Forage Production and its Use in Korea

Moon-Chul Kim
Department of Animal Biotechnology,
Cheju National University, Cheju, Korea

Introduction

Korea will focus her attention on raising more animal in future as she has been consuming a greater amount of animal food with the rise in the standard of living of her people. Animal feed produced from herbivore has the merit of being able to utilize unused resources within this country. Herbage feeding to animal, instead of concentrate feeding, is a way to be able to lower management cost with low concentrate use, and help to form soil organic matter. This helps solve pollution problems and with the return of animal waste on soil, a beautiful landscape on extensive grasslands is facilitated.

Korea, however, faces some problems. Sixty-five percent of her total area is forest, there are problems with infertile soil and climate conditions are not suitable to grassland forming. Korea's grasses characterized by climate conditions are classified as temperate grasses and tropical grasses. Temperate grasses grow well at around 20℃ while tropical grasses do best at around 30-35℃. Neither grass is particularly well-suited to our climate. Temperate grasses undergo stress at temperatures of more than 25℃ but tropical grasses at lower than 10℃.

Another problem for extensive pasture production is small-scale farms. Sixty-five percent of Korean farms are small-scale(1-9 animals) which is an obstacle to improving a native grassland with automatic eqiupment. Because of all these factors, farmers loose interest in producing more forage.

However, in order to cope with problems that arise when the cost of imported foods increases, Korea thinks that she must become more self-sufficient in food production instead of relying too much on imported food. In 1996, Korea witnessed grain prices 230-240 dollars per ton due to decreased crop production area in USA due to drought and to the fact that China changed into a grain importing country. Korea livestock industries which imported grains from foreign countries for animal feed experienced great hardships. Korea will continue to experience hardship in her livestock if she is not able to secure native roughage feed.

Though Korea finds it difficult to increase roughage feed production due to several difficult conditions, she should find a way to increase the self-supply rate of roughage feed. If the technology for forage production would be advanced with constant research, it will be possible to get closer to roughage self-supply.

History of forage production and its use

Since the establishment of Korean people on the Korean peninsula, there has been no report about improving pasture with Korean native plants(Kim *et al*, 1965). Mr J.N. Sutter-Japan resident, Australia trade counselor-donated seeds of 34 pasture species to Korea in 1906, with which the 1st experiment was carried out in 1907. Legume forages were also introduced from Japan and the USA in 1908, while white clover(T. repens) was introduced from Canada in 1909(Kim *et al*, 1987).

It was in 1956 that Korea began to have a great interest in seed introduction and forage production. Since that time, a lot of forage seed has been introduced with the help of the I.C.A. of the US and forage has begun to be produced positively. As dairy industry was being developed in Korea, more forages were produced throughout the country. The total area of arable pasture with forage area was about 200,000 *ha* in 1996, but this is a very small area in comparison with other advanced countries.

Environmental conditions and forage growth in Korea

1. Climate

(1) Rainfall

Korea located on a peninsula between the Eur-Asia Continent and the Pacipic Ocean, shows high temperature and high rainfall in summer as affected by the ocean climate and low temperature and low rainfall in winter as affected by the continental climate. According to Figure 1, average monthly rainfall is 270 ㎜ in Korea during the period from June to September, while average monthly rainfall is 35 ㎜ from October to March of the next year. This demonstrates that the rainfall in Korea is disadvantageous to pasture growth which needs evenly 70 ㎜ throughout the year.

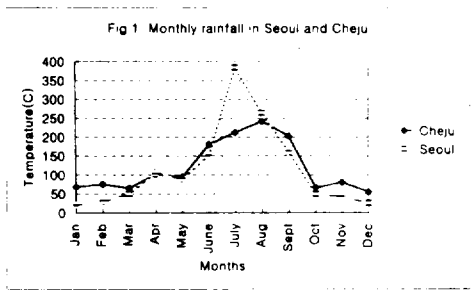

Fig 1. Monthly rainfall in Seoul and Cheju

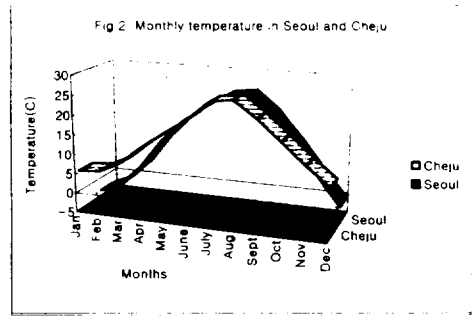

Fig 2. Monthly temperature in Seoul and Cheju

(2) Temperature

Introduced temperate grasses are mainly used in Korea and have a characteristic of being weak in high temperatures of more than 25℃. Figure 2 shows the average monthly temperatures of central Korea. As you can see the average temperature in July and August rises to 25℃ or more. So high temperature cause the pasture grasses to undergo stress which hinders growth and results in changing gradually improved perennial grasses into weeds, tall fescue or clover-dominated pasture.

(3) Soil

Soil conditions are also not good for pasture growth. Table 1 describes chemical characteristics of the soil of crop fields and hill areas in Korea. The pH of field crop soil is 5.7, compared with the hill soil's 5.3. Rates of organic matter, available phosphorus,and base saturation of hill area soil in Korea are 0.9%, 11.3ppm and 26% respectively, being more infertile than that of crop field soil. So proper fertilizer must be applied, when grasslands on hill area are newly improved.

Table 1. Chemical characteristics of hill and field crop soil

Item	OM (%)	Available phosphorus (ppm)	pH	Cation exchangeable(me/100g)			Base saturation (%)	Cation exchangeable capacity (me/100g)
				Ca	Mg	K		
Field crap	2.9	101.0	5.7	4.20	1.20	0.34	60	9.6
Hill	0.9	11.3	5.3	0.75	0.73	0.22	26	6.5

Kim et al(1987)

Table 2. Fresh yield of native grassland

Unit : kg/*ha*

Item	Meadow			Grazing field		
	High	Medium	Low	High	Medium	Low
Whole country	11,543	6,892	5,265	4,710	3,203	1,410
Cheju	13,140	8,030	-	6,230	3,270	1,350

Kim(1987)

Native grassland and improved pasture production and its use in Korea

1. Native grassland

Native grasses of Korea are worse in regrowth and DM production than those of improved pasture, as shown in Table 2. Improved pasture or forage obtains fresh yield of 30-50ton/*ha* in meadow, in comparision with that of 10-13ton in native grasses. Grazing field yields are similar to those of native grasses.

Table 3, 4 and 5 deal with native legumes, native grasses and native poison plants distributed all around South Korea. Native legume families which are proliferating in Korea are *Cassia mimosoides* var. nomame Makino, *Kummerowiastriata* Schindler, *Lespedeza bicolar* Turcz., Lespedeza cuneata G. Don., *Pueraria thunbergii* Bentham, *Rhynchosia* volubilis Lour. and *Robinia pseudoacacia* L., while proliferating grass families are *Andropogon brevifolius* SW., *Arthraxon hispidus* Makino, *Aruninella hirta* Koirdz., *Cymbopogon tortilis* var. geringii Hand-Maz. *Festuca ovina* L., *Miscanthus sinensis* var. purpuraseens Rendle, *Themeda triandra* var. japonica Makino and *Zoysia japonica* Steud. *Convallaria keiskei* Miquel, *Pteridium aquilinum* var.

latiuculum Und., *Pursatilla koreana* Nakai, *Ranunculus jaonicus* Thunb. *Rhododendron mucronulatum* Turcz. *Rhododendron schlippenbachii* Max. are proliferous native poison. In the past, a lot of cattle first introduced into Cheju from foreign countries died from fern poison in the process of grazing pasture dominated with more fern than they were accustomed to before they adapted to their new environment.

Table 3. Legume plants distributed in native grassland

Scientific name
Aeschinomene indica L.
Albizzia julibrissin Durazzini
Amorpha fruticosa L.
Amphicarpaea edgworthii var. Japonica Oilver
Cassia mimosoides var. nomane Makino
Desmodium oxyphyllum DC.
Dunbaria villosa Makino
Indigofera kirilowi Max.
Kummerowia stipulacea Makino
Kummerowiastriata Schindler
Lathyrus davidii Hance
Lespedeza bicolar Turcz.
Lespedeza bicolar var. melanantha T. Lee
Lespedeza cuneata G. Don.
Lespedeza cyrtobotrya Miquel
Lespedeza maritima Nakai
Lespedeza maximowiczii Schneider
Lespedeza pilosa Sieb. et Zucc.
Lespedeza thunbergii var. intermedia T. Lee
Lespedeza tomentosa Thunb.
Lespedeza virgata DC.
Maackia amurensis Rupr. et Max.
Phaseolus nipponesis Ohwi
Pueraria thunberigii Bentham
Rhynchosia volubilis Lour.
Robinia pseudoacacia L.
Sophora flavescens Ait
Trifolium repens L.
Vicia amoena L.
Vicia amurensis var. pratens Hara
Vicia unijuga Al. Br.
Vicia venosa var. cuspidata Max.
Vigna vexillata var. tsusimensis Matsum.

Kim *et al*(1987)

Table 4. Grass plants distributed in native grassland

Scientific name
Agropyron tsukusiense var. transiens Ohwi
Agrostis clauca var. nukabo Ohwi
Alopeculus aequalis Sobol
Andropogon brevifolius SW.
Arthraxon hispidus Makino
Arundinella hirta Koidz.
Bothriochloa parviflora Ohwi
Bromus japonicus Thunb
Bromus remotiflorus Ohwi
Calamagrostis epigeios Roth
Calamagrostis langsdorfii Trin.
Cleistosgenes hackelii Honda
Cymbopogon tortilis var. geringii Hand−Maz.
Digitalia sanguinalis Scopoli
Echinochloa crusgalii Beauv.
Eleusine indica L.
Ergrostls ferruginea Beauv.
Eriochlosa villosa Kunth
Eularia speciosa Kuntze
Festuca ovina L.
Festuca parvigluma Steud.
Imperata cylindrica var. koeringii Durand et Sunitz
Isachne globosa O. Kuntze
Isachaemum cassipes Thell.
Koeleria cristata Pers.
Microstegium vimineum var. polystachyum Ohwi
Miscanthus sinensis var. purpurascens Rendle
Molinia japonica Hackel
Paspalum thunbergii Kunth
Penniselum alopecuroide Spreng
Phragmites communis Trin.
Poa sphondylodes Trin.
Sasamorpha purpurascens Nakai
Setaria glauca Beauv.
Setaria viridis Beauv.
Setaria viridus var. gigantea Matsumura
Sorghum nitidum Pers.
Spodiopogon cotulifer Hackel
Spodiopogon sibiricus Trin.
Sporobolus elongatus R. Br.
Themeda triandra var. japonica Makino
Zizania latifolia Turcz.
Zoysia japonica Steud.

Kim *et al*(1987)

Table 5. Poison plants distributed in native grassland

Scientific name
Aconitum jaluense Kom.
Ambrosia artemisiifolia elatior Descourtils
Arisaema amurense var. serratum Nakai
Caesalpinia japonica S. et Z.
Caltha minor Nakai
Chelidonium majus var. asiaticum Ohwi
Cicuta virosa L.
Cirsium japonicum var. spinosissimun Kitam.
Cirsium rhinoceros Nakai
Convallaria keiskei Miquel
Datura fasuosa L.
Datura stramonium L.
Euphorbia pekinensis Rupr.
Hylomecon hylomeconoides T. Lee
Hylomecon vernale Max.
Hyosciamus agrestis Kitaubel et Schultes
Persicaria blumei Gross ex Nakai
Persicaria chinensis var. thunbergiana Hara
Persicaria filiforme Nakai
Persicaria hydropiper L.
Persicaria makinoi Nakai
Persicaria viscofera Gross.
Phryma leptostachya var. asiatica Hara
Pinellia ternata(Thunb.) Breitenb.
Pteridium aquilinum var. latiusculum Und.
Pursatilla koreana Nakai
Ranunculus acris var. stevenii Regel
Ranunculus chinensis Bunge
Ranunculus japonicus Thunb.
Ranunculus tachiroei Fr. et Sav.
Rhododendron mucronulatum Turcz.
Rhododendron mucronulatum var. ciliatum Nakai
Rhododendron schlippenbachii Max.
Rhododendron yedoense var. poukhanense Nakai
Scopolia japonica Max.
Sium suave Walt Stellera chamaejasme L.
Stellera rosea Nakai
Urtica angustifolia Fischer
Urtica latevirens Max.
Urtica latevirens var. robusta Maekawa
Urtica thunbergiana s. et Z.
Veratrum japonicum Losen. f.
Veratrum patulum Roesner
Veratrum versicolor for. albidum Nakai

Kim *et al*(1987)

2. Roughage production and its use

(1) Comparison of roughage use between Korea and other countries

Korea has been interested in rice farming for food from times past. Animals have been raised as a means of cutivation and draft and native plants or rice straw has been used as roughage feed for animals. Increasing the importance of the livestock industry since 1960, the Korean government has begun supporting a farmer's fund for pasture improvement. The rate of improved pasture to total land in South Korea changed little from 1985(0.5 %) to 1996(0.6%) while the rate of roughage product area to total land(including forage product area) only increased from 1.3% to 2.0% during the period from 1985 to 1996 respectively (Table 6). The U.S., Germany, and U. K. are 33%, 20% and 50% in the rate of pasture area to total land, respectively, compared with Korea at 2.0%. The most important reasons that Korea has only a 2.0% rate of pasture area to total land are an environment unfit for pasture growth and a land area that is 65% forest, of which is prohibited from being converted into improved pasture under several kinds of laws.

Table 6. Production base for roughage in Korea

Unit : Thousand *ha*

Item	1980	1990	1995	1996	'96/'80
Pasture area	48	90	66	63(1.2%)	131
Forage area	78	181	164	132(6.7%)	169
Dry field	40	138	140	98(12.3%)	245
Rice field	38	43	24	34(2.9%)	89
Total	126	271	230	195	155

Choi(1997)

Pasture and forage area in Korea increased 131% and 169% between 1980 and 1996, respectively. Conversion of crop field into forage product area increased 245%. The great increase from crop field to forage production was caused by industrialization because a great movement of farmers into urban communities left a lot of crop field unused. So crop field area of crop field will increase in the future. However, pasture production on hill area will not be enlarged greatly as long as mountain development is prohibited.

Table 7. Pasture production and its use

Unit : Thousand *ha*

Pasture	Grassland Grade			Land owner			Grazing animal		
Area	High	Medium	Low	Nation	Public	Private	Beef	Dairy	Others
63	22(35%)	29(46%)	12(19%)	47(74%)	8(13%)	8(13%)	31	16	16

Choi(1997)

Pasture graded at medium or high condition is 80% or more among improved pasture(Table 7). Private ownership of pasture is low(13%) because it is difficult to purchase land due to the rise of the land value

(2) Roughage production in foreign countries.

Table 8 compares the sources of roughage feed supply in some major countries.

Korea uses 69% rice straw and 31% pasture and forage as roughage feed, while the rate of forage to total roughage is 80% in Japan and the U.S.

Table 9 shows the rate of roughage to concentrate supplied in some countries.

The rate of roughage to concentrate is 33% in Korea, 48% in Japan, and 70% or more roughage in the U.S., the UK and NZ. This table shows that Korea feeds cattle in an unecomonical way.

Table 8. Roughage feed supply of some main countries(%)

Item	Country			
	Korea	Japan	USA(I)	USA(II)
Pasture	6	61	54	61
Forage(Dry,Rice)	25	22	31	23
Rice straw	69	15	–	–
Native grass	–	2	15	16

Choi(1997)

Table 9. Rate of roughage supply to concentrate(normal level 60 : 40)

Unit : %

Item	Korea	Japan	USA	UK	NZ	Remark
Roughage	33	48	66	70	95	TDN Level
Concentrate	67	52	34	30	5	〃

Choi(1997)

Program for roughage supply and its use

1. Demand-supply program of roughage feed

According to the roughage demand-supply program of the Korean government(Table 10), the rate of good roughage supply is only 24% of the total roughage supply rate at the present but will be improved to the level of 56% in the future, as the government has plans to enlarge roughage production.

Table 10. Program for roughage demand and supply

Unit : Thousand tons

Item		1996	1998	2001	2004
Demand	Beef	6,240	6,655	5,795	5,409
	Dairy	1,610	1,623	1,659	1,688
	Total(A)	7,850	8,278	7,454	7,097
Supply	High Pasture	441	469	518	560
	Roughage Forage	1,176	1,440	2,080	2,800
	Rice field	238	350	481	640
	Total(B)	1,855	2,439	3,079	4,000
Rate of supply(B/A)%		24	29	41	56
	Imported roughage	211 (26%)	285 (33%)	390 (47%)	640 (63%)
	Native roughage	2,252	2,795	3,365	2,597
	Total(C)	4,318	5,519	6,833	7,097
Deficit(A-C)		3,532	2,759	621	0

Choi(1997)

2. Use of good forage variety

According to an investigation of a Seoul Dairy Cooperative about the kind of forage planted by its farmers in Korea in 1995, corn(*Zea mays*) was the highest of several forage crops at 52.1%(Table 11). This means that dairy farmers plant more corn(*Z. mays*) in consideration of its production or feed quality. From a lot of experiments comparing the difference between several forage species on DM and TDN yield, Kim(1993) reported that corn(*Z. mays*) had the highest rate in Korea(Table

12). I also recommend that it is good to use corn(*Z. mays*) silage as summer season crop and Italian ryegrass(*Lolium multiflorium*) as a winter forage crop in the case of dairy farm.

Table 11. Percentage of forage planting for roughage production(%)

Item	Corn	Sudangrass	Rye	Oat	Rape	Others	Total
	Z.mays	S.bicolor	S.cereale	A.satava	B.napus		
Rate(%)	52.1	18.0	14.9	10.0	4.3	0.6	100

Note : '95 Survey on farm management of Seoul Dairy Cooperative member Seo(1996)

Table 12. Dry matter yield and TDN yield of major forage crop under two crops a year

Item	Dry matter yield(%)	TDN yield(%)
Z. mays	100	100
S. bicolor	102	83
S. cereale(Early)	64	51
S. cereale(Late)	51	41
B. napus	31	27
A. sativa(Early)	25	21

Note : Kim(1993)

Table 15 also shows that Italian ryegrass(*L. multiflorum*) harvested more dry matter yield than other grasses. Korea has to look for forage crops that get higher yields per unit area because she has a small amount of arable land.

3. Selection of good pasture and forage adapted for the Korean environment

As technology to breed new varieties of forage has not developed yet in Korea, mostly foreign varieties have been used after adaptation experiments have been conducted in Korea. Table 13 shows government recommended varieties on pasture and Table 14 shows those on forage. There are some varieties bred in Korea such as Hapsung in orchardgrass(*D. glomerate*), Suweon 19 and Hoyengseong in corn(*Z. mays*), Paldang in Rye(*S. cereale*) and Samjealguyri in oats(*A. sativa*).

Table 15 shows dry matter yields and environmental adaptations of pasture varieties growing in mostly mixed pasture. As the results on Table 15 demonstrate, Hapsung No 2, Fawn and Tetila are the best varieties in orchardgrass(*D. glomerata*), tall fescue(*F. arundinacea*), and Italian ryegrass(*L. multiflorium*) in Korea, respectively. However, as good varieties continue to be bred in foreign countries, scientists must carry out adaptation trials on new foreign varieties and have to make known to farmers the results.

Table 13. Korean government recommanded varieties of pasture species

Species	Name of varieties
D. glomerata	Homemade : Hapseong No 2
	Import : Potomac, Frode, Frontier, Ambassador, Hallmark, Summer green, Amba
F. arundinacea	Fawn, Alta, Fastorina, Felopa, AU−triumph
P. pratense	Climax, Clair, Odenwalder, Hokuo
L. perenne	Norlea, Taptoe, Reveille, Bastion, Ellett, Bison, Tetrelite
P. pratensis	Kenblue, Monopoly
A. alba(redtop)	Streaker
P. arundinacea	Frontier, Venture, Vandage
L. multiflorum	Dalita, Terone, Barmultra, Tetraflorum, Bettina, Wencke, Gordo, Sikem, Bartissimo, Wilo, Combita, Tosca, Florida 80, Tachiwase
M. sativa	Pacer, Scout, Taem, Luna, Vernal, 5444, Drummor
T. repens	Califonia Ladino, Regal
T. pratense	Kenland, Titus, Atlas
L. corniculatus	Empare, Viking

Korean Livestock Cooperative(1994)

Table 14. Government recommanded varieties of forage species

Species	Name of varieties
Z. mays	Homemade : Suweon 19, Hyongseongok, Kwangsanok, Jungbuok
	Import : P 3352, P 3282, P 3144, G4743, DK689, DK729, DK 713, G4624, P3394
S. bicolor	P988, P855F, G83F, Jumbo, T.E.Haygrazer, Sordan 79,
Hybrid	T.E. Haygrazer−R, GW9110G, NC+855, SX−17, Speed feed.
	P931, P947, P956, NK367, T.E. Silomaker
S. cereale	Homemade : Paldang, Singi, kumsanjerae, Jinanjerae, Chunchuhomaek,
	Import : Koolgrazer, Elbon, Vitagraze, Bonel, Athens abruzzi, Maton, Wrean abuzi, Kodiak, Wintermore, Danko, Wintergrazer 70, Luchs
A. sativa	Homemade : Sanjeolgwiri, Megwiri.
	Import : Cayuse, Magnum, Foothill, West, Murray, Swan, Ensiler.
B. napus	Akela, Velox, Ramon, Sparta, Barnapoli, Choengyeadankyo No4.

Korean Livestock Cooperative(1994)

Table 15. Dry matter yield of major import forage varieties

Name of species	Import country	Cold endurance	Disease endurance	Regrowth	Period of maturity	DM yield (kg/*ha*)
D. glomerata						
Potomac	USA	MS	S	S	MM	9,460
Frode	〃	S	MS	S	MM	9,930
Frontier	〃	S	S	S	MM	9,680
Hapseong No2	〃	S	MS	MS	MM	10,370
F. arundinacea						
Fawn	USA	S	MS	S	MM	10,620
Festal	〃	MS	MS	S	MEM	9,630
Festorina	Netherland	S	MS	M	MLM	9,380
Kentucky 31	USA	S	S	S	MM	10,960
P. pratense						
Clair	USA	S	S	MS	MM	8,760
S51	UK	M	M	−	−	10,100
L. multiflorum						
Tetron	Netherland	MW	M	MS	EMM	8,970
Tetrelite	USA	MS	S	S	EM	11,110
Tetila	−	MS	S	S	MM	11,780

Note : Medium Strong MS, Strong S, Weak Medium WM, Medium M, Middle Maturity MM, Middle Early Maturity MEM, Early Maturity EM, Early Middle Maturity EMM, Middle Late Maturity MLM.

Korean Livestock Technology Institute(19

Kim et al(1997) compared Fawn tall fescue(F.arundinacea) with Roa tall fescue(endophyte free variety) under grazing trial and obtained a better daily weight gain in Roa tall fescue, endophyte free, than that in Fawn(Figure 3).

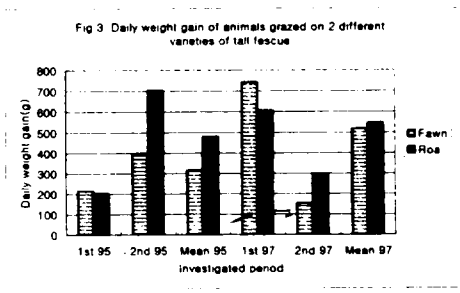

Fig 3. Daily weight gain of animals grazed on 2 different varieties of tall fescue

4. Positive use of legume forages

Legume plants plays several good roles in offering animals a good protein source, in improving physical and chemical charateristics of soil, in decreasing nitrogen application with nitrogen fixation by microorganism and in protecting soil contaminates from nitrogen pollution.

Figure 4 compares the effect of the clover rate on weight gain of grazing animals in mixed pasture. Daily weight gains are getting higher with the increase of clover composition in mixed pasture. This is thought to be due to the high protein content of clover plants. In the future, we must also have

more interest in planting alfalfa(*M.sativa*) for haymaking and do a lot of research to find proper places for alfalfa(*M.sativa*) planting in Korea.

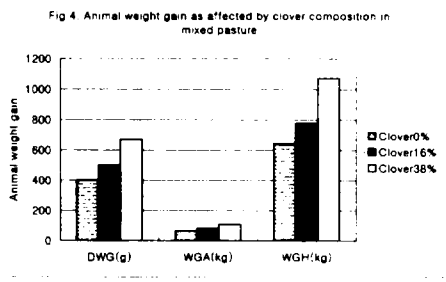

Fig 4. Animal weight gain as affected by clover composition in mixed pasture

5. Enlargement into large scale areas for pasture and forage production

Korean farms which own small grasslands of 1−5*ha* are 24% of total farms while farms possessed of 10*ha* or less grassland are 90%. So in the process of hay or silage making, it is not easy to work with large−scale machinery. Because of high personal expenses, it is very difficult to cut down production costs under these systems. The central government has to fund and equipment this project, and lend fund and equipment to farmers to enlarge private land and to make agriculturally a productive use of public land through a government project.

6. Enlargement of the production base for good quality roughage feed

The area of pasture improvement at the present is 63,000*ha*, making up 0.6% of the total area of South Korea. This area must be broadened to 15% or more, exploiting some of the 65% forest area. Exploitation of forest must make progress under a system that keeps both herbage production and forest protection, in addition to keeping beautiful views as tourist places.

A new system that enables using unused land positively, including rice paddy field, must be prepared, in order to hire farmers for these land easily.

7. Water storage and its use in drought seasons

Forage is greatly stressed during low rainfall or drouhgt and is shown to be produced at low rates during the period from October to February in Korea. However, the period between June and September has too high a rainfall, flooding into the sea and causing damage. So, flooding water in summer is stored in many dams and is supplied into forage and other crops during drought periods.

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