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Research Article

Effects of Seeding Date and Cultivar on the Dry Matter Yield and Nutritive Value of Forage Rye in Yeongseo Region of Gangwondo

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ABSTRACT

This study was carried out to evaluate the seeding date and performance of early maturing rye cultivars for the Dry matter yield (DMY) and nutritive value during 2016 and 2017 in Yeongseo region of Gangwondo, South Korea. The experimental field was designed as a split-plot arrangement. The treatments were two planting dates on September 25 and October 02 as the main plots, and two cultivars of forage rye including Gogu and Koolgrazer as sub-plots. The cultivars were harvested on April 26 at the heading stage of both years. In this experiment, the sowing dates and cultivars of the forage rye did not effect on DMY. The DMY had no significant differences among the cultivars of forage rye and seeding date of both years. Similarly, no significant difference was observed in the DMY of Gogu and Koolgrazer in both seeding date and years. The CP, NDF, ADF, and RFV had no significant differences among the cultivars of forage rye and seeding date of both years. Considering the DMY and nutritive value of the current experiment, seeding of forage rye cultivars Gogu and Koolgrazer on September 25 and October 2 could be used as an recommended seeding date at northern area. In addition, based on the climate characteristics of the region, both cultivars had relatively similar forage yield and quality that makes them to be recommended for cultivation in the region. This study is meaningful in that DMY was first presented in Yeongseo region where there is no cultivation data for forage rye.

(**Key words**: Cultivar, Dry matter yield, Forage rye, Seeding date, Yeongseo region)

Ⅰ. Introduction

In Korea, forage rye (*Secale cereale* L.) is one of the major winter forage crops known for the ability to maintain growth under cold temperature conditions (Han et al., 2015). It has also been recognized as a cover crop for controlling soil erosion and enhancing soil productivity through maintenance of organic matter (Keles et al., 2016). In addition to providing an excellent quality of forage for improving livestock productivity, rye can also provide a double cropping option by planting after harvest of other main crops such as silage corns (Webb et al., 2013).

In the northern part of Korea, especially in the Yeongseo region of Gangwon, due to low temperatures in winter (KMA, 2022), the cultivation of winter forage such as Italian Ryegrass (IRG) and forage barley is poor, so forage rye is mainly cultivated. However, from 1978 to 2013, a total of 549 data of forage rye in Korea (Peng, 2017), of which only 11 data was in Pyeongchang, and even this data is the result of the National Agricultural Cooperative Federation, the report of an adaptability test of imported varieties of grasses and forage crops, so cultivation techniques such as sowing date, harvesting date, and fertilization were fixed. In Pyeongchang, the dry matter yield DMY of forage rye data was 4.9 ton/ha (2.5 to 5.9 ton/ha), which was lower than RDA (2011) presented 7.7 ton/ha (6.4 to 8.9 ton/ha) . The reason why forage rye DMY was low in Pyeongchang is due to the relatively short number of production days due to its low temperature due to its higher altitude than in Yeongseo region such as Chuncheon, Wonju, Hwacheon, and Hongcheon. Therefore, it is judged that it is difficult to represent the Yeongseo region of Gangwondo for the DMY of forage rye of Pyeongchang. Since, there is no data on forage rye cultivation in the Yeongseo region, it is necessary to study cultivation techniques such as sowing date,

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harvesting date, and cultivar when cultivating it as a cropping system with summer forage.

Therefore, this study was aimed to evaluate the effect of seeding date and cultivars on the DMY and nutritive value of forage rye during 2016 and 2017 in Yeongseo region of Gangwondo, South Korea.

Ⅱ. Materials and Methods

The experiments were conducted at the experimental field of Kangwon National University farm in Chuncheon, Yeongseo region of Kangwondo, Republic of Korea, over two growing seasons, 2016-17 and 2017-18, which are hereafter termed as 2016 and 2017, respectively. The longitude and latitude of the experimental site were 37°56’20.46’’N and 127°46’57.51’’E, respectively. The soil chemistry of forage rye cultivation sites was presented in Table 1. As a result of comparing the appropriate soil chemistry and cultivation sites when cultivating rye suggested by RDA (2019), the pH, Available phosphorous, and K content were appropriate and the OM was low.

The treatments were arranged as split-plot design with four replications of two planting dates (September 25 and October 02) as the main plots, and two cultivars of forage rye (Gogu and Koolgrazer) were randomized as sub-plots. The total size of test field was 322 m^2 and the sub-plot had a size of 2 m × 4 m. In experimental soil, 150 kg/ha forage rye seed, and chemical fertilizer of Nitrogen (150 kg/ha), Phosphorous (100 kg/ha), and Potassium (100 kg/ha) were applied. Nitrogen and potassium were applied as a basic fertilizer at seeding time and as an additional fertilizer in early spring, whereas phosphorus was applied only at seeding period. In both years, the plant was harvested at heading stage on April 26.

In order to estimate the winter survival rate of the standing plant, a 30 × 20 cm quadrats were put in each plot, and the plant were counted before and after winter. The plant height of forage rye was measured on the day of harvesting by measuring the height each plant from the ground to the topmost part of the plant. After harvesting, 300 – 500 g of forage samples was collected and dried in an oven of 65 ℃ for a period of 72 hrs to calculate the DMY of forage rye. The dried samples were grounded to pass 2 mm sieve prior to analysis of chemical contents. Ash and crude protein (CP) content were analyzed according to the method of AOAC (1990), and neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to the method described by Goering and Van Soest (1970).

DMY and nutritive value of forage rye were analyzed using PROC GLM procedure of split-plot design with repeated measures. Means were separated by least significance difference (LSD) test, and the significance was declared at $p<0.05$. The data were analyzed with SAS program of 9.4 (SAS Institute Inc., Cary, NC, 2018).

Ⅲ. Results and Discussion

The growing season mean temperature and precipitation was presented in Fig. 1. The lowest monthly average temperature in January, was -2.3 and −5.5 ℃ in 2017 and 2018, respectively. Considering that the over wintering temperature of rye is −25 ℃, there was no problem with over wintering. On the other hand, in the case of precipitation, 2016 was higher than 2017 before wintering and 2017 was higher than 2016 after wintering.

The DMY of forage rye cultivars are presented in Table 2. In 2016, DMY of the September 25 and October 02 sowing were 7,093 and 7,644 kg/ha, respectively, and Gogu and Koolgrazer were 7,709 and 7,028 kg/ha, respectively, showing no significant difference the sowing date and variety ($p>0.05$). Meanwhile, in 2017, DMY of the September 25 and October 02 sowing were 8,344 and 8,140 kg/ha, respectively, and Gogu and Koolgrazer were 7,932 and 8,552 kg/ha, respectively,

Table 1. Soil properties of experimental soil

Soil texture	pH (1:5)	TN (%)	OM (g kg^{-1})	Ave. P_2O_5 (mg kg^{-1})	CEC (cmol+kg^{-1})	Exchangeable cation (cmol+kg^{-1})		
						Ca	K	Mg
Sandy loam	6.58	0.55	8.60	255.66	4.69	3.03	0.50	0.84

TN: total nitrogen, OM: organic matter, CEC: cation exchange capacity.

showing no significant difference the sowing date and variety (p>0.05). In 2-year total, DMY of the September 25 and October 02 sowing were 7,718 and 7,892 kg/ha, respectively, and Gogu and Koolgrazer were 7,821 and 7,790 kg/ha, respectively, showing no significant difference the sowing date and variety (p>0.05). The plant height of forage rye was in the range of 110 – 118 cm in 2016 and 2017 and there was no significant difference in sowing date and variety (Fig. 2; p>0.05). In 2016, the winter survival rate of Gogu and Koolgrazer on September 25 sowing were 84 and 83%, respectively, and there was no significant difference (Fig. 3; p>0.05). Meanwhile, the winter survival rate of Gogu and Koolgrazer on October 2 sowing were 92 and 66%, respectively, which Gogu was significantly higher than Koolgrazer (Fig. 3; p<0.05), but it did not affect DMY. In 2017, the winter survival rate of Gogu and Koolgrazer was 100% in both seeding date and cultivars, so there was no significant difference (Fig. 3; p>0.05).

The DMY had no significant differences (p>0.05) among the cultivars of forage rye and seeding date of both years. Similarly, no significant difference (p>0.05) was observed in the DMY of Gogu and Koolgrazer in both seeding date and

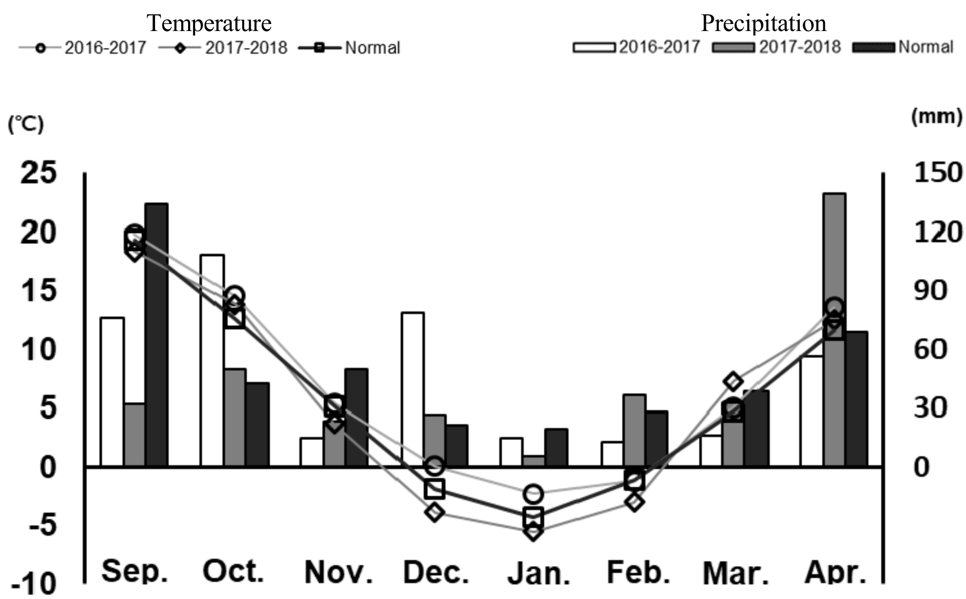

Fig. 1. The mean temperature and precipitation during the cultivation season.

Table 2. Dry matter yield of forage rye for experimental years

	2016	2017	Mean
	-- kg/ha of DM	--	
Seeding date (A)			
25. Sep.	7,093 ± 1,407 ^{ns}	8,344 ± 859 ^{ns}	7,718 ± 1,298 ^{ns}
02. Oct.	7,644 ± 1,577 ^{ns}	8,140 ± 759 ^{ns}	7,892 ± 1,223 ^{ns}
Cultivar (B)			
Gogu	7,709 ±1,644 ^{ns}	7,932 ± 496 ^{ns}	7,821 ± 1,179 ^{ns}
Koolgrazer	7,028 ±1,293 ^{ns}	8,552 ± 934 ^{ns}	7,790 ± 1,344 ^{ns}
Interaction (A × B)			
	ns	ns	ns

GG: Gogu, KG: Koolgrazer; ^{ns} no significance of each column.

years. The DMY of Gogu and Koolgrazer were 7,821 and 7,790 kg/ha, respectively during experimental period. Considering that the DMY of Gogu is 7.1 ton/ha (RDA, 2011), the results of this study were all high. In addition, DMY of Koolgrazer was 6.7 to 8.2 ton/ha (RDA, 2011), showing similar results to the results of this study. Considering this, it is judged that there is no problem with the cultivation of forage rye in the Yeongseo region of Gangwondo.

DMY of all sowing date and varieties was higher 2017 than 2016. The reason for this is that the precipitation 2017 was higher than that of 2016 at from March to April when growing the forage rye after wintering (Fig. 1). In addition, Spring precipitation amount of 171.5 mm reported to be required for optimal DMY of forage rye in South Korea (Beyenssa, 2019). In addition, the reason why DMY was higher in 2016 than in 2017 is that the winter survival rate was higher in 2016 than in 2017. Considering this, it is judged that DMY of forage rye contributed to 2017 higher than 2016 because the appropriate precipitation for forage rye cultivation was close to 2017.

Unlike the southern and central region of South Korea, the climate condition in the northern region somewhat different, and particularly the winter season temperature reported to be lower than the rest part of the country and it could be extend well into early spring season (Chung et al., 2004). This could affect regrowth of the grass, and could also contribute for heading date to be extended. On the other hand, in the uplands of South Korea,

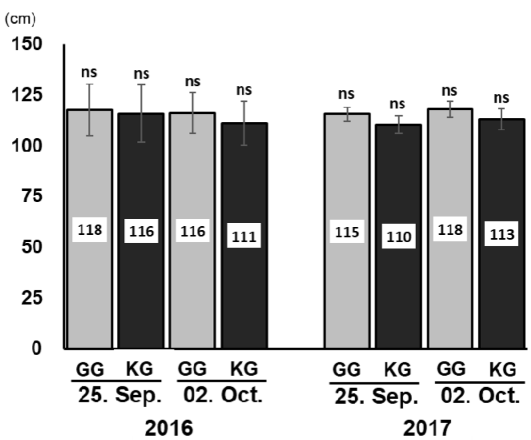

Fig. 2. Plant height of forage rye for experimental years. GG: Gogu, KG: Koolgrazer.; ^{ns} no significance of each bar.

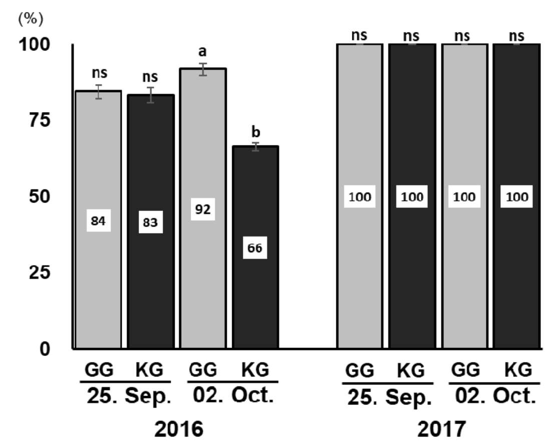

Fig. 3. Winter survival rate of forage rye for experimental years. GG: Gogu, KG: Koolgrazer.; ^{ab} Means within the same bar with different superscripts differ ($p<0.05$).; ^{ns} no significance of each bar.

Table 3. Nutritive value of cultivars of forage rye

Year	Seeding date	Cultivar	DM	CP	ADF	NDF	RFV
			-- % --	% of DM			
2016	Sep. 25	Gogu	22.3^{ns}	11.7^{ns}	32.1^{ns}	55.8^{ns}	144.0^{ns}
		Koolgrazer	21.4^{ns}	12.5^{ns}	30.9^{ns}	54.0^{ns}	148.9^{ns}
	Oct. 02	Gogu	23.0^{ns}	12.3^{ns}	33.6^{ns}	55.2^{ns}	145.3^{ns}
		Koolgrazer	22.6^{ns}	11.3^{ns}	32.6^{ns}	55.0^{ns}	146.0^{ns}
2017	Sep. 25	Gogu	19.7^{ns}	11.3^{ns}	32.6^{ns}	56.6^{ns}	141.9^{ns}
		Koolgrazer	19.4^{ns}	12.1^{ns}	32.5^{ns}	57.3^{ns}	140.2^{ns}
	Oct. 02	Gogu	18.4^{ns}	12.9^{ns}	32.9^{ns}	57.6^{ns}	139.4^{ns}
		Koolgrazer	18.8^{ns}	12.2^{ns}	32.0^{ns}	56.5^{ns}	142.2^{ns}

DM: Dry matter, CP: Crude protein, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, RFV: Relative feed value.
^{ns} no significance of each column.

the main forage crops are summer forage crops such as maize (Shin et al., 2014), and harvesting the winter or spring forage crops in the advanced growth stages presents a delay in the optimal seeding time of these main crops in the region. Therefore, harvesting the field grasses earlier could open the way for the double cropping system to be feasible in the region.

With regard to the forage nutritive value, there was not different in CP, NDF and ADF contents between the two seeding dates and cultivars, as presented in Table 3.

In the study, no major differences were observed in the DMY and nutritive value of forage rye varieties, and are comparable to previous field experiments carried out on similar grasses in the country (Kim et al., 2001; Kim et al., 2005; Li and Kim, 2017; Han et al., 2015). However, in the uplands where double cropping system widely practiced for optimum use of land, the cultivation of late maturing cultivars could pose a delay in the seeding date of major summer forage crops. Thus, in the Yeongseo region of Gangwondo where the winter season cold weather persist through to early spring, cultivation of early maturing forage rye variety is recommended. Considering the DMY and nutritive value of the current experiment, seeding of forage rye cultivars Gogu and Koolgrazer on September 25 and October 2 could be used as an recommended seeding date at Yeongseo region of Gangwondo. In addition, based on the climate characteristics of the region, both cultivars had relatively similar forage yield and quality that makes them to be recommended for cultivation in the region.

Thus, the DMY of forage rye in the Yeongseo region was 6,579.7 to 8,693.4 kg/ha regardless of the seeding date and cultivar, which was similar to the DMY suggested by RDA (2011), and was different from Pyeongchang. This study is meaningful in that DMY was first presented in Yeongseo region where there is no cultivation data for forage rye.

Ⅳ. REFERENCES

AOAC. 1990. Official methods of analysis (15th ed.). Association of Official Analytical Chemist International. Arlington. VA.

Beyenssa, B.C. 2019. Effective climatic variables for the yield of forage crops in the Republic of Kora. Ph.D. thesis. Kangwon National University. Chuncheon. Korea. pp. 1-36.

Chung, Y.S., Yoon, M.B. and Kim, H.S. 2004. On climate variations and changes observed in South Korea. Climate Change. 66(2):151-161.

Goering, H.K. and Van Soest, P.J. 1970. Forage fiber analysis (apparatus, reagents, procedures, and some applications). Agricultural Handbook No. 379, Agricultural Research Service-USDA.

Han, O.K., Hwang, J.J., Park, H.H., Kim, D.W., Oh, Y.J., Park, T.I., Ku, J.H., Kwon, Y.U., Kweon, S.J. and Park, K.G. 2015. A New High Grain Yielding Forage Rye Cultivar, “Seedgreen”. Journal of the Korean Society of Grassland and Forage Science. 35(2):105-111.

Keles, G., Ates, S., Coskun, B., Alatas, M. and Isik, S. 2016. Forage yields and feeding value of small grain winter cereals for lambs. Journal of Science of Food and Agriculture. 96:4168-4177.

Kim, J.D., Kwon, C.H., Shin, C.N., Kim, C.H. and Kim, D.A. 2005. Effect of location, year and variety on forage yield and quality of winter rye. Asian-Australian Journal of Animal Science. 18(7): 997-1002.

Kim, J.G., Chung, E.S., Seo, S., Ham, J.S., Kang, W.S. and Kim, D.A. 2001. Effects of maturity at harvest and wilting days on quality of round baled rye silage. Asian-Australian Journal of Animal Science. 14(9):1233-1237.

KMA. 2022. The climate atlas of Korea-1991~2020. Korea Meteorological Administration. National Climate Data Center. Seoul. Korea.

Li, Y.W. and Kim, J.G. 2017. Effect of cutting height on the feed value and drying rate of rye (*Secale cereale* L.) hay. Journal of the Korean Society of Grassland and Forage Science. 37(3):201-207.

Peng, J.L. 2017. Suitability mapping and yield prediction modeling using climatic and geographic information for improving forage crops production in South Korea. Ph.D. thesis. Kangwon National University. Chuncheon. Korea. pp. 1-181.

RDA. 2011. Technical textbook for forage production and utilization. Ministry of Agriculture. Food and Rural Affairs. Gwacheon. Korea. pp. 16-54.

RDA. 2019. Fertilizer use prescription by crop (Revised 4th). Rural Development Administration, National Institute of Agricultural Science. Wanju. Korea. pp. 363.

SAS. 2018. Statistical analysis system version 9.4. SAS Institute Inc. Cary. NC.

Shin, J.H., Han, J.H., Lee, J.K. and Kim, K.S. 2014. Characterization of the maize stalk ro pathogens Fusarium subglutinans and F. temperatum and the effect of fungicides on their mycelial growth and colony formation. Plant Pathology Journal. 30(4):397-406.

Webb, S.L., Mosali, J., Baker, J.L. and Newell, M.A. 2013. Estimates of variance components and repeatability for total forage yield in rye: Implications for breeding. Plant Breeding. 132:580-585.

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