Journal of the Korean Society of Grassland and Forage Science 43(4): 199~205, 2023
https://doi.org/10.5333/KGFS.2023.43.4.199
ISSN 2287-5824 (Print)
ISSN 2287-5832 (Online)

Research Article

Vegetation Changes and Yields of Tall Fescue-based Mixture Pasture in the Central Region of South Korea

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ABSTRACT

Pasture formation and management are crucial to avoid yield reduction. This experiment aimed to examine the effects of tall fescue-centered mixed-seeding combinations on yield and vegetation changes in perennial pastures in the central region for two years, from September 2020 to October 2022. The treatments were arranged in three replications in a randomized block design: control (C), tall fescue-based mixture-1 (T-1), and tall fescue-based mixture-2 (T-2). The tall fescue (TF), orchard grass (OG), perennial ryegrass (PRG), Kentucky bluegrass (KBG), and white clover (WC) were used. The emergency rate of grasses (70.0 to 73.3%) did not differ among mixed seeding combinations. Overwintering rates (81.7 to 83.3%) were similar among treatments. The plant height of grasses was similar at each harvest date, with the highest height (86.2 cm) recorded in the second harvest of the first year, followed by that (58.4 cm) in the third harvest of the first year; it was least (38.9 cm) in the fourth harvest of the second year. There was no significant difference in the dry matter yield of grasses among the mixed seeding combination treatments in the first, third, or fourth harvests of the first year ($p>0.05$). For second-year grasses, dry matter yield was not significantly different in harvest date among the treatments ($p>0.05$). Based on mixed seeding ratio, orchard grass showed the highest yield at 70% in the C treatment, followed by tall fescue at 80% and 60% in the T-1 and T-2 treatments, respectively, in the first harvest after seeding. There was no significant difference in feed value between treatments ($p>0.05$), but a significant difference was observed between the third and fourth harvest ($p<0.05$). Therefore, it indicated that it is important to create perennial pastures in the central region through mixed seeding combinations centered on tall fescue.

(**Key words**: Pasture, Mixtures, Overwintering rate, Vegetation, Dry matter yield)

Ⅰ. INTRODUCTION

The area of domestic grassland since its formation in 1959 has continued to decrease from 89,902 ha in 1990 (the largest) to 32,012 ha in 2022 (MAFRA, 2023). Of the total grassland area, Jeju Island accounts for the most at 48.3% (15,456 ha), followed by Gangwon at 15.4%, and Chungnam at 7.5%. The utilization rate of grassland was estimated to be approximately 67%, with 42% for livestock grazing (13,425 ha), 22% for fodder crop cultivation, 3% for livestock and auxiliary facilities, and the remaining 33% unused. Lee et al. (2019) conducted a survey on 106 farms with grassland in Korea and found that only 64.2% of the farms were used as grassland, whereas 28.3% were being neglected or used for other purposes. An established grassland must be used semi-permanently to avoid yield reduction through continuous management (Jung et al., 2020). Conversely, when grassland formation and management are neglected, weeds may invade and reduce the yield of the grassland.

The main grasses used for pasture formation are orchard grass (*Dactylis glomerata* L.) and tall fescue (*Festuca arundinacea* Schreb.) (Jung et al., 2017). Orchard grass shows excellent regeneration and yield but has the disadvantage of being vulnerable to summer depression, which is a major cause of pasture deterioration (Chae et al., 2015). A frequent occurrence is increasing the extreme weather conditions, such as high temperature and humidity in summer and extreme cold in winter. So, making provisions for the future, we need to consider the appropriate mixed seeding and mixture rate (Hwang et al., 2016). Moreover,

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owing to the effects of climate warming, the growth environment of northern-type grasses is becoming unfavorable, and a large number of tropical malignant weeds are making pasture management more challenging (Choi et al., 2010).

Studies on pasture mixed seeding combinations have presented several results, including those of Lee and Lee (2003), Kim et al. (2016), and Kim et al. (2017). However, a mixed seeding combination cannot be applied to different pastures because the pasture conditions of each regional farm are different owing to various factors such as altitude, soil, and weather; hence, mixed seeding combinations must be applied based on farm conditions.

Therefore, this study aimed to examine the effects of tall fescue-centered mixed-seeding combinations on yield and vegetation changes in pastures in the central region.

Ⅱ. MATERIALS AND METHODS

1. Experimental design

This test was conducted for two years, from September 2020 to October 2022, to evaluate the regional yield and vegetation composition of pasture based on mixed seeding combinations, with emphasis on tall fescue. The test location was Cheonan-si, Chungcheongnam-do (36° 56′ 07.65″ N, 127° 05′ 47.74″ E). The treatments were arranged in three replications in a randomized bock design: control (C), tall fescue-based mixture-1 (T-1), and tall fescue-based mixture-2 (T-2) (Table 1). The pasture used in the test were tall fescue (*Festuca arundinacea* Schreb., TF), orchard grass (*Dactylis glomerata* L., OG), perennial ryegrass (*Lolium prenne* L., PRG), Kentucky bluegrass (*Poa pratensis* L., KBG), and white clover (*Trifolium repens* L., WC). For mixed seeding combination, the C treatment comprised TF 9, OG 16, PRG 3, KBG 3, and WC 2 kg/ha; T-1 treatment comprised TF 20, OG 5, PRG 3, KBG 3, and WC 2 kg/ha; and T-2 treatment comprised TF 15, OG 10, PRG 3, KBG 3, and WC 2 kg/ha (Table 1).

The seeding date was September 22, 2020. The seeding rate was 33 kg/ha, and the fertilization rate (N-P_2O_5-K_2O) 80-200-70 kg/ha for primary fertilizer and 210-150-180 kg/ha for supplementary fertilizer. Harvesting was carried out four times in total: 1st year April 27, June 2, July 19 and October 12, 2nd year April 25, June 7, August 18 and October 14.

2. Investigation parameters

The growth characteristics of pasture were investigated before and after wintering, and the survey items included emergence rate (%), growth condition (1: strong, 9: weak), tillering number (number/plant), and plant height (cm). The growth characteristics of pasture, pasture height, and vegetation ratio were investigated for each growing period in accordance with RDA (Rural Development Administration, 2012) research and analysis standards, and the vegetation composition ratio was determined through sensory evaluation for each test plot. In addition, dry matter (DM) was analyzed according to the procedure of AOAC (1990) to calculate the forage value of the pasture. Thereafter, the collected samples were dried in a hot air dryer at 65°C for 72 h, pulverized with a 0.7 mm mesh mill, and stored in plastic sample containers. The crude protein (CP) content was measured using an elemental analyzer (Vario Max CUBE, Elementar, Germany) according to the Dumas method (Dumas, 1884), and the total nitrogen and crude protein contents (% CP = % N × 6.25) were calculated. In addition, neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined according to the method described by Goering and Van Soest (1970) with the aid of an Ankom fiber analyzer (ANKOM Technology Corporation, Fairport, NY, USA).

Table 1. Species and seeding rate of mixtures in in the central region

Treatments[1]	Seeding rate (kg/ha)					
	TF[2]	OG	PRG	KBG	WC	Total
C	9	16	3	3	2	33
T-1	20	5	3	3	2	33
T-2	15	10	3	3	2	33

[1] Control(C), Tall Fescue based Mixtures-1(T-1), Tall Fescue based Mixtures-2(T-2).
[2] TF=Tall fescue, OG=Orchard grass, PRG=Perennial ryegrass, KBG=Kentucky bluegrass, WC=White clover.

3. Statistical analysis

One-way analysis of variance was conducted using SPSS 26 (IBM Corporation, Chicago, IL, USA), and the statistical differences in treatment means were tested at a 5% significance level using Duncan's multiple range test.

Ⅲ. RESULTS AND DISCUSSIONS

1. Weather conditions and wintering potential

The precipitation and average temperature in Cheonan during the test period are shown in Fig. 1 (KMA, 2023). The precipitation to 162.2 mm from September 1 to 12, 2020, but after that, the only days with more than 10 mm of precipitation were October 3 and November 19. Rainfall in June 2021, when grass grows well, was low at 44.8 mm. However, the rainfall in June 2022 was 168 mm, which was higher than in the first year.

The lowest average winter temperature recorded in the first year after seeding was -14.1℃ on January 8, 2021. The lowest average temperature recorded in the following winter was -9.8℃ on December 26, 2021, but this was higher than that in the first year. Temperatures above 25℃ were observed for 88 days, when summer heat occurred between July and August; of it, there was 50 days in 2022, which was higher than the 38 days in 2021.

The emergence rate of pasture ranged from 70.0 to 73.3%, with no differences between the mixed-seeding combinations (Table 2). Jung et al. (2018) showed that the emergence rate of grass stand reduced to less than 70% in the Pyeongchang area when seeding was performed after mid-September. Although the average temperature in Cheonan was more than 15℃, it is believed that the seedling rate was low because of low rainfall

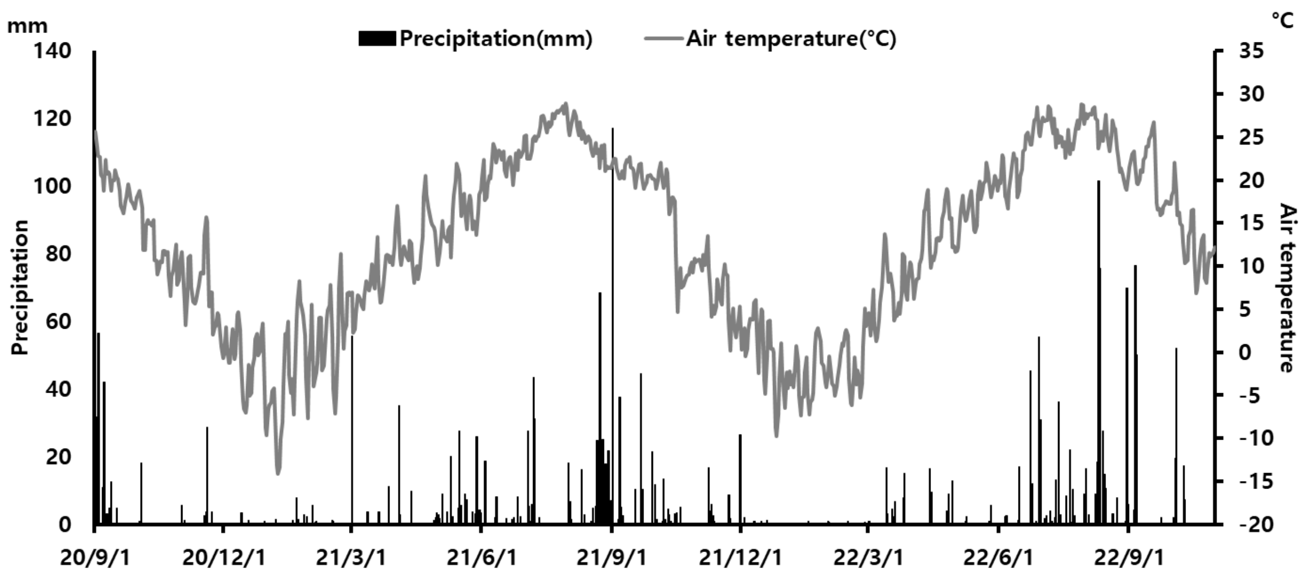

Fig. 1. Precipitation and air temperature in the central region from 2020 to 2022.

Table 2. Growth characteristics of mixtures before and after wintering

Treatments[1]	Emergence (%)	Growth state (1-9)[2]		Plant height (cm)		No. of tillers (No./plant)		Overwintering rate (%)
		Seedling vigor	Cold resistance	Before wintering	After wintering	Before wintering	After wintering	
C	71.7	1.0	1.3	12.2	8.6	3.4	4.7	83.3
T-1	73.3	1.0	1.7	14.1	9.8	4.0	7.0	81.7
T-2	70.0	1.0	1.3	11.2	10.1	3.3	6.9	83.3

[1] Control(C), Tall Fescue based Mixtures-1(T-1), Tall Fescue based Mixtures-2(T-2).
[2] Rating score: 1=strong, 9=weak.

after seeding. Kim et al. (2009) reported that delayed seeding time caused the number of tillers before wintering to be less than two and decreased the overwintering rate. The number of tillers before winter in this study was between 3.3 and 4.0 (Table 2), indicating that the seeds were sown at the appropriate time. Overwintering rates, ranging from 81.7 to 83.3%, were similar between the treatments. This suggests that the weather conditions had no significant impact on the overwintering rate, because the number of days with an average temperature of 5°C from the date of seeding was more than 60 days.

2. Dry matter yield of pasture

The dry matter yield of pasture after treatment during the test period is shown in Table 3. The pasture height was similar at each harvest date, but the highest (86.2 cm) was recorded in the second harvest in the first year. The pasture height in the third harvest in the first year was 58.4 cm, and that in the fourth harvest in the second year, which was the least, was 38.9 cm. However, the plant height of T-1, which had a high proportion of tall fescue, tended to be greater than that of the C and T-2 treatments, which had a high proportion of orchard grass. Kim et al. (2017) reported that plant height increased with mixed seeding combinations with high proportion of orchard grass, but this was not consistent with the result of this study. Jung et al. (2017) did not observe any significant difference in pasture height between orchard grass-and tall fescue-based mixes.

There was no significant difference in dry matter yield of pasture between the mixed seeding combination treatments in the first, third, and fourth harvests in the first year (p>0.05). However, in the second harvest, the T-2 treatment showed a significantly higher than the C and T-1 treatments at 5.55 ton/ha (p<0.05). There was no significant difference in total dry matter yield in the first year between treatments(p>0.05). This was similar with a previous report that dry matter yield was high in a mixed pasture, which was majorly dominated by orchard grass (Kim et al., 2016).

For second-year pasture, significant differences were not observed in harvest date between the treatments (p>0.05). However, from the second harvest in the second year, the dry matter yield was approximately 2.55 to 3.83 tons. The total dry matter yield in the C treatment in the second year was high (15.30 ton/ha). There was no significant difference in the dry matter yield of the first harvest; however, the dry matter yield was higher in the second year than in the first year (p>0.05). The dry matter yield in the second, third, and fourth harvests were significantly higher in the first year (p<0.05) than in the second year. Hwang et al. (2017) reported that the first-year dry matter yield in mixed pasture was 15.2 ton/ha for orchard grass, 14.7 ton/ha for tall fescue, and 15.0 ton/ha for orchard grass + tall fescue. In addition, their dry matter yields in the second year were 18.2 ton/ha for orchard grass, 19.0 ton/ha for tall fescue, and 20.0 ton/ha for orchard grass + tall fescue. However, in this study, the dry matter yield in the first year was 17.94 ton/ha, which was higher than the 15.09 ton/ha in the second year. Dry matter yield reduced from the second harvest in the second year, probably owing to summer heat and weed emergence of bare shoots. Oh et al. (2018) reported that summer depression causes the proportion of bare shoots to increase in perennial mixed pasture.

3. Vegetation changes and feed value of pasture

The vegetation ratio of pasture with different mixing ratios are shown in Fig. 2. The vegetation ratio of pasture differed based on mixing ratio and harvest date but showed a similar pattern. In the first harvest after seeding, based on mixed seeding ratio, orchard grass was the highest at 70% in the C treatment, followed by tall fescue at 80% and 60% in the T-1 and T-2 treatments, respectively. The seeding ratio was based on the mixed ratio of pasture; however, as the harvest date passed, the proportion of orchard grass decreased and the proportion of white clover increased. After the third harvest (August), the proportion of grasses, such as tall fescue and orchard grass, decreased significantly. White clover was more than 57% in all the treatments in the second year and more than 90% in the fourth harvest. In the third harvest, orchard grass was at 0%, and tall fescue was at 22-25% in all the treatments. This result is similar with a report from the central region that mixed seeding combinations centered on tall fescue was more suitable than orchard grass, which is less susceptible to summer heat (Hwang et al., 2016).

The Chemical composition of pasture after mixing are shown in Table 4. There was no significant difference in Chemical composition between the treatments (p>0.05), but a

Table 3. Forage yield of mixtures according to harvest time in the central region from 2021 to 2022

Year	Treatments	1st Harvest			2nd Harvest			3rd Harvest			4th Harvest			Total dry matter yield (ton/ha)
		Harvest date (m.d)	Plant height (cm)	Dry matter yield (ton/ha)	Harvest date (m.d)	Plant height (cm)	Dry matter yield (ton/ha)	Harvest date (m.d)	Plant height (cm)	Dry matter yield (ton/ha)	Harvest date (m.d)	Plant height (cm)	Dry matter yield (ton/ha)	
1st year (2021)	C		73.6±6.29^{ns}	4.80±0.24^{ns}		86.3±1.34^{ns}	4.76±0.10^{b}		58.3±3.09^{ns}	4.17±0.42^{ns}		66.3±2.52^{ns}	3.64±0.29^{ns}	17.37±0.42^{ns}
	T-1	Apr. 27	76.5±0.92	4.80±0.45	Jun. 2	86.6±0.70	4.86±0.22^{b}	Jul. 19	60.0±1.77	4.23±0.13	Oct. 12	68.7±3.24	3.65±0.69	17.54±0.93
	T-2		69.8±2.90	4.78±0.27		86.0±0.54	5.55±0.23^{a}		56.7±3.08	4.19±0.09		67.7±4.97	4.40±0.35	18.92±0.13
	Average	-	73.3±2.2^{A}	4.79±0.17^{A}	-	86.2±0.5^{A}	5.06±0.16^{A}	-	58.4±1.4^{B}	4.20±0.13^{A}	-	67.6±1.9^{A}	3.90±0.27^{A}	17.94±0.39^{A}
2nd year (2022)	C		64.3±0.76^{ns}	5.73±0.63^{ns}		65.5±10.59^{ns}	3.09±0.74^{ns}		67.7±2.91^{ns}	3.76±0.08^{ns}		41.1±0.41^{ns}	2.72±0.21^{ns}	15.30±0.36^{ns}
	T-1	Apr. 25	63.9±2.14	5.09±0.33	Jun. 7	73.5±0.27	3.55±0.64	Aug. 18	74.7±1.99	3.99±0.08	Oct. 14	36.7±5.77	2.23±0.18	14.86±0.40
	T-2		66.4±0.79	5.06±0.11		71.6±10.47	3.60±1.10		70.7±1.11	3.74±0.11		38.9±5.60	2.71±0.26	15.11±0.73
	Average	-	64.9±0.8^{B}	5.29±0.23^{A}	-	70.2±4.5^{B}	3.41±0.43±0.43^{B}	-	71.0±1.5^{A}	3.83±0.06^{B}	-	38.9±2.4^{B}	2.55±0.13^{B}	15.09±0.27^{B}

[1] Control(C), Tall Fescue based Mixtures-1(T-1), Tall Fescue based Mixtures-2(T-2).
[2] TF=Tall fescue, OG=Orchard grass, PRG=Perennial ryegrass, KBG=Kentucky bluegrass, WC=White clover.
Mean±standard error.
[a-b, A-B] means within a column and row without a common superscript letter are significantly different ($p < 0.05$); [ns] means not significantly different.

Table 4. Feed value of mixtures according to harvesting time in the central region from 2021 to 2022

Year	Treatments[1]	1st Harvest				2nd Harvest				3rd Harvest				4th Harvest			
		DM	CP	NDF	ADF	DM	CP	NDF	ADF	DM	CP	NDF	ADF	DM	CP	NDF	ADF
1st year (2021)	C	23.3±0.7^{ns}	14.1±0.9^{ns}	56.3±0.5^{ns}	29.4±0.3^{ns}	19.5±0.3^{ns}	10.8±0.3^{ns}	58.7±1.0^{ns}	33.7±0.8^{ns}	23.9±1.9^{ns}	14.3±0.2^{a}	57.6±0.9^{ns}	33.3±0.3^{a}	14.1±0.6^{ns}	17.6±1.2^{ns}	52.4±2.6^{ns}	29.2±1.0^{ns}
	T-1	23.1±0.7	13.3±0.2	58.1±0.6	30.3±0.2	20.2±0.4	9.6±0.7	59.7±0.7	34.3±0.3	21.3±0.3	12.3±0.4^{b}	55.4±0.7	32.0±0.3^{b}	13.3±0.8	17.3±0.4	52.9±2.1	29.2±0.0
	T-2	23.4±0.8	14.0±0.5	57.8±0.6	29.8±0.6	20.9±0.3	9.8±0.5	59.3±0.8	33.8±0.6	21.2±0.5	11.1±0.5^{b}	55.7±0.9	32.2±0.3^{b}	15.2±1.5	17.2±1.4	53.3±2.7	29.0±0.4
	Average	23.3±0.4^{A}	13.8±0.3^{B}	57.4±0.4^{A}	29.8±0.2^{A}	20.2±0.3^{B}	10.1±0.3^{B}	59.2±0.4^{A}	33.9±0.3^{A}	22.1±0.7^{B}	12.6±0.5^{B}	56.2±0.5^{A}	32.5±0.3^{A}	14.2±0.6^{A}	17.4±0.5^{B}	52.9±1.2^{A}	29.1±0.3^{A}
2nd year (2022)	C	17.5±1.4^{ns}	22.9±0.7^{ns}	45.0±0.5^{ns}	23.8±0.4^{ns}	26.9±2.1^{ns}	17.9±1.2^{ns}	41.0±2.9^{ns}	23.4±2.3^{ns}	26.1±2.6^{ns}	16.5±0.5^{b}	53.7±1.1^{a}	34.0±3.1^{ns}	14.6±0.8^{ns}	21.5±1.3^{ns}	35.8±1.3^{b}	22.7±1.3^{ns}
	T-1	15.7±0.1	24.7±1.4	46.3±1.2	24.0±0.2	26.8±4.0	17.9±0.6	42.4±1.0	23.7±1.2	24.9±1.6	19.3±0.7^{a}	47.9±0.5^{b}	30.2±1.1	11.7±0.6	22.7±0.6	40.0±1.0^{a}	24.5±0.6
	T-2	15.2±1.3	24.9±1.5	45.8±0.7	24.1±0.2	25.4±3.7	17.2±1.0	45.3±4.0	24.7±2.3	26.2±1.4	18.5±0.2^{a}	49.6±1.6^{b}	30.6±1.2	13.1±0.5	22.8±0.5	37.6±1.0^{ab}	24.5±1.0
	Average	16.1±0.6^{B}	24.2±0.7^{A}	45.7±0.5^{B}	24.0±0.2^{B}	26.3±1.7^{A}	17.7±0.5^{A}	42.9±1.6^{B}	23.9±1.0^{B}	25.8±1.0^{A}	18.1±0.5^{A}	50.4±1.0^{B}	31.6±1.2^{A}	13.1±0.5^{A}	22.3±0.5^{A}	37.8±0.8^{B}	23.9±0.6^{B}

[1] Control(C), Tall Fescue based Mixtures-1(T-1), Tall Fescue based Mixtures-2(T-2).
Mean±standard error.
[a-b, A-B] means within a row without a common superscript letter are significantly different ($p < 0.05$); [ns] means not significantly different.

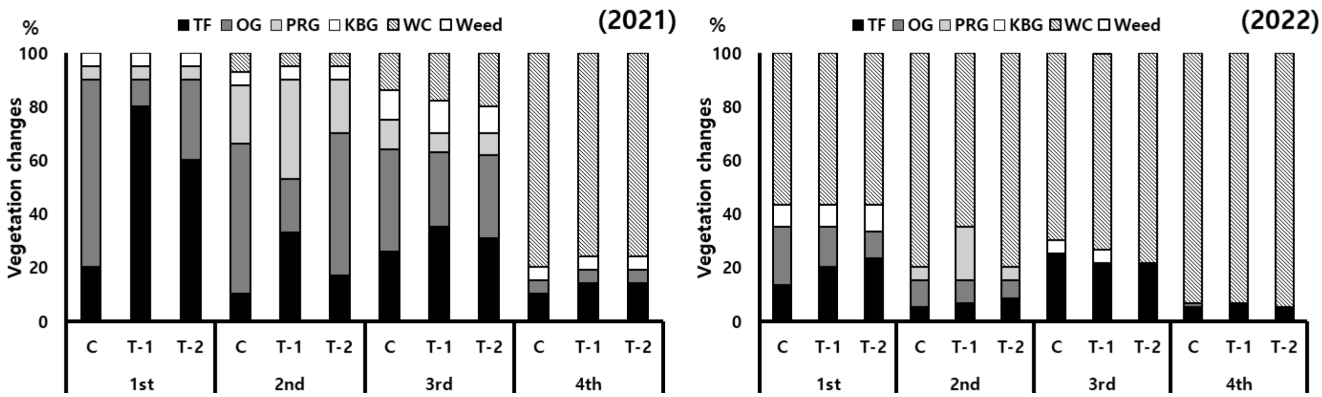

Fig. 2. Vegetation of mixtures according to harvesting time in the central region from 2021 to 2022. Control (C), Tall Fescue based Mixtures-1(T-1), Tall Fescue based Mixtures-2(T-2). TF=Tall fescue, OG=Orchard grass, PRG=Perennial ryegrass, KBG=Kentucky bluegrass, WC=White clover.

significant difference was observed between the third and fourth harvest ($p<0.05$). Some of these differences could be because of summer heat and differences in the growth of pasture. The crude protein and fiber contents of the first harvest in the first and second years indicate good feed values because the plant height is small at the time of harvest. The feed value of mixed pastures varied greatly with vegetation composition and harvest date, making it difficult to determine a consistent trend. However, the CP recorded in this study was similar to or lower than those reported by Chae et al. (2015) for August pasture (CP 16.5~18.16%).

Ⅳ. CONCLUSIONS

Orchard grass and Tall fescue is advantageous in terms of production and vegetation composition in pasture emergence; however, it is highly likely to deteriorate due to its vulnerability to summer depressions. If an orchard grass dies, the yield of the pasture will decrease because of the growth of weeds or leguminous grasses. Therefore, it is important to create perennial pastures in the central region using mixed seeding combinations that have more of tall fescue.

Ⅴ. ACKNOWLEDGEMENT

This research was supported by the “Damage assessment in forages and development of cultivation technology for their damage reduction according to extreme weather (PJ01499601)” of National Institute of Animal Science, Rural Development Administration, Republic of Korea.

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(Received : September 14, 2023 | Revised : December 13, 2023 | Accepted : December 16, 2023)