
Namil	134/134	124/124	178/178	130/130	122/122	168/168	147/147	214/214	299/299	137/137
Jungmo1010	150/150	128/128	164/164	136/136	137/137	168/168	147/147	214/214	298/298	137/137
Pungmi	142/142	128/128	166/166	136/136	122/122	162/162	165/165	212/212	298/298	137/137
Wonpum	134/134	128/128	172/172	136/136	122/122	162/162	165/165	214/214	289/289	137/137
Jeokjinjuchal	138/138	136/136	164/164	130/130	122/122	164/164	147/147	212/212	289/289	137/137
Handeul	138/138	136/136	164/164	136/136	122/122	168/168	147/147	214/214	298/298	137/137
Joami	142/142	128/128	164/164	136/136	122/122	168/168	139/139	214/214	299/299	137/137
Honong	134/134	128/128	156/156	130/130	122/122	162/162	145/145	212/212	295/295	139/139
Namcheonbyeo	132/132	142/142	148/148	141/141	143/143	164/164	145/145	246/246	293/293	180/187
Orae	138/138	142/142	172/172	136/136	122/122	162/162	145/145	214/214	289/289	137/137
Dasan1	150/150	128/128	148/148	141/141	155/155	170/170	145/145	246/246	??	185/192
Seolhyangchal	142/142	136/136	176/176	136/136	137/137	162/162	147/147	214/214	299/299	137/137
Juanbyeo	138/138	148/148	166/166	136/136	155/155	168/168	147/147	214/214	295/295	137/137
Areum	150/150	142/142	148/148	141/141	155/155	174/174	147/147	246/246	293/293	137/137
Gangbaek	138/138	128/128	170/170	136/136	122/122	168/168	147/147	214/214	287/287	137/137
Gancheokbyeo	134/134	128/128	166/166	130/130	137/137	164/164	147/147	212/212	299/299	137/137
Wonchu	138/138	128/128	164/164	137/137	122/122	168/168	145/145	212/212	285/285	137/137
Dasan2	150/150	128/128	148/148	141/141	137/137	170/170	145/145	214/214	293/293	139/139
Jungsan	138/138	136/136	164/164	130/130	122/122	168/168	190/190	214/214	299/299	137/137
Manwol	134/134	148/148	170/170	136/136	122/122	168/168	147/147	212/212	299/299	137/137
Cheongdam	150/150	124/124	164/164	130/130	122/122	164/164	147/147	214/214	289/289	137/137
Geumobyeo1	134/134	128/128	172/172	136/136	137/137	168/168	147/147	214/214	299/299	137/137
Seonong12	150/150	124/124	148/148	141/141	132/132	168/168	147/147	246/246	295/295	137/137
Cheonga	142/142	128/128	164/164	136/136	122/122	162/162	145/145	214/214	299/299	137/137
Manpung	156/156	142/142	164/164	136/136	122/122	164/164	145/145	214/214	287/287	141/141
Yoonnongchamssal	150/150	124/124	144/144	141/141	155/155	174/174	147/147	248/248	293/293	182/189
Hyangmiby eo1	132/132	124/124	148/148	141/141	155/155	174/174	147/147	244/244	293/293	180/187
Jungan	138/138	128/128	164/164	132/132	122/122	164/164	147/147	212/212	295/295	137/137
Seongjochal	150/150	124/124	144/144	139/139	155/155	174/174	145/145	248/248	293/293	182/189
Nongan	150/150	148/148	148/148	139/139	122/122	168/168	145/145	246/246	306/306	134/134
Wonmi	138/138	128/128	170/170	132/132	122/122	168/168	147/147	214/214	287/287	137/137
Milkikwin	142/142	128/128	164/164	136/136	122/122	162/162	147/147	212/212	289/289	137/137
Hangangchal1	150/150	120/120	144/144	139/139	155/155	174/174	177/177	244/244	306/306	134/134
Hwaseonchalbyeo	134/134	136/136	176/176	132/132	137/137	162/162	147/147	214/214	298/298	137/137
Nokyang	134/134	128/128	176/176	136/136	122/122	162/162	147/147	212/212	299/299	137/137
Onojjinoijji	142/142	128/128	164/164	137/137	122/122	162/162	147/147	212/212	291/291	137/137
Seomyeong	150/150	128/128	170/170	136/136	122/122	162/162	147/147	212/212	287/287	137/137
Suan	138/138	128/128	170/170	136/136	122/122	162/162	147/147	212/212	287/287	137/137
Gopum	138/138	128/128	178/178	136/136	122/122	168/168	147/147	212/212	299/299	137/137
Sanggol	138/138	148/148	174/174	136/136	122/122	162/162	147/147	212/212	289/289	137/137
Dasan	150/150	124/124	148/148	139/139	132/132	170/170	157/157	244/244	293/293	182/189
Seonong15	138/138	128/128	170/170	136/136	122/122	168/168	147/147	212/212	301/301	137/137
Saegyehwa	142/142	128/128	172/172	136/136	122/122	162/162	147/147	212/212	287/287	137/137
Sinbaek	138/138	128/128	172/172	136/136	122/122	164/164	147/147	212/212	287/287	137/137
Jinbo	138/138	128/128	170/170	132/132	122/122	162/162	147/147	212/212	289/289	137/137
Hanmaeum	138/138	128/128	170/170	136/136	122/122	162/162	147/147	212/212	289/289	139/139
Samdeok	138/138	128/128	170/170	132/132	122/122	168/168	147/147	212/212	299/299	137/137
Gangchan	134/134	142/142	170/170	136/136	122/122	164/164	147/147	212/212	299/299	137/137
Haepyeong	138/138	128/128	170/170	132/132	122/122	162/162	147/147	212/212	287/287	137/137
Hanareum2	150/150	136/136	148/148	141/141	155/155	174/174	147/147	244/244	293/293	137/137
Daeanbyeo	134/134	136/136	176/176	136/136	137/137	162/162	147/147	212/212	299/299	137/137
Geumnabyeo	134/134	136/136	170/170	132/132	137/137	162/162	147/147	212/212	285/285	137/137
Hwamy eongbyeo	134/134	128/128	172/172	136/136	137/137	162/162	147/147	212/212	299/299	137/137
Boseokchal	138/138	128/128	172/172	132/132	137/137	162/162	147/147	212/212	299/299	137/137
Migwang	138/138	128/128	162/162	132/132	122/122	162/162	147/147	214/214	298/298	139/139

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Variety	RM21	RM249	RM257	RM253	RM224	RM264	RM204	RM493	HsSSR01-52	RM307
Seoan1	140/140	148/148	166/166	132/132	137/137	168/168	147/147	212/212	299/299	137/137
Dongbo	138/138	128/128	166/166	132/132	122/122	162/162	145/145	212/212	299/299	137/137
Sura	140/140	128/128	168/168	132/132	155/155	162/162	162/162	212/212	299/299	137/137
Hwabong	134/134	136/136	170/170	136/136	137/137	162/162	147/147	212/212	299/299	137/137
Jinsang	140/140	128/128	162/162	137/137	122/122	162/162	147/147	214/214	299/299	137/137
Yeongan	140/140	136/136	170/170	136/136	122/122	162/162	147/147	212/212	287/287	139/139
Segyejinmi	150/150	120/120	148/148	141/141	155/155	164/164	148/148	244/244	293/293	180/187
Suryeojimi	134/134	128/128	172/172	132/132	122/122	162/162	147/147	212/212	299/299	137/137
Cheongho	134/134	128/128	156/156	132/132	137/137	164/164	145/145	212/212	287/287	137/137
Samgwang	138/138	128/128	166/166	132/132	122/122	162/162	147/147	212/212	299/299	137/137
Heukgwang	138/138	128/128	170/170	136/136	122/122	162/162	147/147	212/212	298/298	137/137
Seojin	138/138	128/128	168/168	132/132	122/122	164/164	147/147	212/212	299/299	139/139
Haepyeongchal	134/134	128/128	172/172	132/132	137/137	162/162	147/147	212/212	299/299	137/137
Daeripbyeol	138/138	128/128	168/168	136/136	155/155	166/166	147/147	212/212	287/287	137/137
Dongwon	140/140	128/128	162/162	136/136	122/122	168/168	147/147	214/214	287/287	137/137
Sangkok	134/134	128/128	166/166	132/132	122/122	162/162	147/147	212/212	299/299	137/137
Jinpum	138/138	128/128	164/164	132/132	122/122	162/162	147/147	214/214	299/299	137/137
Keunnunjami	138/138	128/128	164/164	136/136	122/122	168/168	145/145	212/212	299/299	137/137
Hongjinju	140/140	148/148	170/170	136/136	122/122	168/168	147/147	212/212	295/295	137/137
Manmi	138/138	146/146	154/154	136/136	137/137	162/162	147/147	212/212	299/299	137/137
Sampyeong	134/134	128/128	164/164	136/136	122/122	168/168	147/147	212/212	299/299	137/137
Daepyeong	138/138	128/128	170/170	132/132	137/137	168/168	147/147	212/212	299/299	137/137
Gwangan	138/138	128/128	164/164	132/132	122/122	166/166	147/147	212/212	287/287	137/137
Manjong	138/138	148/148	170/170	136/136	122/122	162/162	147/147	212/212	291/291	137/137
Neomgeongbyeol	134/134	146/146	170/170	136/136	122/122	162/162	147/147	212/212	299/299	137/137
Hwaan	134/134	128/128	162/162	136/136	122/122	168/168	147/147	210/210	299/299	137/137
Nunbora	138/138	120/120	170/170	136/136	132/132	152/152	147/147	212/212	298/298	137/137
Hwajungbyeol	134/134	128/128	162/162	136/136	122/122	166/166	147/147	214/214	301/301	137/137
Dongjin1	140/140	128/128	162/162	136/136	122/122	148/148	147/147	212/212	299/299	137/137
Keunnun	156/156	128/128	160/160	136/136	137/137	162/162	147/147	212/212	287/287	137/137
Noreunjachal	134/134	120/120	170/170	132/132	122/122	162/162	147/147	212/212	287/287	137/137
Geuman	150/150	128/128	170/170	132/132	122/122	164/164	147/147	212/212	299/299	137/137
Seonong14	138/138	140/140	166/166	136/136	122/122	162/162	147/147	212/212	299/299	137/137
Haiami	134/134	128/128	166/166	136/136	122/122	162/162	147/147	212/212	287/287	137/137
Daeyabyeo	134/134	128/128	170/170	136/136	122/122	164/164	147/147	214/214	299/299	137/137
Seogan	138/138	128/128	166/166	136/136	122/122	162/162	147/147	212/212	299/299	137/137
Jungmo1005	138/138	128/128	166/166	136/136	122/122	162/162	147/147	214/214	287/287	137/137
Haoreumi	138/138	128/128	166/166	136/136	122/122	162/162	147/147	214/214	299/299	137/137
Cheongcheongjimi	134/134	128/128	154/154	132/132	137/137	164/164	147/147	212/212	287/287	137/137
Boseokheukchal	134/134	148/148	172/172	132/132	122/122	166/166	147/147	212/212	299/299	137/137
Cheongnam	138/138	128/128	162/162	132/132	122/122	162/162	147/147	212/212	299/299	137/137
Goami3	138/138	148/148	172/172	136/136	122/122	162/162	147/147	214/214	299/299	137/137
Jungmo1006	134/134	146/146	162/162	136/136	122/122	162/162	147/147	212/212	287/287	137/137
Hojin	138/138	146/146	154/154	132/132	122/122	162/162	147/147	214/214	301/301	137/137
Yangjobyeyo	134/134	136/136	174/174	136/136	155/155	162/162	147/147	212/212	287/287	137/137
Dongjin2	138/138	128/128	154/154	136/136	122/122	162/162	147/147	212/212	299/299	137/137
Chinnong	138/138	128/128	172/172	132/132	122/122	162/162	147/147	212/212	299/299	137/137
Onnuri	138/138	128/128	172/172	136/136	122/122	164/164	147/147	214/214	299/299	139/139
Mipung	156/156	128/128	166/166	136/136	122/122	162/162	116/116	212/212	299/299	137/137
Boramchan	138/138	128/128	172/172	132/132	122/122	162/162	147/147	214/214	299/299	137/137
Donghaejinmi	138/138	128/128	154/154	136/136	122/122	162/162	147/147	212/212	299/299	137/137
Wonhwang	134/134	128/128	172/172	136/136	137/137	162/162	147/147	212/212	299/299	136/136
Goami2	138/138	146/146	172/172	136/136	122/122	162/162	147/147	214/214	289/289	137/137
Jungmo1013	136/136	130/130	166/166	136/136	122/122	162/162	147/147	212/212	287/287	136/136
Hwarang	134/134	140/140	164/164	132/132	122/122	164/164	147/147	214/214	287/287	137/137
Jongnam	136/136	130/130	170/170	136/136	137/137	160/160	147/147	212/212	299/299	137/137
Juan1	140/140	148/148	170/170	136/136	122/122	160/160	147/147	212/212	291/291	137/137
Nongho	136/136	146/146	170/170	136/136	137/137	160/160	147/147	212/212	287/287	143/143

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Variety	RM21	RM249	RM257	RM253	RM224	RM264	RM204	RM493	HsSSR01-52	RM307
Keunseom	150/150	146/146	146/146	141/141	122/122	162/162	183/183	246/246	295/295	182/189
Deurimi2	140/140	130/130	164/164	136/136	122/122	160/160	147/147	212/212	299/299	137/137
Goami4	140/140	146/146	170/170	136/136	122/122	160/160	147/147	212/212	289/289	137/137
Seonong6	140/140	130/130	164/164	136/136	122/122	166/166	145/145	212/212	287/287	137/137
Yeonghaebyeo	140/140	130/130	166/166	132/132	137/137	160/160	147/147	214/214	299/299	137/137
Woncheong	142/142	146/146	170/170	136/136	155/155	164/164	147/147	212/212	287/287	137/137
Sinmyeongheukchal	156/156	146/146	164/164	132/132	137/137	160/160	147/147	214/214	287/287	137/137
Mihyeong	136/136	130/130	170/170	136/136	137/137	162/162	147/147	214/214	299/299	125/125
Junam	140/140	130/130	166/166	136/136	122/122	160/160	147/147	212/212	299/299	137/137
Baekjinju	140/140	130/130	170/170	136/136	122/122	160/160	147/147	212/212	289/289	137/137
Seopyeong	142/142	130/130	166/166	136/136	137/137	160/160	147/147	214/214	287/287	139/139
Nampyeongbyeo	156/156	146/146	164/164	136/136	137/137	160/160	147/147	210/214	287/287	137/137
Hoan	136/136	146/146	164/164	136/136	122/122	166/166	147/147	214/214	299/299	137/137
Seo Eun	136/136	136/136	174/174	136/136	122/122	166/166	147/147	212/212	285/285	137/137
Dongan	136/136	136/136	154/154	136/136	137/137	160/160	147/147	212/212	299/299	137/137
Dami	140/140	146/146	164/164	136/136	122/122	160/160	147/147	212/212	289/289	137/137
Deasanbyeo	140/140	146/146	154/154	132/132	122/122	160/160	147/147	212/212	299/299	137/137
Anmi	140/140	130/130	166/166	136/136	122/122	160/160	147/147	214/214	299/299	137/137
Seonong9	136/136	130/130	174/174	136/136	122/122	168/168	147/147	214/214	287/287	137/137
Heuknam	134/134	148/148	164/164	132/132	122/122	160/160	147/147	212/212	287/287	137/137
Malgeumi	140/140	130/130	164/164	132/132	122/122	168/168	147/147	212/212	285/285	137/137
Dongjinchal	136/136	148/148	154/154	136/136	137/137	160/160	147/147	212/212	289/289	137/137
Pyeongan	140/140	130/130	166/166	136/136	122/122	160/160	147/147	214/214	289/289	137/137
Sindongjin	140/140	130/130	166/166	136/136	122/122	160/160	147/147	214/214	289/289	??
Saechucheong BIL-3	140/140	130/130	162/162	132/132	122/122	168/168	147/147	212/212	287/287	137/137
Nokwonchal	140/140	140/140	174/174	136/136	122/122	168/168	147/147	214/214	285/285	137/137
Seolgaeng	140/140	148/148	170/170	136/136	122/122	160/160	147/147	214/214	289/289	137/137
Cheonghaejinmi	140/140	128/128	174/174	136/136	155/155	160/160	147/147	214/214	285/285	137/137
Jungmo1014	140/140	130/130	166/166	136/136	122/122	160/160	147/147	214/214	299/299	137/137
Wongwang	136/136	146/146	170/170	136/136	137/137	160/160	147/147	212/212	299/299	137/137
Anda	150/150	128/128	146/146	141/141	132/132	170/170	147/147	239/239	293/293	182/189
Aranghyangchalbyeo	142/142	130/130	170/170	132/132	137/137	160/160	147/147	214/214	299/299	134/134
Sujin	136/136	130/130	170/170	136/136	137/137	160/160	147/147	214/214	299/299	137/137
Jungmo1009	140/140	130/130	166/166	136/136	122/122	160/160	147/147	212/212	299/299	137/137
Pungmi1	136/136	140/140	170/170	136/136	137/137	164/164	147/147	216/216	299/299	136/136
Hwasin1	156/156	128/128	166/166	132/132	122/122	162/162	147/147	214/214	285/285	137/137
Hwasambyeo	140/140	130/130	170/170	132/132	122/122	160/160	147/147	214/214	299/299	137/137
Seonong10	142/142	130/130	170/170	132/132	122/122	168/168	147/147	214/214	299/299	137/137
Seonong8	136/136	130/130	172/172	136/136	122/122	168/168	147/147	214/214	285/285	137/137
Hyangnambyeo	142/142	130/130	174/174	136/136	137/137	160/160	147/147	214/214	299/299	137/137
Hyanambyeo	136/136	146/146	170/170	136/136	137/137	160/160	147/147	214/214	299/299	136/136
Hwasinbyeo	156/156	128/128	174/174	136/136	122/122	162/162	147/147	214/214	287/287	137/137
Seokjeong	136/136	130/130	166/166	136/136	122/122	164/164	147/147	214/214	299/299	136/136
Geumobyeo2	156/156	130/130	170/170	136/136	122/122	168/168	125/147	214/214	299/299	137/137
Sobi	142/142	130/130	170/170	132/132	122/122	160/160	147/147	212/212	299/299	137/137
Daeripjami	156/156	130/130	166/166	136/136	122/122	162/162	147/147	214/214	299/299	137/137
Goami	136/136	146/146	156/156	132/132	137/137	164/164	147/147	212/212	299/299	137/137
Hopyeong	140/140	130/130	170/170	136/136	122/122	160/160	147/147	214/214	297/297	137/137
Geumtap	140/140	128/128	164/164	136/136	155/155	160/160	147/147	214/214	285/285	137/137
Mokyang	134/134	128/128	170/170	136/136	155/155	170/170	147/147	214/214	299/299	137/137
Geonganghongmi	136/136	140/140	156/156	136/136	122/122	160/160	147/147	214/214	285/285	137/137
Garak	136/136	128/128	176/176	136/136	122/122	166/166	147/147	212/212	299/299	137/137
Saenuri	134/134	128/128	156/156	132/132	122/122	160/160	132/147	214/214	287/287	137/137
Jinbaek	138/138	128/128	172/172	136/136	122/122	160/160	147/147	214/214	285/285	137/137
Cheongpungheukchal	132/132	148/148	220/220	136/136	122/122	160/160	147/147	214/214	289/289	137/137
Deuraechan	138/138	136/136	174/174	136/136	122/122	160/160	147/147	214/214	295/295	137/137
Hwanggeumnodeul	138/138	128/128	176/176	132/132	122/122	160/160	147/147	212/212	299/299	137/137
Jungmo1004	142/142	148/148	180/180	136/136	122/122	166/166	147/147	212/212	289/289	136/136

Supplementary Table 1 Continued

Variety	RM21	RM249	RM257	RM253	RM224	RM264	RM204	RM493	HsSSR01-52	RM307
Danmi	142/142	136/136	172/172	136/136	122/122	166/166	147/147	212/212	299/299	134/134
Jinsumi	138/138	128/128	160/160	136/136	122/122	160/160	147/147	214/214	299/299	137/137
Baekokchal	138/138	128/128	176/176	136/136	122/122	160/160	147/147	214/214	289/289	137/137
Heukhyang	156/156	128/128	174/174	136/136	122/122	160/160	147/147	212/212	289/289	137/137
Baekjinjul	138/138	148/148	178/178	136/136	122/122	166/166	147/147	214/214	287/287	137/137
Sintoheukmi	132/132	148/148	180/180	136/136	122/122	160/160	147/147	214/214	291/291	137/137
Seonong16	134/134	128/128	172/172	132/132	137/137	166/166	147/147	214/214	287/287	137/137
Jungmo1015	142/142	128/128	174/174	136/136	122/122	160/160	147/147	214/214	289/289	137/137
Syupeojami	152/152	128/128	176/176	136/136	122/122	162/162	147/147	214/214	299/299	137/137
Yeonghojinmi	134/134	128/128	156/156	132/132	122/122	160/160	147/147	214/214	287/287	137/137
Dacheong	138/138	128/128	180/180	136/136	122/122	160/160	147/147	214/214	299/299	182/189
Moku	170/170	124/124	148/148	141/141	143/143	172/172	119/147	246/246	293/293	137/137

Supplementary Table 2 Number and frequency of simple sequence repeat (SSR) alleles observed in 243 Korean rice varieties using 10 SSR markers

Variety	RM276	RM333	RM117	RM580	RM241	RM334	RM48	RM1306	RM157	RM286
Honggwang	132/132	196/196	213/213	234/234	134/134	142/142	206/206	114/114	106/114	??/??
Joun	132/132	186/186	211/211	234/234	136/136	142/142	206/214	114/114	106/114	124/124
Seolbaek	132/132	188/188	213/213	218/218	136/136	142/142	206/206	114/114	106/114	124/124
Sinunbong1	132/132	210/210	213/213	234/234	196/196	142/142	206/212	110/110	106/114	126/126
Dunnaebyeo	132/132	212/212	211/211	234/234	136/136	142/142	206/206	106/106	106/114	124/124
Unjangbyeo	132/132	186/186	211/211	234/234	132/132	142/142	206/206	??/??	104/114	124/124
Cheongbaekchal	132/132	186/186	213/213	224/224	136/136	142/142	206/206	130/130	106/114	124/124
Goun	132/132	220/220	213/213	222/222	136/136	142/142	208/2214	106/106	106/114	124/124
Undu	132/132	210/210	213/213	234/234	136/136	142/142	206/213	114/114	106/114	126/126
Taebong	132/132	222/222	211/211	234/234	136/136	142/142	208/208	114/114	106/116	124/124
Odae1	130/130	186/186	211/211	220/220	134/134	141/141	206/206	106/106	105/114	124/124
Durujinmi	132/132	190/190	213/213	224/224	136/136	142/142	206/213	110/110	106/114	126/126
Joan	132/132	212/212	213/213	234/234	136/136	142/142	202/202	114/114	108/116	124/124
Heukjinjubyeo	132/132	173/173	213/213	??/??	132/132	142/142	206/213	102/102	104/112	128/128
Hwanggeumchal	114/114	210/210	213/213	224/236	136/136	142/142	206/206	106/106	106/114	126/126
Jagwangchal	108/108	186/186	215/215	212/212	136/136	142/142	206/206	126/126	108/114	104/104
Boseok	132/132	190/190	213/213	228/228	138/138	142/142	206/206	108/108	106/114	137/137
Pyeongwon	132/132	188/188	213/213	234/234	136/136	142/142	206/206	114/114	106/114	126/126
Hoban	132/132	188/188	213/213	220/220	134/134	142/142	206/206	106/106	106/114	124/124
Unmi	132/132	222/222	213/213	226/226	134/134	142/142	206/206	106/106	106/114	124/124
Jungmo1008	132/132	188/188	213/213	224/224	134/134	142/142	206/214	110/110	106/114	136/136
Wolbaek	132/132	186/186	213/213	226/226	136/136	142/142	206/206	106/106	104/112	126/126
Inwol	132/132	186/186	213/213	224/224	136/136	142/142	206/213	114/114	106/114	126/126
Sambaekbyeo	132/132	222/222	213/213	224/224	136/136	142/142	206/206	114/114	104/112	124/124
Joryeongbyeo	132/132	222/222	211/211	220/220	134/134	142/142	206/206	114/114	106/114	126/126
Sangsanyeo	132/132	222/222	213/213	224/224	138/138	142/142	206/206	114/114	106/114	124/124
Naepungbyeo	132/132	186/186	211/211	234/234	134/134	142/142	206/206	106/106	106/114	128/128
Heukseonchal	132/132	200/200	213/213	226/226	132/132	142/142	206/215	114/114	106/114	126/126
Munjang	132/132	222/222	213/213	220/220	136/136	142/142	206/206	114/114	106/114	??/??
Sandeuljinmi	132/132	186/186	213/213	234/234	136/136	142/142	206/206	106/106	106/114	126/126
Geurubyeo	132/132	186/186	213/213	228/228	136/136	142/142	206/206	114/114	106/114	126/126
Geumyeong	132/132	220/220	213/213	226/226	136/136	142/142	206/206	114/114	106/114	124/124
Sangjuchalbyeo	132/132	228/228	213/213	220/220	136/136	142/142	206/206	??/??	106/114	124/124
Jungmo1007	130/130	222/222	213/213	224/224	136/136	142/142	206/206	114/114	104/112	124/124
Manna	132/132	190/190	??/??	226/226	136/136	142/142	206/214	106/106	106/114	124/124
Daevin	132/132	186/186	213/213	234/234	136/136	142/142	206/213	114/114	??/??	??/??
Ansanyeo	132/132	200/200	213/213	212/212	136/136	142/142	206/214	112/112	106/114	124/124
Heukgawichal	132/132	204/204	213/213	208/208	132/132	142/142	206/213	??/??	110/118	??/??
Jungmo1011	132/132	220/220	213/213	234/234	136/136	142/142	??/??	114/114	106/114	126/126
Manchu	132/132	186/210	213/213	224/224	134/134	142/142	206/206	106/106	106/114	124/124
Samcheonbyeo	132/132	186/186	209/209	222/222	136/136	142/142	206/206	106/106	106/114	124/124
Junghwabyeo	132/132	186/186	213/213	226/226	136/136	142/142	206/216	102/102	106/114	124/124
Jinbong	132/132	186/186	211/211	224/224	136/136	142/142	206/213	106/106	106/114	126/126
Jopyeong	132/132	210/210	213/213	222/222	136/136	142/142	206/206	112/112	106/114	124/124
Wonpyeong	132/132	186/186	211/211	226/234	132/132	142/142	206/206	116/116	106/114	126/126
Hwadongbyeo	132/132	186/186	213/213	234/234	136/136	142/142	206/213	100/100	104/112	126/126
Hyangmibyeo2	108/108	182/182	213/213	212/212	138/138	187/187	206/206	98/98	108/114	104/104
Manan	132/132	208/208	213/213	224/224	136/136	142/142	202/202	104/104	106/114	126/126
Jungmo1012	132/132	222/222	213/213	224/224	138/138	142/142	206/206	112/112	106/114	124/124
Wonhae	132/132	190/190	213/213	220/220	134/134	142/142	206/206	106/106	106/116	124/124
Jeokjinju	132/132	186/186	211/211	234/234	136/136	142/142	206/213	100/100	106/114	126/126
Josaengheukchal	132/132	173/173	213/213	224/224	134/134	142/142	206/206	102/102	104/112	126/126
Saesanju	132/132	220/220	213/213	222/222	136/136	142/142	206/206	106/106	106/114	124/124
Geumseong	132/132	222/222	213/213	226/226	136/136	142/142	206/206	106/106	104/114	124/124
Manho	132/132	188/188	211/211	224/224	134/134	142/142	206/213	108/108	106/114	126/126

Supplementary Table 2 Continued

Variety	RM276	RM333	RM117	RM580	RM241	RM334	RM48	RM1306	RM157	RM286
Sangmi	132/132	222/222	213/213	224/224	136/136	142/142	206/206	114/114	104/112	124/124
Daechan	132/132	186/186	215/215	212/212	134/138	138/138	206/206	98/98	106/114	124/124
Jungmol001	132/132	186/186	213/213	234/234	136/136	142/142	206/206	110/110	106/114	124/124
Taeseong	132/132	224/224	213/213	234/234	136/136	142/142	206/214	106/106	106/112	124/124
Hwanggeumbora	132/132	168/168	213/213	234/234	136/136	142/142	206/214	102/102	108/118	124/124
Namil	132/132	204/204	213/213	224/224	136/136	142/142	206/206	130/130	106/114	126/126
Jungmol010	132/132	228/228	213/213	236/236	136/136	142/142	206/206	114/114	106/114	126/126
Pungmi	132/132	220/220	205/205	226/226	136/136	142/142	206/206	112/112	104/112	124/124
Wonpum	132/132	173/173	209/209	234/234	134/134	142/142	206/206	106/106	106/114	126/126
Jeokjinjuchal	130/130	182/182	213/213	234/234	136/136	142/142	206/214	100/100	106/114	126/126
Handeul	132/132	228/228	213/213	224/224	136/136	142/142	206/206	112/112	106/114	124/124
Joami	132/132	222/222	213/213	???	136/136	142/142	206/206	112/112	106/114	124/124
Honong	132/132	220/220	213/213	224/224	136/136	142/142	206/213	112/112	106/114	124/124
Namcheonbyeo	108/108	188/188	215/215	212/212	138/138	194/194	206/206	98/98	112/118	104/104
Orae	132/132	190/190	213/213	220/220	134/134	142/142	206/206	106/106	106/114	124/124
Dasan1	108/108	184/184	215/215	206/206	173/173	194/194	206/206	98/98	108/116	118/118
Seolhyangchal	132/132	173/173	213/213	234/234	136/136	142/142	206/213	112/112	102/110	124/124
Juanbyeo	132/132	190/190	213/213	220/220	136/136	142/142	206/206	112/112	106/114	???
Areum	108/108	184/184	215/215	246/246	138/138	194/194	206/206	112/112	110/116	118/118
Gangback	132/132	186/186	213/213	234/234	134/134	142/142	206/206	130/130	106/114	126/126
Gancheokbyeo	132/132	173/173	213/213	226/226	138/138	142/142	206/206	112/112	106/114	128/128
Wonchu	132/132	216/216	213/213	226/226	132/132	142/142	206/206	106/106	106/114	124/124
Dasan2	108/108	184/184	215/215	212/224	136/136	194/194	206/214	114/114	110/116	118/118
Jungsan	134/134	224/224	213/213	224/224	134/134	142/142	206/206	114/114	106/114	122/122
Manwol	132/132	186/186	213/213	226/226	136/136	142/142	206/213	114/114	106/114	124/124
Cheongdam	132/132	228/228	215/215	226/226	136/136	142/142	206/206	114/114	106/112	126/126
Geumbyeo1	132/132	184/222	213/213	212/226	134/134	172/172	206/206	110/128	106/114	124/124
Seonong12	108/108	200/200	213/213	212/212	136/136	176/176	206/206	130/130	108/114	128/128
Cheonga	132/132	186/186	213/213	???	136/136	142/142	206/206	106/106	106/114	124/124
Manpung	132/132	190/190	213/213	224/224	136/136	142/142	204/204	100/100	106/114	124/124
Yoonongchamssal	108/108	186/186	???	212/212	138/138	172/172	206/206	98/98	108/116	106/106
Hyangmiby eo1	108/108	???	215/215	210/210	138/138	187/187	206/206	98/98	106/112	106/106
Jungan	132/132	188/188	211/211	226/226	134/134	142/142	206/206	108/108	100/108	126/126
Seongjochal	108/108	184/184	???	212/212	138/138	172/172	206/206	98/98	108/114	104/104
Nongan	108/108	192/192	213/213	212/212	138/138	172/172	206/206	98/98	106/114	118/118
Wonmi	132/132	206/206	213/213	224/224	134/134	142/142	206/206	130/130	106/116	124/124
Milkikwin	132/132	224/224	213/213	226/226	136/136	142/142	206/206	106/106	106/114	124/124
Hangangchal1	108/108	192/192	215/215	212/212	140/140	174/174	206/206	98/98	108/114	106/106
Hwaseonchalbyeo	132/132	173/173	213/213	224/224	138/138	142/142	206/214	112/112	106/116	126/126
Nokyang	132/132	186/186	???	222/222	132/132	142/142	206/206	130/130	104/114	126/126
Onojjinoijji	132/132	222/222	215/215	226/226	136/136	140/140	206/206	106/106	108/116	124/124
Seomyeong	132/132	222/222	215/215	222/222	134/134	142/142	206/206	112/112	108/116	124/124
Suan	132/132	220/220	215/215	222/222	136/136	142/142	206/206	114/114	108/116	124/124
Gopum	132/132	224/224	215/215	218/218	136/136	142/142	206/206	112/112	108/116	124/124
Sanggol	132/132	190/190	213/213	220/220	134/134	142/142	206/206	104/104	108/116	118/118
Dasan	108/108	176/176	215/215	212/212	138/138	194/194	206/206	98/98	110/116	118/118
Seonong15	132/132	173/173	213/213	222/222	132/132	142/142	206/213	114/114	108/116	128/128
Saegyehwa	132/132	192/192	207/207	226/226	136/136	142/142	206/206	114/114	108/118	124/124
Sinback	132/132	188/188	213/213	234/234	134/134	144/144	206/206	130/130	108/116	126/126
Jinbo	132/132	228/228	213/213	222/222	136/136	142/142	206/206	106/106	110/118	124/124
Hanmaeum	132/132	220/220	213/213	234/234	134/134	142/142	206/206	112/112	110/118	126/126
Samdeok	132/132	220/220	213/213	222/222	136/136	140/140	206/206	134/134	108/116	124/124
Gangchan	132/132	188/188	215/215	222/222	136/136	142/142	206/214	134/134	110/118	124/124
Haepyong	132/132	188/188	213/213	222/222	136/136	142/142	206/206	106/106	108/116	124/124
Hanareum2	108/108	184/184	215/215	212/212	138/138	194/194	206/206	100/100	110/116	104/104
Daeanbyeo	132/132	173/173	215/215	220/220	138/138	142/142	206/206	112/112	110/118	124/124

Supplementary Table 2 Continued

Variety	RM276	RM333	RM117	RM580	RM241	RM334	RM48	RM1306	RM157	RM286
Geumnabyeo	132/132	224/224	217/217	220/220	136/136	142/142	206/206	112/112	110/118	126/126
Hwamyongbyeo	132/132	173/173	215/215	222/222	136/136	142/142	208/208	112/112	108/116	??
Boseokchal	132/132	220/220	215/215	222/222	138/138	142/142	206/214	112/112	108/116	124/124
Migwang	138/138	196/196	215/215	222/222	136/136	142/142	206/206	130/130	108/118	124/124
Seoan1	132/132	173/173	213/213	226/226	138/138	142/142	206/214	114/114	108/116	128/128
Dongbo	132/132	220/220	211/211	222/222	134/134	142/142	206/206	114/114	108/116	124/124
Sura	132/132	190/190	213/213	234/234	132/132	142/142	206/206	132/132	108/116	126/126
Hwabong	132/132	220/220	213/213	222/222	136/136	142/142	206/214	136/136	108/116	126/126
Jinsang	132/132	188/188	213/213	226/226	136/136	142/142	206/206	106/106	108/116	124/124
Yeongan	132/132	173/173	213/213	222/222	132/132	142/142	206/206	128/128	108/116	124/124
Segyejinmi	108/108	184/188	215/215	212/212	138/138	194/194	206/206	98/98	112/118	106/106
Suryeojimi	132/132	220/220	213/213	220/220	136/136	142/142	206/206	112/112	108/116	124/124
Cheongho	132/132	210/210	213/213	222/222	134/134	142/142	206/206	132/132	110/118	124/124
Sangwang	132/132	222/222	213/213	222/222	132/132	142/142	206/213	110/110	108/116	124/124
Heukgwang	132/132	220/220	213/213	??	136/136	142/142	206/206	134/134	108/116	139/139
Seojin	132/165	206/206	213/213	222/222	134/134	142/142	206/213	114/114	108/118	130/130
Haepyeongchal	132/132	186/186	213/213	222/222	134/134	142/142	206/206	112/112	108/116	126/126
Daeripbyeol	132/132	188/188	213/213	222/222	134/134	142/142	206/206	130/130	108/116	126/126
Dongwon	132/132	190/190	??	224/224	136/136	142/142	206/206	106/106	110/118	126/126
Sangok	132/132	216/216	213/213	222/222	134/134	142/142	206/206	112/112	108/116	124/124
Jinpum	132/132	222/222	215/215	234/234	136/136	142/142	206/206	102/102	110/118	128/128
Keunnunjami	132/132	173/173	211/211	222/222	132/132	142/142	206/214	114/114	108/116	128/128
Hongjinju	132/132	182/182	215/215	220/220	136/136	142/142	206/206	140/140	108/116	124/124
Manmi	132/132	224/224	213/213	222/222	136/136	142/142	206/214	134/134	108/118	128/128
Sampyeong	132/132	188/188	215/215	222/222	136/136	142/142	206/206	128/128	108/116	126/126
Daepyeong	132/132	222/222	215/215	220/220	136/201	142/142	206/206	106/132	108/118	126/126
Gwangan	132/132	206/206	213/213	226/226	138/138	142/142	206/213	130/130	108/118	126/126
Manjong	132/132	190/190	215/215	222/222	136/136	142/142	206/206	132/132	110/118	124/124
Neongeongbyeo	132/132	224/224	213/213	218/218	136/136	142/142	206/206	112/112	108/118	126/126
Hwaan	132/132	206/206	213/213	222/222	136/136	142/142	206/206	128/128	110/118	126/126
Nunbora	134/134	212/212	213/213	239/239	136/136	164/164	206/215	140/140	108/116	132/132
Hwajungbyeo	132/132	206/206	213/213	226/226	134/134	142/142	206/206	114/114	110/118	130/130
Dongjin1	132/132	224/224	213/213	222/222	136/136	??	206/206	114/114	108/116	124/124
Keunnun	132/132	190/190	213/213	226/226	136/136	142/142	206/206	114/114	108/116	124/124
Noreunjachal	132/132	206/206	213/213	222/222	138/138	142/142	206/213	132/132	108/118	126/126
Geuman	132/132	194/194	215/215	220/220	138/138	142/142	206/206	114/114	108/116	126/126
Seonong14	132/132	204/204	215/215	234/234	134/134	142/142	208/208	114/114	110/118	126/126
Haiami	132/132	173/173	213/213	234/234	138/138	142/142	206/214	106/106	108/116	126/126
Daeyabyeo	132/132	206/206	213/213	224/224	136/136	142/142	206/206	114/114	108/116	124/124
Seogan	132/132	220/220	215/215	222/222	136/136	138/138	206/206	114/114	110/118	126/126
Jungmo1005	132/132	226/226	213/213	222/222	136/136	140/140	206/206	112/112	108/118	124/124
Haoreumi	132/132	188/188	213/213	222/222	138/138	142/142	208/208	114/114	108/116	124/124
Cheongcheongjimi	132/132	210/210	215/215	222/222	136/136	142/142	210/210	134/134	108/118	124/124
Boseokheukchal	132/132	173/173	215/215	222/222	134/134	142/142	??	114/114	108/118	126/126
Cheongnam	132/132	190/190	213/213	224/224	138/138	142/142	206/206	114/114	108/116	124/124
Goami3	132/132	192/192	213/213	220/220	136/136	144/144	206/206	112/112	108/116	124/124
Jungmo1006	132/132	224/224	213/213	222/222	136/136	142/142	206/206	112/112	108/116	124/124
Hojin	132/132	222/222	211/211	222/222	136/136	142/142	204/204	112/112	108/116	124/124
Yangjobyeo	132/132	224/224	213/213	222/222	136/136	142/142	206/206	114/114	106/114	124/124
Dongjin2	132/132	220/220	213/213	232/232	136/136	144/144	202/202	112/112	108/116	124/124
Chinnong	132/132	220/220	215/215	220/220	136/136	142/142	206/206	114/114	108/116	124/124
Onnuri	132/132	222/222	215/215	234/234	134/134	142/142	206/206	112/112	110/118	124/124
Mipung	132/132	218/218	213/213	226/226	136/136	142/142	206/206	106/106	??	124/124
Boramchan	132/132	220/220	215/215	234/234	134/134	142/142	206/206	114/114	108/116	124/124
Donghaejinmi	132/132	220/220	213/213	222/222	130/130	142/142	206/206	114/114	108/116	124/124
Wonhwang	132/132	224/224	213/213	222/222	136/136	142/142	206/206	134/134	108/116	126/126

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Variety	RM276	RM333	RM117	RM580	RM241	RM334	RM48	RM1306	RM157	RM286
Goami2	132/132	190/190	215/215	220/220	134/134	142/142	206/206	106/106	108/116	124/124
Jungmo1013	132/132	224/224	215/215	222/222	138/138	142/142	208/208	112/112	108/116	124/124
Hwarang	132/132	222/222	215/215	222/222	136/136	142/142	206/214	112/112	108/116	126/126
Jongnam	132/132	220/220	213/213	222/222	???	142/142	206/206	???	108/500	128/128
Juan1	132/132	190/190	213/213	220/220	???	142/142	206/206	106/106	108/116	124/124
Nongho	132/132	220/220	215/215	226/226	136/136	142/142	206/206	114/114	108/116	126/126
Keunseom	108/108	186/186	215/215	212/212	140/140	192/192	206/206	100/100	112/118	124/124
Deurimi2	132/132	222/222	213/213	234/234	136/136	142/142	206/206	112/112	108/118	124/124
Goami4	132/132	190/190	215/215	220/220	136/136	142/142	206/206	106/106	108/116	124/124
Seonong6	132/132	216/216	213/213	224/224	134/134	142/142	206/214	114/114	108/116	124/124
Yeonghaebyeo	132/132	222/222	215/215	222/222	136/136	142/142	206/206	114/114	108/118	124/124
Woncheong	132/132	188/188	215/215	234/234	136/136	142/142	206/206	130/130	110/118	???
Sinmyeongheukchal	132/132	204/204	211/211	226/226	136/136	142/142	206/206	104/104	108/116	???
Mihyeong	132/132	208/208	213/213	222/222	136/136	142/142	206/206	114/114	108/118	124/124
Junam	132/132	???	213/213	234/234	134/134	142/142	206/206	114/114	108/116	120/120
Baekjinju	132/132	190/190	215/215	222/222	136/136	142/142	206/206	106/106	106/116	124/124
Seopyeong	132/132	194/194	213/213	226/226	136/136	142/142	206/206	114/114	108/116	124/124
Nampyeongbyeo	132/132	190/190	213/213	222/222	136/136	142/142	206/213	112/112	108/116	120/120
Hoan	138/138	224/224	215/215	222/222	138/138	142/142	206/214	114/114	108/116	118/118
Seoeun	132/132	224/224	213/213	222/222	138/138	142/142	206/213	114/114	108/116	126/126
Dongan	132/132	220/220	213/213	222/222	136/136	142/142	206/213	114/114	108/116	126/126
Dami	132/132	220/220	215/215	220/220	136/136	142/142	206/206	114/114	110/118	???
Deasanbyeo	132/132	224/224	213/213	226/226	138/138	142/142	206/214	114/114	108/116	???
Anmi	132/132	186/186	213/213	236/236	136/136	142/142	206/206	114/114	110/118	124/124
Seonong9	132/132	224/224	213/213	224/224	136/136	142/142	206/206	112/112	110/118	126/126
Heuknam	132/132	202/202	213/213	226/226	134/134	142/142	206/214	114/114	110/118	124/124
Malgeumi	132/132	???	213/213	228/228	140/140	142/142	206/214	114/114	110/118	124/124
Dongjinchal	132/132	224/224	211/211	236/236	138/138	142/142	206/213	136/136	110/118	126/126
Pyeongang	132/132	224/224	213/213	222/222	136/136	142/142	208/208	112/112	110/118	124/124
Sindongjin	132/132	220/220	213/213	222/222	136/136	142/142	206/206	112/112	110/118	136/136
Saechucheong BIL-3	132/132	226/226	213/213	228/228	134/134	142/142	206/206	112/112	84/106	124/124
Nokwonchal	132/132	208/208	213/213	236/236	136/136	142/142	206/206	114/114	110/118	136/136
Seolgaeng	132/132	190/190	211/211	222/222	128/128	142/142	206/206	106/106	110/118	124/124
Cheonghaejinmi	132/132	224/224	213/213	224/224	138/138	142/142	206/206	114/114	110/118	124/124
Jungmo1014	134/134	222/222	213/213	224/224	136/136	142/142	202/209	112/112	110/118	124/124
Wongwang	132/132	173/173	213/213	224/224	138/138	142/142	206/206	110/110	110/118	126/126
Anda	108/108	186/186	215/215	210/210	138/138	174/174	206/206	100/100	112/118	118/118
Aranghyangchalbyeo	132/132	173/173	213/213	224/224	138/138	142/142	206/206	114/114	110/118	124/124
Sujin	132/132	224/224	213/213	224/224	138/138	142/142	208/208	132/132	110/118	126/126
Jungmo1009	132/132	222/222	213/213	224/224	136/136	142/142	206/214	114/114	110/118	126/126
Pungmi1	132/132	220/220	213/213	224/224	???	142/142	208/208	112/112	112/119	126/126
Hwasin1	132/132	224/226	213/213	222/222	136/136	142/142	206/206	112/112	110/118	124/124
Hwasambyeo	132/132	220/220	213/213	224/224	136/136	142/142	206/206	114/114	110/118	???
Seonong10	132/132	206/206	213/213	226/226	138/138	142/142	206/214	102/102	110/118	124/124
Seonong8	132/132	224/224	213/213	224/224	138/138	142/142	206/214	114/114	110/118	124/124
Hyangnambyeo	132/132	222/222	213/213	224/224	138/138	142/142	206/206	114/114	110/118	124/124
Hyanambyeo	132/132	224/224	213/213	224/224	138/138	142/142	206/206	114/114	110/118	124/124
Hwasinbyeo	132/132	210/210	211/211	224/224	136/136	142/142	206/206	114/114	110/118	124/124
Seokjeong	132/132	186/186	211/211	224/224	138/138	142/142	206/214	130/130	110/118	124/124
Geumbyeo2	130/130	224/224	211/211	224/224	136/136	142/142	206/206	114/114	110/118	126/126
Sobi	132/132	224/224	211/211	224/224	138/138	142/142	206/206	112/112	110/118	124/124
Daeripjami	130/130	192/192	211/211	224/224	130/130	142/142	206/213	102/102	110/118	128/128
Goami	132/132	224/224	211/211	217/217	136/136	142/142	206/214	134/134	110/118	116/116
Hopyeong	132/132	220/220	213/213	224/224	136/136	142/142	206/206	114/114	110/118	136/136
Geumtap	108/108	206/206	213/213	232/232	136/136	192/192	206/206	100/100	110/118	124/124
Mokyang	108/132	206/206	213/213	228/228	???	190/190	206/206	114/114	110/118	122/122

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Variety	RM276	RM333	RM117	RM580	RM241	RM334	RM48	RM1306	RM157	RM286
Geonganghongmi	132/132	184/184	213/213	222/222	138/138	142/142	206/206	114/114	110/118	126/126
Garak	138/138	224/224	213/213	238/238	128/128	142/142	208/208	116/116	110/118	126/126
Saenuri	132/132	194/194	213/213	224/224	136/136	142/142	206/206	114/114	110/118	124/124
Jinbaek	132/132	188/188	213/213	236/236	134/134	142/142	206/206	112/112	110/118	124/124
Cheongpungheukchal	132/132	204/206	213/213	228/228	134/134	142/142	206/206	112/112	110/118	124/124
Deuraechan	132/132	190/190	213/213	220/220	134/134	142/142	206/206	114/114	110/118	124/124
Hwanggeumnodeul	132/132	224/224	213/213	236/236	136/136	144/144	206/206	114/114	110/118	124/124
Jungmo1004	132/132	190/190	213/213	222/222	136/136	142/142	206/206	106/106	110/118	122/122
Danmi	132/132	190/210	211/211	222/224	138/138	142/142	206/206	106/106	??	126/126
Jinsumi	132/132	220/220	211/211	224/224	134/134	142/142	206/206	112/112	110/118	124/124
Baekokchal	132/132	224/224	213/213	236/236	136/136	142/142	206/206	112/112	110/118	124/124
Heukhyang	130/130	186/186	211/211	228/228	132/132	142/142	206/206	112/112	110/118	124/124
Baekjinju1	132/132	188/188	??	234/234	134/134	142/142	206/206	104/104	110/118	122/122
Sintoheukmi	132/132	110/204	211/211	220/220	136/136	142/142	206/206	112/112	110/118	124/124
Seonong16	132/132	??	213/213	226/226	136/136	142/142	208/216	112/112	110/118	124/124
Jungmo1015	132/132	220/220	213/213	222/222	136/136	142/142	206/206	112/112	110/118	126/126
Syupeojami	132/132	173/173	213/213	224/224	136/136	142/142	206/216	112/112	110/118	124/124
Yeonghojinmi	132/132	194/194	211/211	224/224	136/136	142/142	206/206	112/112	110/118	126/126
Dacheong	132/132	220/220	213/213	236/236	134/134	138/138	206/206	112/112	110/118	122/122
Moku	147/147	??	215/215	214/214	138/138	176/176	208/208	130/130	112/118	104/104