Chapter 2
Development of Forage Industry in China

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Forage grass is an important part of crop production and the foundation of modern livestock development, which plays an important role in agricultural system in most countries. China's forage industry has gradually risen since the mid-twentieth century, experiencing the slow development from 1978 to 1998, the rapid development from 1999 to 2003, the adjustment stage from 2004 to 2008, and the achieving development stage from 2009. The yield of high-quality forage grass has been greatly improved, providing the solid foundation for the rapid development of the animal husbandry. After nearly 30 years of development, China's forage industry chain has transformed from barely existing into near perfection. It is mainly composed of forage seed industry, forage cultivation, production and processing, forage efficient utilization and intensive processing industry, etc.

Analysis of Forage Requirement

As people's living standard in China improves, food consumption pattern has undergone major changes. From 1985 to 2017, the proportion of total rations in the grain consumption structure dropped sharply from 71.9 to 27.3%. At the same time, residents' annual consumption of meat, eggs, milk, and other animal foods increased from 15.2 kg per capita to 57.7 kg per capita, up 3.8 times. In addition, due to the population growth in China, residents' demand for the total consumption of meat, eggs, and milk was also exploding. In terms of the meat' consumption structure, the proportion of pork decreased from 83 to 62%, while the proportion of herbivorous livestock products such as beef and mutton increased from 7.8 to 9.9%. The increasing need for livestock products inevitably lead to a rapid increase in the number of cattle and sheep breeding.

Until the end of 2019, the total number of large domestic animals was 98.777 million in China, and the number of sheep was 300.7214 million (data source:

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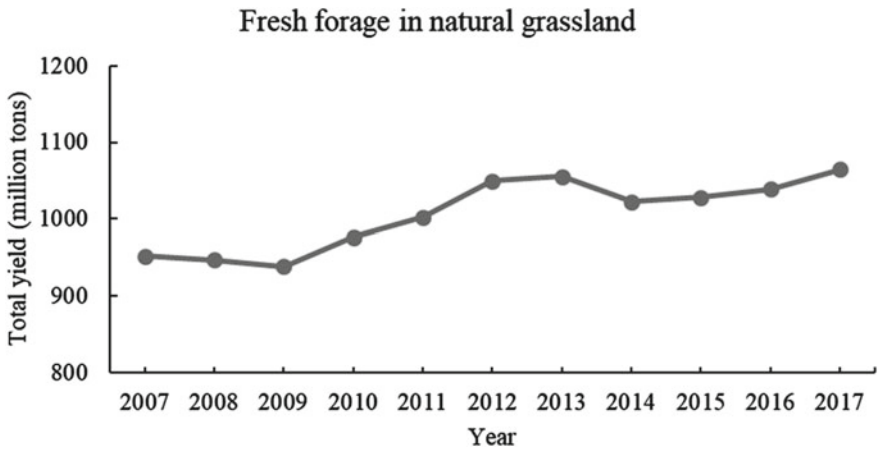

Fig. 2.1 Total yield of fresh forage grass of natural grassland in China from 2007 to 2017 (*Data resource* NBS)

National Bureau of Statistics, NBS). Cattle and sheep are mainly herbivorous livestock. Assuming that the conversion rate of dry pasture to mutton and beef is 10/1 and 15/1, respectively, it means that 500 million tons of hay is needed to feed the livestock in China every year. However, the National Grassland Resources Monitoring Report of 2017 showed that the total yield of fresh grass in natural grassland in China was 1064.91 million tons (Fig. 2.1), equivalent to about 328.42 million tons of hay, so the current domestic forage output is far from the needs of herbivorous livestock industry. Although the area of cultivated grassland and the import of forage hay have been expanding, the demand-supply gap is still large. Therefore, there is an increasing need for forage grass and grassland in China to satisfy the ever-growing need for feeding the livestock.

2.1 General Development of Forage Industry

2.1.1 Forage Farming

From world-wide perspective, forage industry, as the symbol of agricultural modernization, is an important part of crop production and agricultural system in the developed agricultural countries like the United States, Canada, France, the Netherlands, Ireland, Australia, New Zealand, etc. In the United States (the U.S.), the proportion of the grassland in total land area is 55%, and then the cultivated area of pasture accounts for more than 60% of its cultivated land. The resulting economic value of forage industry accounts for 60–70% of its total agricultural output. Among them, alfalfa is the fourth largest crop after wheat and corn, with planting areas of 25

million hectare and annual output of more than 140 million tons of high-quality hay (Putnam 2013). Hence, the total output value of pasture planting was 28 billion dollars combined with alfalfa seeds. In addition, Canada, Australia, New Zealand, and others are major countries in forage production. The area of planted pasture in Canada 2019 was 7.379 million hm^2, which produced grass of 30.432 million tons. In Australia, the output of all kinds of hay exceeds 6.5 million tons, and the output of high-grade silages is about 2.2 million tons.

In China, the area of artificial pastures has expanded since 2015 after the call for "accelerating the development of grass husbandry" by the No. 1 Document of the Central Committee. According to the statistics of China Grassland Development Report (2017) and other relevant data (The Ministry of Agriculture of the People's Republic of China 2017), the area of artificial pastures planting was 180 million hectares until 2017. The top 10 of forage grass in planting area include alfalfa, silage corn, perennial ryegrass, wheatgrass (*Elymus dahuricus*), oat, etc., with a total area of 142 million hectares, accounting for 78.7% in total the artificial region (Fig. 2.2). Most of the artificial alfalfa grassland is located in Shaanxi, Gansu, Xinjiang, and the area of the northeast and the yellow river delta.

In recent years, the production area of commercial forage grass in China showed a downward trend. As shown in Fig. 2.3, in 2012, the planting area of commercial grass was about 1.16×10^6 hectare, and reached a peak with 3.178×10^6 hectare in 2013. However, by 2018, the production area of commercial forage declined to 1.36×10^6 ha. Despite the decline of planting area, the yield of commercial grass from 2015 to 2018 remained mostly stable, and the output of commercial grass industry in 2018

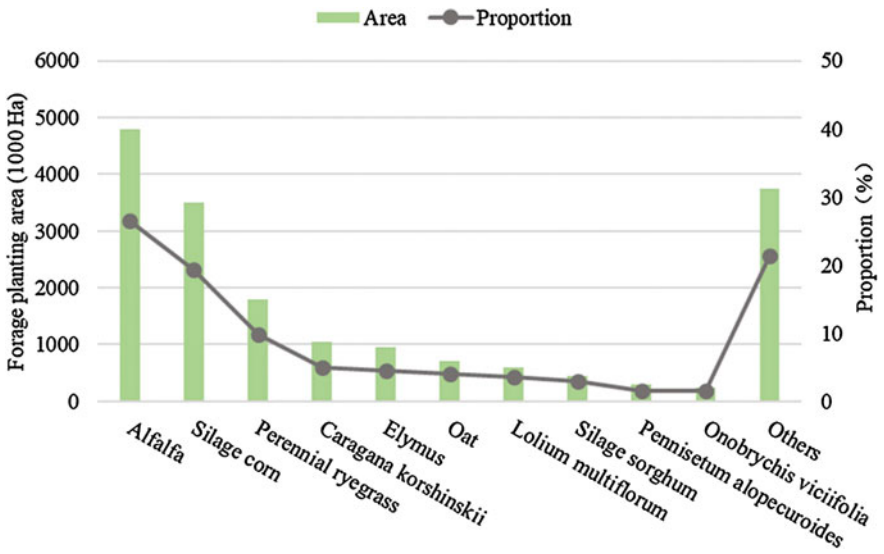

Fig. 2.2 Area and proportion of planting forage and its species in China 2017 (*Data resource* National Bureau of Statistics)

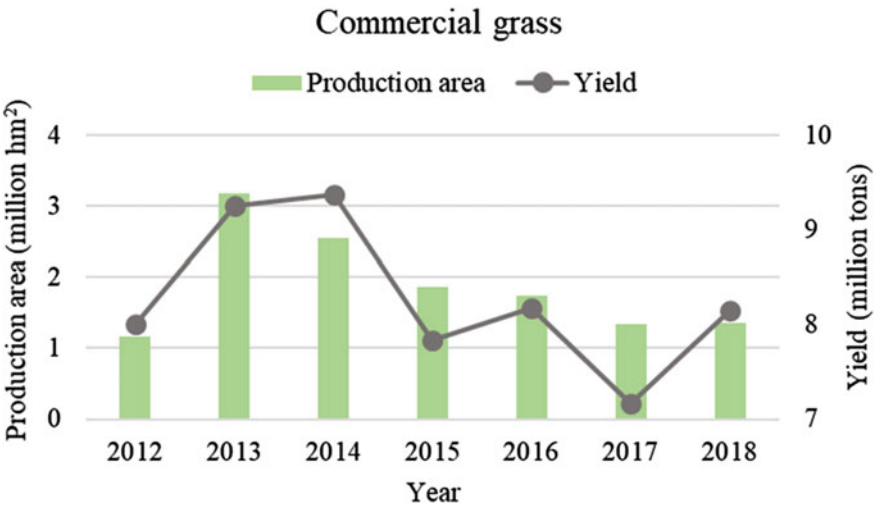

Fig. 2.3 The production area and yield of commercial grass in China from 2012 to 2018

was about 8.15 million tons which increased by 2.39% compared with 7.96 million tons in 2017(Fig. 2.3). The relatively stable change of the total supply indicates that the planted pattern of pastures in China has gradually developed into the stage of higher-quality and fast-growing forage. It implies that the yield per unit has increased, which offsetting the adverse effects caused by the decrease of planted area.

2.1.2 Forage and Pasture Seeds

The development of grassland husbandry cannot be separated from the grass seed industry. For example, the system of grass seed industry was excellent in the most developed countries, like the United States, Canada, Denmark, New Zealand, Australia, and other countries were an important exporter of forage seed production in the world. North America is currently the world's largest producer of forage and turfgrass seed, with most of them coming from Oregon, lowa, Washington State in the western United States and four provinces in southwestern Canada, whose commercial seed production accounts for about 50% of the world's commercial seeds. According to the statistics of USDA (United States Department of Agriculture (2017), there was 2999.9 km^2 of grass seed fields in the United States in 2017, most of which *Fescue* species had the largest seed field (74.93%) of all grass seed fields (Fig. 2.4a). Then, the total number of grass seeds in the United States in 2017 was 354,851.1 tons with higher quantity of ryegrass, fescue, and alfalfa seeds (Fig. 2.4b). Europe is the second largest producer of grass seeds in the world, mostly from Netherlands and Denmark in the north-central part of Europe, most of which were planting ryegrass

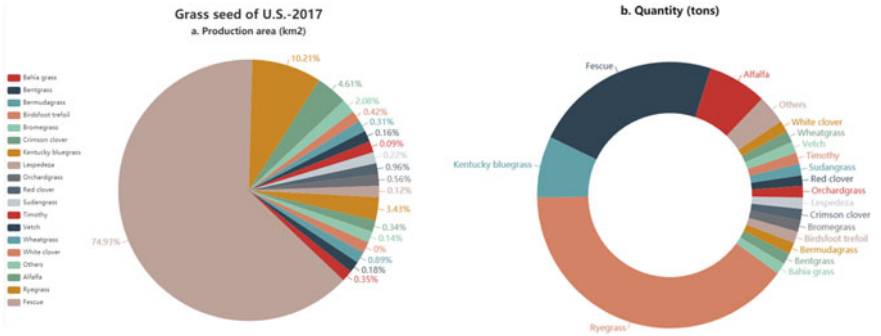

Fig. 2.4 The production area (**a**) and quantity (**b**) of various grass seeds of the United States in 2017 (*Data resource* Census of Agriculture in US-2017)

(1,398,770 ha), alfalfa (84,700 ha), fescue (57,700 ha), clover (64,785 ha), wild pea (25,415.7 ha), etc. (Fig. 2.5).

For China, the total field of forage seed production in 2017 was 851.36 km^2, and the quantity of grass seed was 70,900 tons, mainly including oats, alfalfa, *Elymus* grass, Triticale and Sudan grass (Fig. 2.6). These seeds are mainly produced in northern part of China, among which Gansu, Qinghai, Ningxia, and Inner Mongolia are the top four supply areas. Their annual supply of forage seeds accounts for 37.82%, 19.61%, 12.68% and 9.35% of China's total output in 2017, respectively (National Animal Husbandry Station 2018).

In term of forage breeding variety in China, there were 379 varieties registered by the National Grass Variety Approval Committee from 2001 to 2019, of which 134 were bred (Fig. 2.7). However, the promotion and application for the bred varieties of forage seeds are very limited, and most of the forage seeds in the domestic market

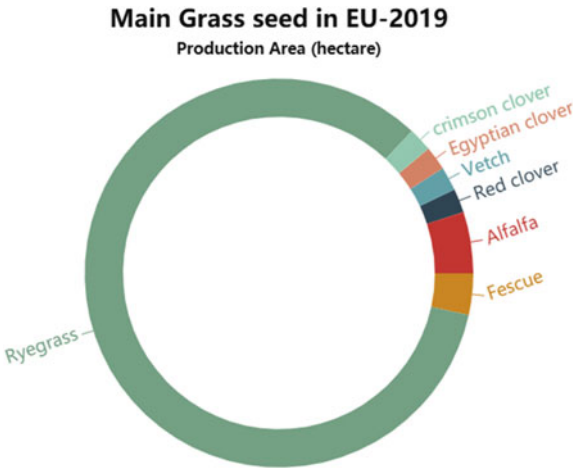

Fig. 2.5 The production area of main grass seed of the Europe in 2019 (*Data resource* European Seed Certification Agencies Association)

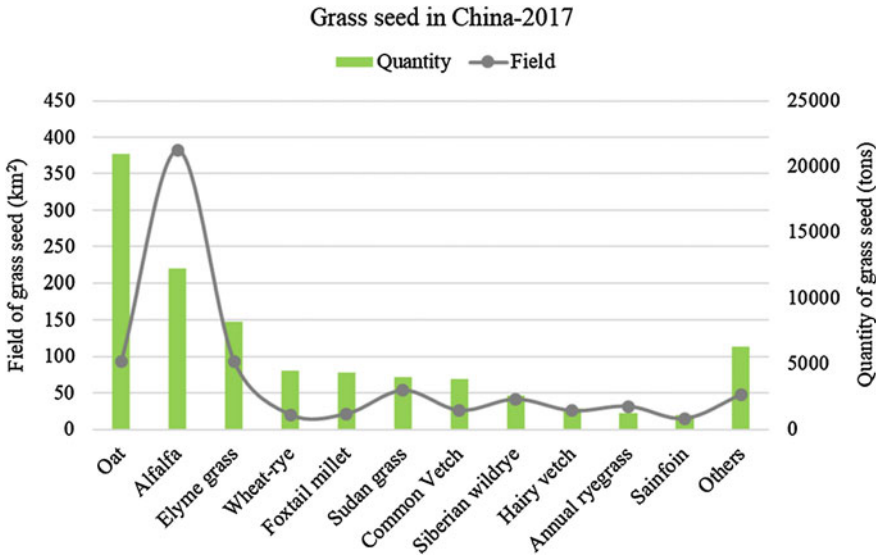

Fig. 2.6 Production area and quantities of grass seed of China in 2017 (*Data resource* Statistics of Grass Industry in China (2017))

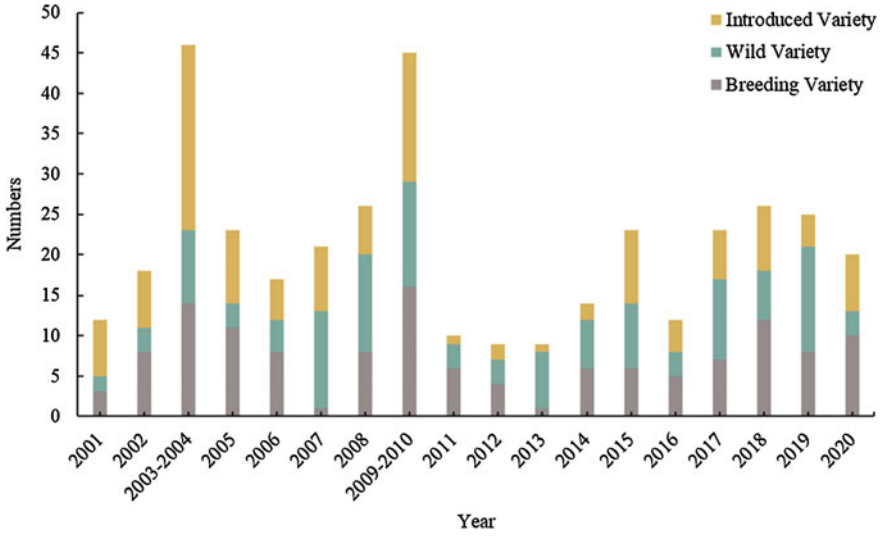

Fig. 2.7 Forage varieties registered by the National Grass Variety Approval Committee from 2001 to 2019

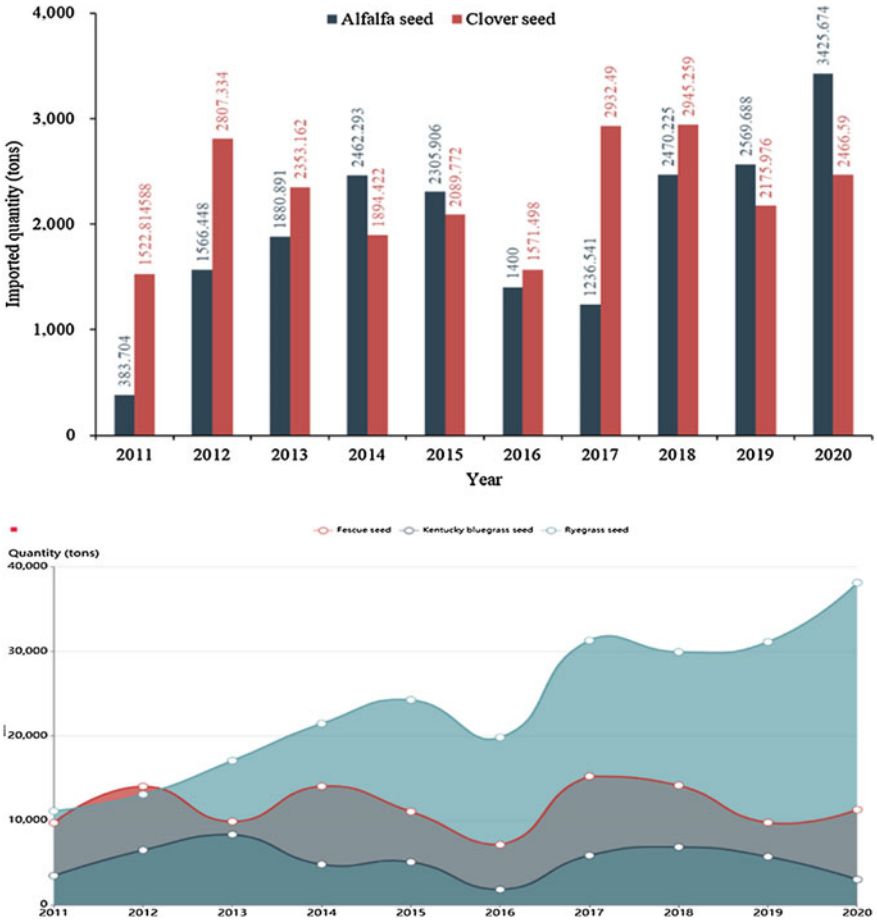

Fig. 2.8 The import quantities of various grass seeds of China from 2011 to 2020 (*Data Source* China customs data)

are imported seeds. In recent years (2011–2020), the total imported grass seeds from different countries have increased annually. In 2020, the total imported grass seeds reached 38,100 tons valued at 107 million U.S. dollars, among which the seed of ryegrass seeds, fescue, and Kentucky bluegrass are the main imported species (Fig. 2.8).

2.1.3 Forage Production

There are various categories of forage production in the world, mainly include hay, haylage, grass silage, greenchop, and leaf protein. The international forage trade

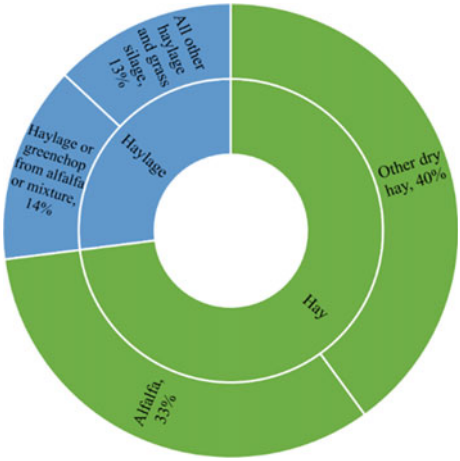

Fig. 2.9 Quantity of forage product of the United States in 2017 (*Data Source* USDA)

reached 6.944 million tons and the value of trade accounted for 2.289 billion U.S. dollars in 2008, which increased nearly 87 times compared to 1962. There are more and more countries actively participated in the trade of forage products, from 60 in 1962 to 180 in 2008. At present, dry hay of grass are the main product form in the international market. According to the USDA, the forage quantity were 163 million tons in 2017, among which hay accounts for 73% of forage products (alfalfa hay at 33% and others at 40%) (Fig. 2.9).

The main varieties of forage products in China are alfalfa and wildrye, of which alfalfa accounts for more than 90%. In the product structure of forage, 77% are bales, 2% are blocks, 8% are particles, 7% are powder, and 6% are other grass products. According to relevant statistics of forage industry, sales volume of domestic forage was 7.16 million tons in 2017, of which the quantity of alfalfa bales was about 1.72 million tons. The yield of these domestic alfalfa hay is far from the level of developed countries and the needs of livestock industry in China. In order to meet the demand of livestock industry development, the demand for alfalfa is increasing rapidly, at the same time, the import of forage products was also increased. From 2014 to 2016, the total import of forage products were raised and reached 1.71 million tons in 2016, of which the import quantity of alfalfa hay was 1.46 million tons. However, during 2017–2020, the total amount of forage imported was stable at about 1.7 million tons with an average price of 360 dollars/ton (Fig. 2.10). It implies that the linkage of grass and livestock in recent years has promoted the rapid development of forage industry in China.

With the development of forage industry, the regional situation of alfalfa industrial belt, the production area of wild rye and ryegrass in southern China has been formed. At present, there are more than 30 companies processing forage products with more than 3000 hectares in the alfalfa industrial belt. By 2017, there were 840 companies of processing forage products in China, which processed 7.327 million tons of forage products including hay, silage, powder, etc. These companies or factories are located

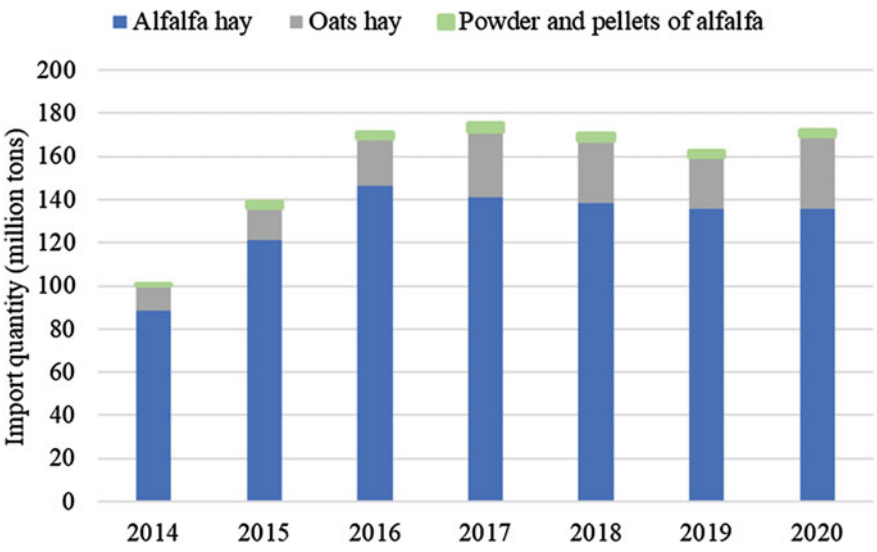

Fig. 2.10 Import quantities of various forage products from 2014 to 2020 in China (*Data Source* china customs data)

in 23 provinces, among which Gansu has 296 companies with 2.702 million tons of forage production. However, most domestic forage processing companies are small in scale, and the quality of various grass products is poor, so it is necessary to further improve the processing technology and ability of forage products.

With the growing demand for forage grass products in China, the development of herbage mechanical engineering and feed additive of forage have been rapidly promoted. However, the herbage machineries and forage additives used by domestic forage product processing companies are mainly imported from abroad. At present, domestic herbage machinery is mainly supplied by Japan's Shidal Company, New Holland Company, Germany's Class Company, France's KUHN Company, etc. Compared to Europe and America, most herbage machinery companies in China have some competitive disadvantages in terms of mechanical quality, type, and technology. However, some herbage machinery companies, such as Huade Grass Machinery Co., Ltd., and Huanong Machinery Co., Ltd. in Inner Mongolia, have make technological breakthroughs in herbage machinery, and some mechanical products have comparative advantages in price.

In terms of feed additives in forage, most products in China are imported from Europe and America. In recent years, the types of additives registered and sold in China are increasing, indicating that the demand for feed additives in forage is also increasing. It implies that the sales volume of feed additives in China will grow in the future, due to the demand of high-quality forage production.

2.1.4 *Efficient Utilization and Intensive Processing of Forage Grass*

European and American countries have attached great importance to the research and production of extracting effective substances from cultivated pastures, such as leaf protein, cellulose, chlorophyll, unsaturated fatty acids, and β carotene. The application of these substances can achieve higher economic benefits. At present, the French alfalfa production complex is the largest commercial producer of forage leaf protein in the world. Countries such as Britain, Denmark, New Zealand, Australia, Russia, Brazil, and India also have different scale factories processing leaf protein condensate. For example, the 'green protein' produced in New Zealand and Australia is called Quintessence, which has high nutrition, equivalent to soybean protein and casein. In terms of improving production technology, Britain, America, Russia, and other countries have researched and designed a helix prescriber, which can complete the processes of crushing and pressing at the same time. It can not only produce a series of concentrated protein of green feed, forage cake, and residue, but also extract single cell protein from its fluid.

Apart from leaf protein, the extraction and industrial production of active substances is also an important field of intensive processing of forage grass in the world. At present, there are many studies on the utilization of flavonoids in red clover. The isoflavones extracted from red clover is known as a botanical drug with excellent effect on climacteric syndrome. Th sale volume of these drug has been ranked among the top 10 botanical drugs in the United States, and a large number of them are exported to China every year. After intensive processing, the value of forage production has been greatly improved. For example, the price of red clover hay is 0.2 dollars per kilogram, while that production of red clover with 8% total flavonoids is 23–38 dollars/kg, that production of red clover withe 20% total flavonoids is 100–130 dollars/kg, even that of red clover isoflavones is 230 dollar/kg.

Although there have been studies on extracting and intensive processing of leaf protein from alfalfa in China, most of them are in the laboratory stage and not in the commercial production stage. However, these high-value forage extraction, like leaf protein, dietary fiber, plant pigment, saponin, flavone, polysaccharide, etc., can be used not only for feeding herbivores, but also for diets of monogastric animals, such as pigs and poultry. This application can not only improve the quality of animal products, but also save feed grain. Therefore, the industrial chain of forage utilization and intensive processing can be extended to grain-consuming animal husbandry, replacing part of the feed grain and improving the quality of livestock products. The various types of forage utilization and products of intensive processing will trigger the upgrading of traditional forage industry and provide better opportunities for the development of forage industry in China.

2.2 Problems and Challenges of Forage Industry

2.2.1 Improved Breeding Varieties of Grass Seeds is not Mature and Relies Too Much on Imports

After the launch of artificial grassland construction and the breeding of new forage varieties, the production of forage seed in China has experienced a process from scratch. Although the industrialized production of forage seeds took off at the end of 1990s, there are still so much deficiencies compared to those in the developed countries. For example, the disadvantage of organization and technical research limit the further development of forage seed industrialization in China. In terms of the production unit, most farmers in China rely on self-produced seeds and specialized seed producers is severely lacking. There were a total of 379 varieties registered by the National Grass Variety Approval Committee from 2001 to 2019, of which 134 were bred. However, most of the approved and registered varieties were not used for production and promotion, or excellent varieties were ignored and resulted to the gradual degradation under extensive production conditions. Most of the grass species used in major ecological conservation and restoration project are imported species. From 2011 to 2020, the imported species of pastures and turfgrass in China mainly include alfalfa, clover, fescue, Kentucky bluegrass, perennial ryegrass, annual ryegrass, and other feed crops. Especially, the import quantity of alfalfa seeds has increased greatly in recent years, with the import volume of alfalfa seeds reaching 3425.7 tons in 2020, an increase of 88% compared with 2011.

2.2.2 The Standardization and Quality of Forage Production is Low, and the Regional Production is Unbalanced

Like other industries, the sustainable and healthy development of forage industry cannot be separated from industry standards and policies to guide scientific production. At present, the corresponding standards for production of forage seeds and processing has been not established in China. Also, there are no specific operating procedures for fertilization, harvesting, drying, storage, etc. Eventually, it leads to many outstanding problems, such as impurities in seeds, weeds in grass, poor quality of grass products, which greatly affects the domestic sales and export of forage products. According to related investigation and statistics, the quality of alfalfa bales in China is low. More than half of the crude protein content cannot meet the secondary standard, and there is almost no top grade of alfalfa hay. Besides, the research and development, the popularization and application of forage additive products are one of the urgent problems to be solved in the development of forage industry in China. In addition, the imbalance between the distribution of forage industry and livestock industry should be highlighted. Using the alfalfa hay as an example, Gansu,

Heilongjiang, Inner Mongolia and Ningxia are the main producers of commercial grass. In 2017, the yield of commercial grass in Gansu Province was the highest, reaching 2.7 million tons, but the dairy farming stock ranked 10th and the milk yield ranked lower, which reflect extreme imbalance.

2.2.3 The Integration of Forage and Livestock is not High and Closely

At present, the integration of forage and livestock in husbandry cannot meet the requirements of modern husbandry production. On one hand, the backward feeding mode of "straw + concentrate" still exists in reality, and farmers don't pay enough attention to the fact that "high-quality pasture is the fundamental guarantee of high-quality and safe livestock and poultry products". On the other hand, forage producers only take pasture as the primary production to obtain a small profit, resulting in the absence of industrial extension for livestock and poultry. Also, the benefits of simply planting grass are very limited, but the potential benefits of grass can be effectively increased with the combination of pasture farming and livestock. The development of herbivorous husbandry has been accelerating, while the supply of forage products is still seriously insufficient for feed. For example, based on the calculation that each cow needs 1 ton of alfalfa hay every year, as there were nearly 15 million cows of China in 2012, 15 million tons of alfalfa hay are needed. At present, the annual circulation of alfalfa hay in the market in China is less than 1 million tons, which is far short of the demand.

2.2.4 The Mechanical Equipment of Forage Processing is not Improved, and Mainly Depends on Importation

Compared to developed countries, there are deficiencies and gaps in the technology and process of herbage machinery in China, and most of them are lagging decades behind. Since 1980s, the investment in grassland and forage industry has been seriously insufficient, causing many companies of herbage machinery to switch or stop production. In addition, there are a host of problems in these companies, such as the low machine quality and poor reliability. Reciprocating mower needs sharpening after working for half a day, and its reliability is less than 80%. The machines of raking grass from international companies work for 400 hectares, and the ratio of broken tooth is only about 4%, while the broken tooth rate of domestic products is about 25% for the same amount of work. Under the same operation conditions, the workload of forage picking and stacking in China is half that of similar models from the developed countries. In addition, the models and combination of various herbage machinery in China is poor. On the basis of introduction and digestion of foreign

machinery in China, the operation process system of loose grass, square bale, round bale, piling, and secondary pressure packing has been initially formed. However, most of the models can only handle one of the process but not multiple processes. At the same time, most domestic manufacturers can only produce simple models such as lawn mowers and shredders, but cannot produce high-grade models such as the combination of mowing and flattening machines, thus, many herbage machines can only rely on imports.

2.2.5 Intensive Processing of Forage Products is Insufficient and Low-Value

Leaf protein from forage grass not only contains the main amino acids needed by livestock, but also be closer to milk proteins easily absorbed by human beings. Therefore, these leaf proteins can be processed into intensively processed substrates of consumption and application for both livestock and human. If the direct feed utilization rate of alfalfa is only 20–30%, the utilization rate of intensive processing could be as high as 80%. In the European market, the value of leaf protein from alfalfa is 10–100 times higher than that of animal protein. Up to now, the process of forage grass in China is still dominated by primary production with few intensive processing products.

Summary

On the development of forage grass and livestock, we firstly focus on advancing the development of forage farming, the processing of forage product, and its related herbivore industry. Secondly, the added value of agriculture, forage and livestock industry will be increased by combining farming, production, and processing. Then, we should enhance the relationship between efficient production system of forage products and the modern ecological agriculture system, thus promote the adjustment that make traditional agriculture in the direction of combining grassland with modern agriculture. These aforementioned improvements will play an important role in ensuring the healthy development of food safety in China.

References

National Animal Husbandry Station (2018) Statistics to Grass Industry in China (2017). China Agriculture Press, Beijing

Putnam D (2013) Envisioning the future of alfalfa in the United States. In: The Fifth China Alfalfa Development Conference. China Animal Agriculture Association, Beijing

The Ministry of Agriculture of the People's Republic of China (2017) China Grassland Development Report (in Chinese). China Agriculture Press, Beijing

United States Department of Agriculture (2019) Census of Agriculture in United States (2017). Geographic Area Series