

Research Article

Review of the Current Forage Production, Supply, and Quality Measure Standard in South Korea

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ABSTRACT

Cattle feeding in South Korea has been heavily dependent on domestically produced rice straw and imported grain. Around 42% of domestically produced rice straw is utilized for forage, and the remainder is recycled to restore soil fertility. Approximately 35% of round bales were made with rice straw. However, higher quality hay is desired over rice straw. Due to increasing stockpiles of rice, there has been an economic burden on the government to store the surplus; therefore production of annual forage crops in rice fields has been further promoted in recent years. Hay import from the USA currently constitutes more than 80% of total imported hays. The main imported hays are alfalfa (*Medicago sativa*), timothy (*Phleum pratense*), and tall fescue (*Festuca arundinacea*). The estimated forage required for cattle feeding was approximately 5.4 million MT in 2016. Domestically produced forage sates only 43% of that value, while low quality rice straw and imported hay covered the rest of demand by 33% and 20%, respectively. As utilization of domestically produced forage is more desirable for forage-based cattle production, long-term strategies have been necessary to promote domestic production of high quality baleage. One such strategy has been utilizing the fertile soil and abundance of fallow rice fields of western region of S. Korea to produce forage crops. Italian ryegrass (*Lolium multiflorum*) is the most successfully produced winter annual in the region and is approximately 56% of the total winter annual forage production. Forage sorghums (*Sorghum bicolor*), sorghum × sudangrass hybrids, and hybrid corn (*Zea mays*) produce a substantial amount of warm-season forage during summer. Produced forage has been largely stored through baleage due to heavy dew and frequent rains and has been evaluated according to S. Korea's newly implemented baleage commodity evaluation system. The system weighs 50% of its total grading points on moisture content because of its importance in deliverable DM content and desirable baleage fermentation; this has proved to be an effective method. Although further improvement is required for the future of forage production in South Korea, the current government-led forage production in rice fields has been able to alleviate some of the country's shortage for quality hay.

(Key words: Winter annual forage, Rice straw, Baleage, Imported hay, Forage quality)

I. INTRODUCTION

As the Korean GDP has increased, the total number of Korean native cattle, 'Hanwoo' (*Bos taurus*), has increased to meet the demand from general Korean consumers and the culinary industry. Although the number of cattle producers has declined in the nation, the cattle producers have increased the average herd size. Historically, the S. Korean cattle industry has been sustained on rice straw feeding, as is reflected in the close proximity of beef cattle farms to rice producing regions; but rice straw is a low quality feed (Kim et al., 2010).

Rice straw baleage has been instrumental in filling the gap between S. Korea's domestic forage supply and the nation's forage demand. Although rice straw still plays a critical role in beef

production, utilization of rice straw as a livestock feed is not promising due to its low nutritive value. Inconsistencies in moisture content and soil contamination also lead to challenges. Therefore, there is a greater need for quality forage.

Limited land availability and the dominance of rice cultivation in South Korea has prevented the cattle industry from gaining a foothold on forage production. However, the increasing surplus of rice provides an opportunity to use fallow rice paddies to grow annual forage crop for domestic production of high quality baleage. Importing grain feed or forage had been possible due to the high market value of domestic beef and dairy products; redirecting funds to purchase S. Korean forage will enable the

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country sustain its cattle industry domestically.

When considering domestic production of forage in S. Korea, it is important to note that heavy dew and frequent rains are large barriers to haymaking. As a result, rice straw and annual forage is generally processed into baleage by agricultural contractors or local agencies (Kim et al., 2018). This process must be completed within a short timeframe so that other forage producers can be served.

Winter annual forage crops such as Italian ryegrass (*Lolium multiflorum*), rye (*Secale cereale*), barley (*Hordeum vulgare*), and oats (*Avena sativa*) cultivate well in S. Korea for domestic production of high quality forage. This group of winter annuals have been grown in marginal lands; with the rice surplus in S. Korea, the national agricultural agency is now promoting cultivation of these forage crops in fallow rice paddies. This approach provides relief for forage shortage while utilizing fallow land, allowing for efficient use of land resources to secure a consistent forage supply for sustainable cattle production.

Various supports and equipment provide by the Korean government seem to contribute to rapid expansion of baleage technology among farmers (Kim et al, 2012; Sea, 2016; MAFRA, 2019). In the recent times, baleage (bale silage) production amounts have increased. However, the distrust of livestock farmer about the produced baleage by the crop farmers have been on the rise.

There are many problem of baleage distribution between producers and supplies of forage in Korea. Then, Korean government, NIAS (National Institute of Animal Science), Korean Society of Grassland and Forage Science were developed and updated forage evaluation standard since 2008 (Lee et al., 2009; Kim et al., 2010; Seo, 2016).

The objectives of this paper are to introduce the current of forage supply in South Korea, and to discuss efforts to secure forage supply and forage quality for forage based livestock production goals.

II. RESULTS AND DISSCUSSION

1. Current forage production and supply in South Korea

The total number of Hanwoo (Korean beef cattle) and dairy cattle were 2,851,746 and 409,243, respectively in 2016 (KOSIS, 2018). Rice straw has been one of the main forage resources for the Korean livestock industry; however, the proportion of market share has decreased in the last six years due to an increase in domestically produced forage (Fig. 1). The estimated forage required for cattle feeding was about 5.4 million MT in 2016. Starting in 2012, the combined proportion of forage crop and pasture reached more than 50% of total domestically produced

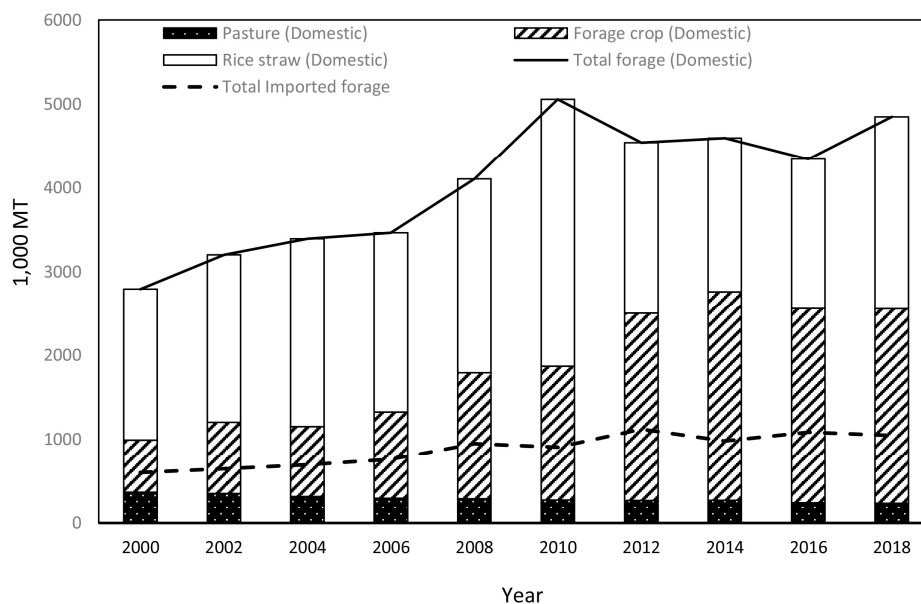


Fig. 1. Proportions of domestic pasture, forage crop, and rice straw produced per year, with overlay of total domestic and imported annual dry forage tonnage (Source: MAFRA, 2017; 2019).

non-grain cattle feed. In 2004, rice straw comprised 66% of total domestically produced non-grain cattle feed, which decreased to 41% in 2016. Despite this decrease, rice straw is still a substantial proportion of domestically produced non-grain cattle feed. Over the last sixteen years, there has been an increase in demands for both domestic and imported forage; however, domestically produced forage has increased at a greater rate than imported forage (Fig. 1). Previously, forage crops were produced in marginal areas where rice or other high value crops cannot grow well. Because an over production of rice has become a financial burden to the government in recent years, fallow rice fields and production of annual forage crops in rice fields have been promoted with subsidies and machinery supports. This agricultural strategy led by the government resulted in a boost of forage crop production from rice fields (Seo, 2016; Kim et al., 2018). As presented in Table 1, commonly produced forage crops from rice fields are Italian ryegrass, rye, and barley. Forage produced from fallow rice fields are utilized through large round baleage.

In addition to providing an alternative to rice production in fallow fields, winter annual forage can be cultivated in active rice fields after the rice is harvested. Regional forage production indicated central and southwestern parts of the country produced the majority of the country's winter forage crop in 2016. Forage production from Jeonnam, Jeonbuk, Chungnam, and Gyeonggi provinces provided 27.9%, 21.6%, 11.0%, and 10.4% of the total national forage production in 2016, respectively. Forage

production in the eastern region is less than that of the western region due to the mountainous landscape and more arid winter climate. The main winter annual forage options in the nation are Italian ryegrass, rye, and forage barley; the main summer annual options are sorghum × sudangrass hybrid and silage corn. Italian ryegrass produced the greatest proportion of the forage crop at around 56.3%. The combined production of the summer annual crops sorghum×sudangrass hybrid and corn produced 22.4% of the total forage crop (Table 1). Traditionally silage corn has been the main summer annual forage crop; the increased forage production of sorghum × sudangrass hybrid in 2016 may reflect a greater flexibility of this summer annual crop for a delayed planting when following a winter annual forage crop. Because farmable land is limited in S. Korea, land price is extremely high, making double cropping rice with forage such as Italian ryegrass-sorghum or sorghum × sudangrass hybrid a promising option. Increased technical support and a greater distribution of round balers act as key players contributing to enhanced annual forage production from rice fields (Kim et al., 2012; Ji, 2016; Seo, 2016). Considering the limited cropland available and many mountainous areas in the nation, forage production from the rice fields can become a promising option for achieving forage based livestock production in Korea.

Rice farm surveys indicated that in 2014 and 2015, an average of 56.5% of harvested rice straw was utilized in restoration of organic matter. During the same time period, rice straw use for cattle feeding was slightly lower at 42.5% (Table 2). The utilization

Table 1. Regional forage production by species in South Korea in 2016 (Unit: 1,000MT, %)

Forage crop	Region [†]									Total	%
	GG	GW	CB	CN	JB	JN	GB	GN	JJ		
IRG [‡]	14,924	0	3,244	32,354	165,827	253,598	34,300	54,039	23,941	582,227	56.3
Barley	217	0	1,187	9,376	16,575	1,937	1,269	0	0	30,561	3.0
Rye	10,451	13,192	5,646	14,324	7,053	815	24,095	22,610	169	98,355	9.5
Oats	12,058	2,537	1,753	4,749	2,070	944	1,836	2,897	0	28,844	2.8
Corn	22,939	9,229	10,651	18,426	9,568	12,820	10,665	5,838	0	100,136	9.7
SS [§]	26,637	10,909	3,798	24,506	17,802	17,231	18,901	11,201	0	130,985	12.7
Others	19,891	3,130	2,256	10,336	4,363	615	4,784	3,238	13,635	62,248	6.0
Total	107,117	38,996	28,537	114,071	223,259	287,959	95,850	99,823	37,745	1,033,356	100
%	10.4	3.8	2.8	11.0	21.6	27.9	9.3	9.7	3.7		

[†]GG = Gyeonggi, GW = Gangwon, CB = Chungbuk, CN = Chungnam, JB = Jeonbuk, JN = Jeonnam, GB = Gyeonbuk, GN = Gyeongnam, JJ = Jeju.

[‡]IRG, Italian ryegrass.

[§]SS = sorghum × sudangrass hybrid.

Table 2. Distribution of rice straw use by number of farms, total area, and proportion in South Korea

Item	Roughage				Soil Restoration	Other	Total	
	Baleage	Square bale	Other	Total				
2014	Farms	401	104	30	535	731	45	1,311
	Area (ha)	1,717.7	228.4	109.7	2,055.7	2,764.8	45.2	4,865.7
	%	35.3	4.7	2.3	42.2	56.8	0.9	100.0
2015	Farms	476	47	10	533	743	47	1,323
	Area (ha)	2,100.9	95.1	10.9	2,207.0	2,904.3	58.9	5,170.2
	%	40.6	1.8	0.2	42.7	56.2	1.1	100.0
2016	Farms	383	37	14	434	939	28	1,401
	Area (ha)	1,481.3	79.9	13.6	1,574.9	4,062.6	42.9	5,680.4
	%	26.1	1.4	0.2	27.7	71.5	0.8	100.0

Source: Korean Livestock Economy Institute (KLEI, 2017).

Table 3. Imported hay amount and proportion by major forage species and exporting countries in 2016

Item	USA		Canada		Australia		Others		Total
	MT	%	MT	%	MT	%	MT	%	
Tall fescue	229,009	99.4	118	0.1	-	-	1,183	0.5	230,309
Alfalfa	193,866	95.8	4,340	2.1	23	0.0	4,226	2.1	202,456
Timothy	168,552	92.4	13,852	7.6	-	-	67	0.0	182,471
Klein grass	71,498	100	-	-	-	-	-	-	71,498
Oats	7,745	5.2	231	0.2	141,748	94.5	229	0.2	149,953
Total	670,670	80.2	18,541	2.2	141,771	17.0	4,705	0.6	836,687

MT = metric ton.

Source: National Agriculture Cooperative Federation (NACF, 2016).

Table 4. Forage species imported as hay and straw in 2017, represented by amount and proportion of the total

Hay [†]	Crop	Alfalfa	Timothy	Oats	Klein grass	Corn (silage)	Mixture	Others	Total
	MT	147,683	147,150	191,607	86,560	16,918	12,266	34	613,209
	%	24.1	24.0	31.2	14.1	27.6	2.0	1.8	100
Straw	Crop	Tall Fescue	Bluegrass	Orchard grass	Italian ryegrass	Perennial ryegrass	Wheat	Mixture	Total
	MT	202,823	7,218	10,580	110,480	76,701	3,608	10,599	422,009
	%	48.1	1.7	2.5	26.2	18.1	0.9	2.5	100

[†]hay includes a small amount of corn silage imported from Southeast Asian countries.

Others = sudangrass, bermudagrass, etc., MT = metric ton.

Source: Korean Livestock Economy Institute (KLEI, 2017).

of rice straw as a roughage declined to 27.7% in 2016, which is presumed to be caused by an inconsistency of rice straw supply due to frequent rains during the rice harvest season. Because of frequent rain events and heavy dew, production of rice straw hay is difficult to achieve in Korea. Large round baleage is the

preferred method to store rice straw, comprising an average of 34.0% of the stored forage over the surveyed years.

The main imported hay products are tall fescue, alfalfa, and timothy (Table 3). More than 90% of the three main hay crops have been imported from the USA. Oat hay is imported from

Australia in substantial amounts among cereal forages, comprising 17% of the total imported hay. However, the heavy dependency on imported hay from the USA makes the Korean forage supply and the related cattle industries affected substantially by the USA hay market conditions.

According to 2017 statistics (Table 4), approximately 41% (422,009 MT) of the total forage importation was straws, which reflected a significant split of demand with hay. Operations anticipating high performance from dairy cattle or racehorses may demand expensive high quality hay while cow-calf, general cattle, and riding horses operations may require cost saving roughage.

2. Price structures of domestically produced forage and imported hay

Traditional cattle feed in Korea has been TMR (total mixed ration) with rice straws. However, recent attempts to enhance

forage supply, particularly with domestically produced Italian ryegrass, cereal forages, and summer annual grasses, have improved cattle feeding (Seo, 2009; 2016). The price of domestic forage is expected to be more competitive than imported forage due to high operational costs of imported hay (Table 5).

Forage is a cheaper feed than grain; however, the cost of transporting forage is much higher than that of grains due to the bulky nature of forage. As a result, the price of imported forage becomes greater than the price of imported feed grain (Kim et al., 2018). Table 6 presents the imported hay price structures from the USA, with much of the cost coming from delivery charges and processing fees. The US local prices of alfalfa, timothy, and tall fescue (straw) were 175, 218, and 55 US dollars, respectively (NIAS, 2016; KLEI, 2017). When those hays were delivered to the livestock producers in Korea, the final retail prices rose to 494, 535, and 350 US dollars, respectively.

Table 5. Annual market prices of domestically produced forage and imported hays in South Korea

Year	Domestic forage (USD [†] /Dry ton)		Imported forage (USD/Dry ton)	
	IRG [‡]	Rice straw	Timothy	Fescue straw
2010	277	162	450	286
2011	289	189	461	275
2012	312	213	470	348
2013	300	194	488	355
2014	231	153	480	306
2015	300	170	503	329

[†]US dollar, rate,0.94 was applied to convert 1,000 won to a dollar.

[‡]Italian ryegrass.

Source: Korean Livestock Economy Institute (2016).

Table 6. Itemized price structure of the imported hays from the USA (USD[†] / MT)

Item	Hay commodity		
	Alfalfa	Timothy	Tall fescue straw
Local price (USA)	175	218	55
Distribution cost in the USA	Shipping fee	123	123
	Storage and processing cost	64	64
	Other cost	20	20
Purchase price for importer	382	425	261
Purchase price of NACF [‡]	461	502	317
Distribution cost in S. Korea	Shipping fee	19	19
	Commission	14	14
Delivery price (Farmer)	494	535	350

[†]US dollar, rate,0.94 was applied to convert 1,000 won to a dollar.

[‡]NACF = National Agricultural Cooperative Federation, MT = metric ton.

Source: Korean Livestock Economy Institute (2017).

Table 7. Local baleage price, gross income, operational cost, and net income of domestically produced forages in South Korea

Price structure	IRG [†]	Barley	Mixture	Rye	Oats	Corn	SS
Local price, USD [‡] /MT	110	98	102	108	110	149	102
Gross income, USD/ha	1,909	1,800	1,026	1,656	1,804	4,753	2,492
Operation costs, USD/ha	1,288	1,557	1,421	1,618	1,625	2,562	1,801
Net income, USD/ha [§]	622	243	367	39	179	2191	691

[†]IRG = Italian ryegrass; Mixture = Italian ryegrass and barley mixture; SS = Sorghum × sudangrass hybrid.

[‡]US dollar, rate,0.94 was applied to convert 1,000 won to a dollar.

[§]Amount after subtracting operation cost from gross income.

Table 8. Baleage grading system based on nutrient value analysis and moisture content proposed by the Korean agricultural ministry and NIAS (National Institute of Animal Science).

Evaluation item (max. point)	Quality point					
Moisture (50)	Moisture, %	<40	40~45	45~50	50~55	55~60
	Point	50	45	40	35	30
	Moisture, %	60~65	65~70	70~75	75~80	>80
	Point	25	20	15	10	5
Relative feed value (30)	RFV	>110	110~100	100~90	90~80	<80
	Point	30	26	22	18	14
Crude protein (10)	CP, %	>12	10~12	8~10	6~8	<6
	Point	10	8	6	4	2
Crude ash (10)	ash, %	<7	7~9	9~11	11~13	>13
	Point	10	8	6	4	2
Baleage quality grade						
Total point (100)	>90	90~80	80~70	70~60	<60	
Final grade	A	B	C	D	E	
Support* (USD/MT)	188	169	150	132	113	

*Support fund of Korean government for forage production farm.
MT = metric ton.

The import cost is unavoidable and can be 145.4% (timothy hay) to 536.4% (tall fescue straw) of the local price.

There are clear differences in economic gains between domestically produced annual forage crops in S. Korea. Among winter annual forages, net gains per ha of Italian ryegrass are significantly more than those of barley, mixture (barley/Italian ryegrass), rye, and oat due to lower operation costs per ha (Table 7). Comparison of the two summer annual crops demonstrated greater net income with cultivation of corn silage than sorghum × sudangrass hybrid. Although the operation cost of silage corn production is highest among the cultivated forage species, the greatest yield, high TDN (total digestible nutrients), and also high market value of corn silage generated the greatest net income per ha in S. Korea.

3. Quality evaluation system for trading domestically produced baleage

Baleage (round bale silage) has greatly increased as an alternative to hay with the technical and financial support of the government. Because baleages are made with wilted forage or rice straw in S. Korea, nutrient value and moisture content vary depending on weather condition at harvest and the collection site. As a result, there are concerns about quality control among customers. This has led Korean government, NIAS (National Institute of Animal Science), Korean Society of Grassland and Forage Science to develop a quality evaluation system to provide a standard to measure fair market value of domestically produced baleage (Lim et al, 2009; Lee et al., 2009; Seo, 2009;

Seo 2016).

The adopted baleage evaluation system puts the most weight on moisture content (Table 8). Out of 100 points, 50 points are allocated to moisture content, 30 points to relative feed value, and 10 points each to crude protein and ash content. Since quality evaluation is determined based on an empirical analysis index, complaints on baleage quality evaluation can be settled objectively. However, the current system does not consider other critical baleage quality criteria such as odor, pH, volatile fatty acids, weed contamination, and mold. Moisture content below 40% receives 50 points in the system because it indicates high DM content in the round bale. However, low moisture baleage is subject to limited fermentation and a high pH silage, which causes moldy baleage. Since baleage is the main marketed forage type in S. Korea, the current evaluation standards could stand to evaluate on more parameters affecting the nature of fermented forage. At its current stage, the evaluation standards focusing on DM content (through moisture content) have been sufficiently meeting baleage trade demands in the country (NIAS, 2016; MIFRA, 2017).

III. CONCLUSIONS

The high cost of land and low priority of forage crop production in South Korea has caused a great dependency on low feed value rice straw and costly imported forage. However, in order to achieve sustainable cattle production, it is essential to attain a consistent supply of high quality forage at low prices. In a country with limited agricultural land, a surplus of rice production has provided an opportunity for domestic forage production in fallow rice paddies to meet the needs of Korean cattle producers. Current agricultural programs promoting annual forage crop production on rice fields has been effective in encouraging domestic forage production. According to recent agricultural surveys, increasing the proportion of domestically produced forage has met around 80 of the nation's forage demand. With this promising start of domestic forage production and an established standard for quality evaluation, S. Korea is on track to achieving significant production of domestic forage for its local cattle producers.

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