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Forage rye cultivars for animal feed in Korea

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Introduction

Rye (*Secale cereal* L.) is well known for its overwintering ability and has the highest tolerance to cold temperature of the small grain cereals such as wheat, barley, and oat. Rye is used as livestock pasture and as green manure in Korea, and its cultivation area for fodder is about 50,000 ha in 2014. Most rye is grown as a fall-sown annual crop, generally called "winter rye". In Korea, rye cultivation for whole crop silage (WCS) in the winter-season rice field can be considered as a promising way to enhance feed supply. The WCS production can be an efficient way to use farm products as livestock feed, and it can also contribute to increasing farm income. Although rye is inferior in several ways to the predominant cereal crops (wheat, rice, and maize), it will continue to be an important crop for farmers in Korea because of its winter hardiness and early harvesting by rapid growing ability.

Materials and Methods

A total of 17 cultivars were developed by the breeding team at National Institute of Crop Science (NICS), Rural Development Administration (RDA) during 1984 to 2013. The cultivars were developed as follows: Paldanghomil, mass selection of Korean landrace; Dooroohomil, re-selection of cultivar 'Heivassee' introduced from USA; Chochunhomil, re-selection from a USA cultivar Vitagrazer; Chibohomil, re-selection from a USA cultivar Dakold, Jangkanghomil and Chunchuhomil, re-selection from a Germany cultivar 'Karlshulder'; Ol, open pollination among 20 rye lines (Koolgrazer, Maton, Heivassee, Dakold, Bonel, Vitagazer, Puma, Wheeler, Paldanghomil, Chungnamjaerae, Kwangsanjaerae, Yongweoljaerae, Kyeongbukjaerae, Kyeongnamjaerae, Mujujaerae, Namweonjaerae, Kumsanjaerae1, Kumsanjaerae2, Hyeongsungjaerae and Buyeojaerae); Okjeonhomil and Sinchunhomil, selection from the same lines with cultivar Olhomil; Wintergreen, a cross between Korean cultivar Paldanghomil and Canadian Kodiak, developed cooperatively by Korea and Canada; Goguhomil, Dagreen, Egreen, Olgreen, Jogreen, Charmgreen and Seedgreen, open pollination among 10 rye lines (Paldanghomil, Chochunhomil, Chilbohomil, Chunchuhomil, Kumsanjaerae, Muanjaerae, Koolgrazer, Maton, Vitagazer, Wintergrazer70). Subsequent generations were handled in a recurrent and mass selection program and all the lines were selected for earliness, winter hardiness and agronomic appearance. After each elite breeding line evaluated in preliminary and advance yield testing for 2 years, the promising lines were subsequently evaluated for earliness (heading date) and forage yield for 3 years in several parts of the country, and each of the cultivars finally named were released to farmers of Korea.

Results and Discussion

High-yielding and early-heading are the major breeding objectives for forage rye in Korea. We have developed 17 forage rye cultivars with some traits such as early forage production, high biomass, and winter survival which is proper to cropping system with rice cultivation since 1984 (Table 1). They showed about 8 to 9 ton ha^{-1} in dry matter yield (about 40 to 48 ton ha^{-1} in fresh matter yield) and 15 March to 8 June in heading, when seeded in mid-October and harvested in the end of April the next year. Most Korean rye cultivars contain seven pairs of somatic chromosomes. Artificially produced tetraploid rye, which contains 14 pairs of chromosomes, is grown in limited areas in Korea. Unlike most Korean rye cultivars, cv. Dooroohomil is unique in that it is a tetraploid. It showed later heading date (5 to 6 days), heavier grain yield (about 10%), smaller number of spike per ㎡, and higher dry matter yield (14%) than other diploid cultivars. The forage yield of the Korean rye cultivars has not improved over time, due in part to limited breeding effort. Because rye is primarily grown as forage in Korea, grown tall with a tendency to lodge. It is an obligate outcrossing species, and is a poor seed producer.

Table 1. Agronomic characteristics and forage yield of forage rye cultivars in Korea

Cultivar	Released year	Heading date	Yield (t/ha)			Polyploidy
			Fresh matter	Dry matter	Seed	
Paldanghomil	1984	April 30	31.7	7.0	3.1	diploid
Dooroohomil	1986	May 4	35.8	7.9	3.1	tetraploid
Chochunhomil	1987	April 26	33.3	6.8	3.1	diploid
Chilbohomil	1988	April 29	35.1	7.3	2.9	″
Jangkanghomil	1989	May 7	41.3	9.8	3.6	″
Chunchuhomil	1989	May 6	39.8	9.3	3.3	″
Olhomil	1995	April 24	41.4	9.5	3.7	″
Okjeonhomil	2000	April 25	-	9.1	3.4	″
Shinchunhomil	2001	April 26	-	8.4	3.5	″
Wintergreen	2002	May 8	-	10.4	5.2	″
Goguhomil	2004	April 23	40.8	8.4	3.0	″
Dagreen	2006	April 24	36.4	7.5	4.1	″
Egreen	2007	April 22	47.6	8.3	3.6	″
Olgreen	2008	April 20	47.5	8.9	3.7	″
Jogreen	2009	April 15	42.5	8.1	3.1	″
Charmgreen	2010	April 17	45.3	9.1	2.9	″
Seedgreen	2013	April 22	39.8	8.3	4.0	″

*Sowing and harvest were mid-October and the end of April (one week after heading stage), respectively.
**This data was average evaluated in 4 to 7 different locations for 3 years.

Conclusion

The major breeding programs that have contributed to improvement of rye for forage in the past have been at National Institute of Crop Science (NICS). All released cultivars currently grown as forage are diploid and are derived from open-pollinated single plant visual selection from earlier culivars, or poly-crosses (Heo *et al*., 2004; Heo *et al*., 2009). A major difficulty in the development of new cultivars is developing cultivars with greater forage yield than early released cultivars. Germplasm resources should be extensively explored, given the apparently narrow germplasm base of Korean cultivars. Evaluation of the germplasm in Korea in target environment may identify useful resources that are not currently being exploited. Even germplasm that has been evaluated previously may have changed genetically over time due to procedures for population maintenance, which may warrant a re-evaluation (Chebotar *et al*., 2003). Intensive efforts have been made to produce polyploid rye. In general, polyploid rye is superior to diploid rye in leaf and culm size etc., but most lines were found to have inferior cold tolerance and heading time. Attempts to improve rye by use of the mutation breeding techniques have been few and have met with limited success. There may be some potential for the use of induced techniques in rye for the improvement of grain quality characteristics; however, the existing variation has not been exhausted, and conventional breeding techniques of forage rye will be more economical for the immediate future. Despite of increasing number of Korean rye cultivars, the seed self-sufficiency of domestic rye cultivar is at low level because of economically infeasible on the industrial front. Therefore, we plan to develop some methods that could make yield grains for forage rye.

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