Research Article

Growth Characteristics and Yield of New Variety Italian Ryegrass (*Lolium multiflorum* Lam.), "Oasis"

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ABSTRACT

The experiment aim to breed an early-maturing variety of Italian ryegrass (*Lolium multiflorum* Lam.). It was conducted at the Grassland and Forage Crops Division, National Institute of Animal Science, RDA, Cheonan, Korea, from 2022 to 2023. The new variety named "Oasis" is a diploid with green leaves and has a semi-erect growth habit in late fall, and an erect growth habit in early spring. With a heading date of May 10, Oasis is categorized as an early-maturing variety. Compared with the "Florida80" as a control variety, Oasis's flag leaf was 1 mm wider and 2 cm shorter, while the plant length was 7.8 cm longer. Additionally, the ear of Oasis was 1.2 cm longer than that of Florida80, and it showed lodging resistance. The dry matter yield of Oasis (8,805 kg/ha) was higher than that of Florida80. The total digestible nutrient and crude protein contents of Oasis were 64.5%, and 9.3%, respectively, which were 1.1% and 0.6% higher than those of Florida80, respectively. The neutral and acid detergent fiber contents in Oasis were 54.2% and 30.8%, respectively, which was 1.9% and 1.4% lower than those of Florida80, respectively. These results indicate that Oasis has good dry matter yield in the most of region and especially, middle and northern region of South Korea.

(Key words: Forage crop, Italian ryegrass, New variety, Oasis)

Ⅰ. INTRODUCTION

Italian ryegrass (*Lolium multiflorum* Lam.) is an annual or biennial forage crop in the family Poaceae. It is originally from the Mediterranean coast, but is currently found worldwide due to its rapid initial growth and excellent yield. Besides being a forage crop with high yield, feed value, and palatability to cattle, Italian ryegrass is also suitable for double cropping due to its high resistance to wet weather. However, the harvest time for domestic Italian ryegrass is mid-May, which creates challenges for farmers who want to intercrop with wheat, as there is not enough working time between harvest and wheat transplanting. There are around 25 varieties of Italian Ryegrass being grown in Korea, including "Hwasan 104" (Choi et al., 2005), "Kowinearly" (Choi et al., 2006b), "Green Farm" (Ji et al., 2011). Of these, three early-maturing Italian ryegrass varieties are currently being grown in Korea ("Kowinearly", "Kogreen", "Kospeed"), and most farmers would still prefer earlier-maturing varieties. Moreover, the roughage market is expected to be completely opened with the declaration of the multiparty Free Trade agreement; starting with Canada in 2024, followed by the US in 2026, and Australia in 2028, vital roughage imports will enter Korea tax-free. Given these circumstances, it is an urgent need to develop highly productive (per unit area) new varieties to allow domestic roughage competitiveness with imported roughage. Therefore, this study aim to grow a new, early-maturing Italian ryegrass variety with excellent production per unit area that could be efficiently grown in a double cropping system with wheat.

Ⅱ. MATERIALS AND METHODS

1. Cross combination composition

To grow a new synthetic variety, crossbreeding was performed with five lines (13LmCb01, 13LmCb08, 13LmCb12, 13LmEs04, and 13LmEs07) grown between 2011 and 2013.

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2. Production of synthetic seed varieties

For the clonal line from the polycross breeding association, synthetic fields were formed in 2014 using the triangle polycross method, rye was cultivated along the perimeter to prevent contamination by external pollen, and seeds were produced for the synthetic lines.

3. Productivity and regional adaptability evaluation

The productivity of the synthetic line was tested for one year at the Cheonan experimental field in 2021. The regional adaptability was tested in four regions (Cheonan, Pyeongchang, Jeongeup and Jinju) over two years from 2022 to 2023. The early-maturing "Florida80" variety was used as a control. Seeds were sown in late september in all four regions. The seeding rate was used 30 kg/ha, and the method employed was narrow-row seeding with 20 cm interrow spaces. The fertilizer rate was N-P$_2$O$_5$-K$_2$O = 200-150-150 kg/ha. For the nitrogen, 20%, 50%, 30% were applied at pre-planting, the start of growth in early spring, and after the first harvest, respectively. For phosphate and potassium, 50% each was applied at pre-planting and at the start of growth in early spring. Plot allocation was performed in triplicate by randomized block design. The winter survival, heading date, lodging, disease, plant height, leaf abundance, and regrowth were recorded as growth characteristics. Yield was calculated by harvesting and weighing all the plants in a 6 m^2 plot. Morphological characteristics were investigated only in Cheonan, but cold resistance was measured by observing the winter survival rate and vegetation in early spring after overwintering at all four regions during the regional adaptability test and grading the outcomes from 1 to 9 (1=strong, 9=weak). Harvesting was performed only once.

4. Feed value analysis

The general compositions dry matter (DM) and crude protein (CP) of samples were analyzed using the internationally recognized AOAC method (1990). The neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were measured using the method published by Goering and Van Soest (1970). Analysis of variance was performed using SAS (2004), and T-test was used for comparisons.

III. RESULTS AND DISCUSSION

1. Variety characteristics

The agronomic characteristics of the new variety "Oasis" are shown in Table 1. Oasis is diploid and shows a semi-erect growth habit before overwintering, with an erect growth habit in spring. At the heading date, the flag leaf width and length were 0.8 mm and 19.8 cm, respectively, which were 1 mm

Table 1. Agronomic characteristics of Italian ryegrass 'Oasis' varieties

Characteristic	Florida80	Oasis
Ploidy	Diploid	Diploid
Growth habit in fall	Semi-erect	Semi-erect
Growth habit in spring	Erect	Erect
Leaf color	Green	Green
Flag leaf width (mm)	7	8
Flag leaf length (cm)	21.8	19.8
Leafiness (1~9)*	1.8	2.0
Plant height (cm)	90.2	98.0
Stem thickness (mm)	2.6	2.7
Length of longest stem (cm)	91.5	99.2
Spike lets per ear	25.2	20.3
Lodging resistance (1~9)*	2.2	1.9
Regrowth (1~9)*	1.0	1.0
Heading date	May 6	May 10

* (1~9) : 1 = Good (strong), 9 = Bad (weak).

thicker and 2 cm shorter than those of Florida80. The plant height was 98 cm at this stage, which was 7.8 cm longer than the average length of the Green Farm variety. The Length of longest stem of Oasis was 99.2 cm, which was 7.7 cm longer than that of Florida80. The length of Kowinearly upon heading was 82 cm, which was about 1 cm shorter than that of Florida 80. (Choi et al., 2011). Oasis showed a similar green leaf color to Florida80. The heading date was May 10th, which was 4 d later than that of Florida80; however, this is compatible with wheat transplantation in double cropping in the central regions of Korea.

2. Cold resistance

The average lowest temperatures and precipitation in January, which have the greatest impact on winter survival of Italian ryegrass, are shown in Table 2. Cheonan region showed a mean minimum temperature of -10.1 to -7.5 ℃ in January from 2022 to 2023, which was lower than the average year.

Precipitation was particularly low in all regions in 2022, creating poor meteorological conditions for overwintering. However, this did not cause significant problems for the Italian ryegrass in surviving winter. As shown in Table 3, Italian ryegrass varieties showed little difference in cold resistance by regions or years. In particular, Oasis could overwinter in Cheonan, Pyeongchang, Jeongeup, and Jinju regions. and showed good cold resistance Since cold resistance in Italian ryegrass was determined by genetic characteristics, in our previous study, the authors grew a cold-resistant variety using a device to test cold resistance and repeatedly select plants with high cold resistance. Based on this, they reported that cold resistance originates from the genetic characteristics of the selected parent lines (Pfahler et al., 1984). According Adhikari et al. (2022), both genetic and conventional techniques are required to improve cold resistance, and studies have also been conducted using cross-species breeding to improve cold resistance (Augustyniak et al., 2018). To develop a variety with

Table 2. Minimum average air temperature and amount of precipitation in January from 2022 to 2023

Region	Min. average air temp. (℃)			Amount of precipitation (mm)		
	2022	2023	Mean	2022	2023	Mean
Cheonan	-10.1	-7.5	-8.8	0.0	9.9	4.9
Pyeongchang	-13.5	-13.8	-13.6	0.0	0.3	0.5
Jeongeup	-6.0	-5.7	-5.8	0.0	0.6	0.3
Jinju	-5.1	-5.0	-5.0	0.0	1.9	0.9

Table 3. Winter survival of Italian ryegrass varieties cultivated in Cheonan, Pyeongchang, Jeongeup and Jinju from 2022 to 2023

Regions	Years	Winter survival degree (1~9)*	
		Florida80	Oasis
Cheonan	2022	1.0	1.0
	2023	1.0	1.0
	Mean	1.0	1.0
Pyengchang	2022	1.0	1.0
	2023	1.0	1.0
	Mean	1.0	1.0
Jeongeup	2022	1.0	1.0
	2023	1.0	1.0
	Mean	1.0	1.0
Jinju	2022	1.0	1.0
	2033	1.0	1.0
	Mean	1.0	1.0
Mean		1.0	1.0

* (1~9) : 1 = Good (strong), 9 = Bad (weak).

Table 4. Dry matter yield of Italian ryegrass varieties cultivated in Cheonan, Pyeongchang, Jeongeup and Jinju from 2022 to 2023

Regions	Years	Dry matter yield (kg/ha)	
		Florida80	Oasis
Cheonan	2022	8,139	8,475
	2023	8,424	9,943
	Mean	8,282	9,209
Pyengchang	2022	6,195	6,266
	2023	6,367	6,289
	Mean	6,281	6,278
Jeongeup	2022	8,449	8,903
	2023	12,045	14,852
	Mean	10,247	11,878[*]
Jinju	2022	6,147	7,132
	2033	8,657	8,575
	Mean	7,416	7,854
Mean		8,056	8,805[*]

[*]Mean in the same column with different superscript differ significantly ($p<0.05$).

Table 5. CP, ADF, NDF, TDN and RFV of Italian ryegrass varieties cultivated in Cheonan from 2022 to 2023

Varieties	CP (%)	ADF (%)	NDF (%)	TDN (%)	RFV
Florida80	8.7	32.2	56.1	63.4	105
Oasis	9.3	30.8	54.2	64.5	111

cold resistance suitable for Korea, selecting and crossbreeding genetic resources with strong cold resistance will be necessary.

3. Yield ability

The dry matter yield of Florida80 and Oasis, a new variety of Italian ryegrass are shown in Table 4. The mean dry matter yield across four regions was significantly higher for Oasis (8,805 kg/ha) compared to the control, Florida80 (8,056 kg/ha). In Pyeongchang, which had the region with the coldest winter temperatures, the dry yield of Oasis (6,289 kg/ha) was lower than that of Florida80, but the difference was not significant. Meanwhile, in Cheonan, Jeongeup, and Jinju, where the winter temperatures were higher than those of Pyeongchang, Oasis showed a higher dry yield than Florida80. According Choi et al. (2011) Kowinearly's dry matter yield was similar to that of Florida80 where the climate is somewhat mild in winter. But Oasis was greater than that of Florida80 somewhat mild in winter.

4. Feed value

The feed value of the novel Italian ryegrass variety "Oasis" is shown in Table 5. The total digestible nutrients (TDN) of Oasis was 64.5%, which was 1.1% higher than Florida80. The neutral detergent fiber (NDF) and acidic detergent fiber (ADF) contents of Oasis were 54.2% and 30.8%, respectively, which were 1.9% and 1.4% lower than those of Florida80. The relative feed value (RFV) of Oasis was 111, higher than Florida80. Oasis may have shown a slightly higher feed value than Florida80 due to its higher lead abundance, as shown in Table 1. According Choi et al. (2011) in terms of feed value, Kowinearly's ADF and NDF are 32.8 and 58.1%, respectively, which is on par with the feed value of Florida80. Oasis is also similar to that of Kowinearly.

Ⅳ. CONCLUSIONS

This study was conducted between 2011 and 2023 at the National Institute of Animal Science's Grassland and Forages

Division to grow a new, multi-harvest, early-maturing Italian ryegrass variety. The new variety Oasis is a diploid crop with green leaves, a semi-erect growth habit before overwintering, and an erect growth habit in spring. Oasis was an early-maturing variety with a heading date of around May 10th, with leaves that were 1 mm thicker and 2 cm shorter than those of Florida80. At the heading stage, the plant length was 98 cm, which was 7.8 cm longer than that of Florida80. The mean dry matter yield of Oasis in the four study regions was 8,805 kg/ha, which was higher than the control, Florida80. Oasis showed a relative feed value of 111, which was much higher than that of Florida80 (105). The TDN and CP were 64.5% and 9.3%, respectively, which were 1.1% and 0.6% higher than the values for Florida80 (63.4% and 8.7%, respectively). The NDF and acidic detergent fiber ADF were 54.2% and 30.8%, respectively, which were 1.9% and 1.4% lower than the values for Florida80. These results indicate that Oasis has good dry matter yield in the most of region and especially, middle and northern region of South Korea.

Ⅴ. ACKNOWLEDGEMENTS

Ⅵ. REFERENCES

Adhikari, L., Baral, R., Paudel, D., Min, D., Makaju, S.O., Poudel, H.P., Acharya, J.P. and Missaoui, A.M. 2022. Cold stress in plants: Strategies to improve cold tolerance in forage species. Plant Stress. 4:100081.

AOAC. 1990. Official methods of analysis (15th ed.). Association & Official Analytical Chemists, Washington DC.

Augustyniak, A., Perlikowski, D., Rapacz, M., Kościelniak, J. and Kosmala, A. 2018. Insight into cellular proteome of Lolium multiflorum/Festuca arundinacea introgression forms to decipher crucial mechanisms of cold acclimation in forage grasses. Plant Science. 272:22-31.

Choi, G.J., Ji, H.C., Kim, K.Y., Park, H.S., Seo, S., Lee, K.W. and Lee, S.H. 2011a. Growth characteristics and productivity of cold-tolerant 'Kowinearly' Italian ryegrass (*Lolium multiflorum* L.) in the northern part of South Korea. African Journal of the Biotechnology. 10:2676-2682.

Choi, G.J., Ji, H.C., Kim, K.Y., Park, H.S., Seo, S., Lee, K.W. and Lee, S.H. 2011b. Growth characteristics and productivity of cold-tolerant "Kowinearly" Italian ryegrass in the northern part of South Korea. African Journal of Biotechnology. 10(14):2676-2682.

Choi, G.J., Lim, Y.C., Rim, Y.W., Kim, K.Y., Sung, B.R., Rim, Y.W., Kim, M.J., Lim, K.B. and Seo, S. 2006. A cold-tolerant and high-yielding Italian ryegrass (*Lolium multiflorum* L.) new variety 'Kowinnner'. Journal of the Korean Society of Grassland and Forage Science. 26:171-176.

Choi, G.J., Lim, Y.C., Rim, Y.W., Sung, B.R., Kim, M.J., Kim, K.Y. and Seo, S. 2006. A cold-tolerant and early-heading Italian ryegrass (*Lolium multiflorum* L.) new variety 'Kogreen'. Journal of the Korean Society of Grassland and Forage Science. 26:9-16.

Choi, G.J., Lim, Y.C., Sung, B.R., Kim, K.Y., Lee, J.K., Lim, K.B., Park, H.S., Seo, S. and Ji, H.C. 2007. A cold-tolerant and early-maturing Italian ryegrass (*Lolium multiflorum* L.) new variety 'Kospeed'. Journal of the Korean Society of Grassland and Forage Science. 27:145-150.

Choi, G.J., Rim, Y.W., Kim, K.Y., Choi, S.H., Sung, B.R., Kim, W.H., Shin, D.E. and Lim, Y.C. 2000. A cold-tolerant and high-yielding Italian ryegrass (*Lolium multiflorum* L.) new variety 'Hwasan 101'. Journal of the Korean Society of Grassland and Forage Science. 20:1-6.

Choi, G.J., Rim, Y.W., Lim, Y.C., Kim, K.Y., Sung, B.R., Kim, M.J. Park, G.J. and Kim, S.R. 2001. Growth characters and productivity of new Italian ryegrass (*Lolium multiflorum* L.)variety 'Hwasan 102'. Journal of the Korean Society of Grassland and Forage Science. 21:157-162.

Choi, G.J., Rim, Y.W., Lim, Y.C., Kim, K.Y., Sung, Choi, S.H. and Park, G.J. 2001. Growth characters and productivity of new Italian ryegrass (*Lolium multiflorum* L.) variety 'Hwasan 103'. Journal of the Korean Society of Grassland and Forage Science. 21:163-168.

Choi, G.J., Rim, Y.W., Sung, B.R., Lim, Y.C., Kim, M.J., Kim, K.Y., Park, G.J., Park, N.K., Hong, Y.K. and Kim, S.R. 2005. Growth characters and productivity of new Italian ryegrass (*Lolium multiflorum* L.) variety 'Hwasan 104'. Journal of the Korean Society of Grassland and Forage Science. 25:275-280.

Ji, H.C., Choi, G.J., Lee, S.H., Kim, K.Y., Lee, K.W. Park, N.G. and

Lee, E.S. 2013. A very early-maturing Italian ryegrass (*Lolium multiflorum* L.) new variety, 'Green Farm Ⅱ'. Korean Society of Grassland and Forage Science. 33:1-10.

Ji, H.C., Lee, S.H., Yoon, S.H., Kim, K.Y., Choi G.J., Park H.S., Park, N.G., Lim, Y.C. and Lee, E.S. 2011. A very early- maturing Italian ryegrass (*Lolium multiflorum* L.) new variety, 'Green Farm' for double cropping system. Korean Society of Grassland and Forage Science. 31:9-14.

Pfahler, P.L., Barnett, R.D. and Luke, H.H. 1984. Diploid-tetraploid comparisions in rye. I. Forage Production. Crop Science. 24:67-1674.

SAS. 2004. SAS/STAT 9.1 user's guide. SAS Inst, In, Cary, NC.