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Thinking on Orientation of Engineering Research of China's Sorghum Industry

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Abstract To solve engineering problems restricting development of China's sorghum industry in the whole chain, this paper firstly introduces functions of sorghum industry to national economic and social development. Then, it analyzes current situations of engineering research of sorghum industry. Finally, it discusses countermeasures for engineering research of sorghum industrial development. On the basis of current situations, it proposes 7 pertinent countermeasures. (i) Collection and storage of sorghum germplasm resource; (ii) Innovation on germplasm resource for sorghum breeding; (iii) Seed selection for new variety of special sorghum; (iv) Integrated innovation on high yield, high quality and high efficient cultivation technology; (v) Research and development of integrated prevention and control technology for disease, pests and weeds; (vi) Improvement in technological extension service system; (vii) Research of sorghum deep processing and use technology. It is intended to promote rapid, sustainable and healthy development of sorghum industry in China.

Key words Sorghum industry, Engineering, Thinking

1 Introduction

Sorghum bicolor (L) Moench, belonging to Sorghum, Andropogoneae of Gramineae, is one of the most ancient cereal crops in the world^[1]. Relevant researches mainly include sorghum taxonomy, research and use of sorghum germplasm resource, morphological anatomy and genesiology of sorghum, traditional hybrid breeding and molecular genetic breeding of sorghum, physiological mechanism and cultivation and cropping system of sorghum, integrated prevention and control technology for sorghum diseases, pests and weeds, sorghum deep processing technology, and conversion mode of sorghum technological achievement. These researches directly serve every link of sorghum industrial chain. This study mainly focuses on problems to be urgently solved for sorghum industry. Launching researches on sorghum industrial engineering technology is to set up research and development platform for selecting new variety of high quality, high yield and high efficient sorghum, deep processing technology and equipment for different varieties of sorghum in different ecological regions. It is hoped to make breakthrough in core, key and common technical problems restricting sorghum industrial development. Finally, through high efficient achievement conversion mechanism, it is expected to establish constant extension circle of achievement radiation, steadily promote sound development of China's sorghum industrial chain, and finally realize rapid, sustainable and healthy development of China's sorghum industry.

2 Functions of sorghum industry to national economic and social development

2.1 Sorghum is the major support crop for wine industry, and plays a great role in promoting development of national economy Sorghum, as major raw material of wine industry, plays a significant role in national economic development^[2]. Famous Chinese spirits, such as Moutai liquor, Fenjiu Wine, Wuliangye, Luzhou Laojiao and Honghualang, takes sorghum groats as major raw material. Unique geographic environment, traditional advantages of wine making industry and historic and cultural advantages, make wine making industry become a pillar industry in regional national economy of China. In 2009, annual profit and tax of wine reached 80 billion yuan, fully manifesting its significant role in national economy^[3]. In this, distilled spirit making industry realized the profit and tax of 24.51 billion yuan, accounting for 30% approximately. With more famous Chinese spirits entering the world market, it will heighten the competitive power of China's sorghum deep processing products at international market.

2.2 Sorghum, as pioneer crop using marginal farmland, plays a significant role in improving benefit of middle-and-low-yielding fields in dry farming areas Sorghum is one of the most ancient crops in China. Thanks to drought-resistant, waterlogging-tolerant, cold resistant, saline-alkali tolerant and highly adaptable features, sorghum has been taken as pioneer crop for reclaiming wasteland in Chinese crop cultivation history^[5]. In hostile ecological restrictions, including drought, waterlogging, saline, alkali, desertification, barren conditions, diseases and pests, sorghum becomes major crop with its unique advantages, and has obtained considerable economic benefits. In addition, it increases vegetation coverage in marginal farmland like alkali flat area, plays a great role in checking winds and fixing drifting sand, and reducing water loss and soil erosion, and has reaped significant

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cant ecological benefits.

2.3 Sorghum, as one of model crops for biological research, plays an important role in promoting research on hybrid advantage of China

As the 5th largest grain crops in the world, sorghum is characterized by strong anti-adversity and high photosynthetic efficiency. Besides, sorghum is one of the crops realizing combination of three lines, hybrid breeding and large area of commercialized planting. It has greatly promoted green revolution of many countries. Furthermore, scientists have completed the whole – genome sequencing of sorghum. Thus, it becomes one of model crops for molecular biological research. Through combining traditional hybrid breeding technology with molecular genetic breeding technology, it is able to accelerate the progress in exploiting advantages of Chinese sorghum hybrid breeding.

2.4 Many functional components have been developed in sorghum, so the sorghum has greatly improved national nutrition and health level

Sorghum is also called milo and durra. Sorghum rice is grained finished product of grain^[7]. 100 g sorghum rice contains about 1525.7 kJ calorific value, 8.4 g protein, 2.7 g fat, 75.6 g carbohydrate, 0.3 g coarse fiber, 0.26 mg vitamin B1, 0.09 mg vitamin B2^[8], so the sorghum has high nutritive value. Some health-benefiting functions of sorghum are being exploited, for example, extracting inhibitor from tannic acid^[9]. These promote fully use of sorghum in weight-reducing food, fresh keeping of natural food, and health care medicines. Gradual extension of fine processing foods of sorghum further improves diet structure of Chinese people, and promotes improvement of national nutrition and health level.

3 Existing problems in engineering research of sorghum industry

3.1 Single structure, mainly for traditional spirit making

The consumption structure of Chinese sorghum products is mainly traditional spirit making. It is estimated that total yield of sorghum in China is about 2.5 million tons, about 80% of which is used for spirit making, 10% for feed, 5% for food, and the rest 5% for other purposes^[10]. Such consumption structure leads to fluctuation and overall reduction of sorghum planting area in China. By contrast, in the United States, sorghum planting area is about 4 million hm², the total yield is 18 million tons, about 45% of which is exported, 36% for feed, 15% for making spirit, 3% for industries, and only 1% for food^[11]. This shows single structure of sorghum industry in China, while feed supports sorghum production in the United States. From this perspective, it indicates that China's sorghum production distribution and industrial structure still have a large gap compared with developed countries.

3.2 Low mechanization level and production operation consuming time and labor

China's agricultural production has stepped into new transformation period, labor cost is gradually increasing, and the desire of farmers for mechanized cultivation of sorghum is steady on the increase. However, the present sorghum variety extended in production has high stalk and big tassel. After

becoming ripe, the tassel is up to 180 cm, so it is not suitable for mechanized harvest and large-scale planting. High labor intensity seriously restricts expansion of sorghum planting area, leads to insufficient supply of sorghum, and consequently impedes development of sorghum industry.

3.3 Industrial chain of energy sorghum not well connected

In recent years, after energy security faces great challenge, energy sweet sorghum, as renewable crop^[12], has attracted extensive attention of scientific circle. China also has made certain achievement in energy sorghum breeding. However, due to backward researches on storage and deep processing of sweet sorghum and few support policies for specific green energy, the industrial chain of energy sweet sorghum is not closely connected.

3.4 Backward application of molecular biological technology into sorghum research

At present, sorghum breeding in developed countries has walked out of the circle of traditional breeding, and the connection between molecular biology and genetic breeding becomes closer and closer. Besides, the connection between traditional breeding and molecular marker has become new breeding model. Important functional genes of sorghum, such as anti-aphis^[13], disease-resistance^[14], and high digestion rate^[15], have been marked, applied in breeding, and sorghum breeding has stepped into molecular breeding times. Take breeding of anti-herbicide of sorghum as an example, Sumitomo Chemical and National Grain Sorghum Producers Foundation (NGSPF) have made cooperation in developing anti – herbicide of sorghum variety. By contrast, the research on sorghum molecular genetic breeding starts later in China, and it is necessary to accelerate relevant researches.

3.5 Sorghum for feed failure to connect with modern feed industry

Since the 8th Five-year Plan period, China has started researches on breeding of high quality sorghum for feed and the feeding effect. The newly bred sorghum variety has grain protein and lysine content 40% higher than general sorghum. From the perspective of pig feeding effect, new feed with sorghum as major material (60%) has higher palatability, accelerates growth of pigs (the weight increase rate is higher than 20%) compared with the feed with corn as major material (60%)^[16]. Nevertheless, due to backward in researches on deep processing technology of feed sorghum industry and the loose connection with feed industry, the mixing of sorghum feed with feed processing industry in China is nearly zero, this restricts breakthrough of application of sorghum into feed.

3.6 Relatively weak different types of sorghum industrial system

China's sorghum industry is low in organizational level. Basically, it takes family as unit, so the scale is small, input is insufficient, and it lacks organization. From production to sales, the connection between each link is weak. There is prominent conflict between small production and big market. Consequently, it is very difficult to realize integration of production, transportation, storage, sales and processing, and it weakens competitive power of end products. Enterprises do not have special large-scale raw

grain production base, so their market competitiveness is lower. Also, farmers fail to establish effective cooperation with enterprises. As a result, it will impair healthy development of sorghum industry.

4 Countermeasures for engineering researches of sorghum industry

4.1 Collection and storage of sorghum gemplasm resource

It is recommended to extensively collect domestic and foreign sorghum gemplasm resources, conduct assessment and evaluation of agronomic traits, anti-adversity and disease and pest resistance of sorghum gemplasm resources, store sorghum gemplasm resources, and promote cooperation with national gemplasm bank and relevant foreign institutions.

4.2 Innovation upon sorghum gemplasm resources Sorghum gemplasm resource is the basis for genetic improvement^[17]. Innovation of sorghum gemplasm resource based on existing gemplasm resource is an important approach to upgrade of gemplasm resource. There are following available technologies. (1) Technology for improving sorghum group. Through incorporating short stalk and excellent anti-adversity resources into LSRP and LSBP, it is able to realize panmictic population, and generate short stalk anti-adversity elite line. (2) SSR marker of sorghum head smut resistance. With the aid of high polymorphism, dominant marker and codominance, high stability and low technical difficulty of SSR molecular marker technology, it is feasible to research SSR marker closely related to head smut gene of sorghum, to provide reference for breeding anti-disease varieties. (3) Application of sorghum transgene technology. Using gene gun method (particle bombardment) and agrobacterium-mediated transformation, it can realize knock-in of drought resistant and herbicide resistant genes, and conduct environmental release and production experiment of drought resistant and herbicide resistant varieties of sorghum. (4) Breeding of sorghum through somatic cell cloning. It is recommended to research sorghum somatic cell cloning variation artificial induction technology system, establish physical, chemical artificial induction technical parameters, and explore safe use method of different chemical screening agent, to obtain stable clonic variant line.

4.3 Breeding of new special sorghum variety According to use of sorghum, breeding of new social sorghum variety is the objective of new variety breeding. Major breeding direction includes: (1) variety special for wine making sorghum. It is proposed to cooperate with wine making enterprises to breed special sorghum variety suitable for wine making and vinegar making. (2) variety for forage sorghum. It is proposed to cooperate with breeding enterprises and cooperatives to select high yield and high quality sorghum varieties suitable for harvesting. (3) variety for feed sorghum. It is proposed to cooperate with feed enterprises and breeding enterprises to select and breed varieties suitable for mixed feed. (4) energy sorghum variety. It is proposed to cooperate with ethanol processing enterprises, select new sweet sorghum

varieties with high sugar content, anti-lodging and high yield advantages.

4.4 Integrated innovation of high yield, high quality and high efficient cultivation technology

In view of different ecological characteristics of 4 large sorghum industrial development zones in China, it is recommended to take pertinent cultivation model. (1) Northeast non glutinous sorghum industrial zone. Northeast region has flat land, which is suitable for mechanized farming. Thus, it is recommended to focus on mechanized integrated cultivation model, and establish stable high yield cultivation model suitable for large-scale, mechanized and standardized production. (2) North China and northwest non glutinous sorghum and forage sorghum industrial zone. These regions have problems of serious shortage of water resource, barren soil, salinization, and low yield. In line with these problems, it is recommended to take high efficient use of limited water resource as the core, and integrate field water storage for soil moisture conservation, high efficient fertilizer application, mechanized planting and chemical weed removal technologies, to form drought-resistant and water saving sorghum cultivation technology. With acceleration of north-western development and animal husbandry development, it is proposed to research high quality forage sorghum suitable for planting and convenient for harvesting, and study support cultivation technology for sorghum. (3) Southwest glutinous sorghum industrial zone. In view of safe maturity problem in the production of high efficient variety regenerative sorghum, it is proposed to establish high yield and high efficient standard cultivation model. (4) Saline and alkaline land sweet sorghum industrial zone around Bohai region and along Bohai coast. Since this region has large area of low-yield field, such as saline and alkaline land and mud flat, it should focus on research of high yield and high efficient cultivation technology of sorghum, to effectively increase output benefit of unit area in saline and alkaline farmland.

4.5 Research on integrated prevention and control technology for diseases, pests and weeds

Diseases and pests of sorghum in different ecological zones mainly include head smut, top root, target spot disease, red stripe virus disease and sorghum aphid. In future, it is recommended to take these diseases and pests as research objects, make clear major types and characteristics of diseases, pests and weeds in ecological zones of sorghum in China, and study integrated prevention and control technology for diseases, pests and weeds of sorghum.

4.6 Improving technological extension service system

Competent authorities should set up and improve sorghum platform, establish technological information collection, processing and issuing system, and speed up propagation and sharing of scientific and technological information. Besides, it should establish the management expert system of whole production process of sorghum, and set up remote expert consultation aided decision-making platform, remote technical consultation advisory service system and product. Through information system, it is expected to realize sharing and interaction of bases, enterprises and institutes. Through

periodic expert presence service, it is expected to realize scientific management of bases and enterprises, and provide guidance for bases and enterprises to solve relevant technical problems. In addition, it should set up key base (enterprise) expert residence model and sci-tech special commissioner or professor team touring base service model, form high efficient long-term sci-tech service mechanism, and improve site technical support for bases and enterprises.

4.7 Research of sorghum deep processing and use technology According to difference in uses, sorghum can be divided into edible sorghum, brewing sorghum, feed sorghum, forage sorghum, and energy sorghum. At the same time, sorghum stalks can be used to make boards, papers, and fiber woven wares. However, at present, deep processing and use of sorghum in China is mainly brewing material. Focusing on uses of sorghum, it should set up special research laboratory separately to carry out technical research and product research and development, and conduct technical achievement conversion through enterprises. In these researches, edible sorghum research mainly relies on food institute of agricultural universities and relevant food research institutions. Brewing sorghum research should take existing sorghum research institutions as backbone, encourage brewing enterprises to set up small brewing laboratory, and through the model of scientific research institutions + brewing enterprises, jointly set up brewing research and development platform, make clear influence of different brewing sorghum varieties on brewing products (spirit and mature vinegar), and finally realize special sorghum for special brewing product. For feed sorghum research, it should set up sorghum research laboratory with sorghum scientific research institutions as major units, cooperate livestock raising and feed processing enterprises to build feed sorghum research and development center, so as to realize technical breakthrough in the whole industrial chain of feed sorghum industry. As to forage sorghum research, it should unite relevant scientific research institutions and livestock raising farms to conduct variety breeding, feeding effect experiment, and technological integration demonstration work. For energy sorghum research, it should provide policy support, set up special fund, directly introduce foreign advanced energy sorghum industrialized equipment, establish superior energy sorghum development zone in China, and build green energy base.

5 Conclusions and prospects

With rapid development of modern engineering technology, researches of key links of sorghum industry have made considerable progress. However, there are still many problems to be solved, including imperfect innovation mechanism of sorghum gemplasm resource, mechanized operation of sorghum not coordinated with agronomy, and different sorghum deep processing products and technologies not mature. In these situations, China has to make breakthrough, set up awareness of solving key problems in the whole industrial chain, and take full advantage of modern engineering technology to make joint effort in key breakthrough points, so as to

realize rapid, constant and healthy development of China's sorghum industry. These include (1) collection and storage of sorghum gemplasm resources; (2) innovation upon gemplasm resources with the aid of molecular biological technology and radioactive induced technology; (3) breeding of new sorghum varieties through combining molecular genetic breeding and traditional hybrid breeding technologies; (4) integrated innovation of high yield, high quality and high efficient cultivation technology; (5) research on integrated prevention and control technology for diseases, pests and weeds; (6) setting up nation-wide technological extension service system in major sorghum production and potential regions; (7) speeding up researching deep processing and use technology of different varieties of sorghum, and giving prominence to promotion of consuming type products.

At present, under guidance of researches of corn, rice and wheat, domestic sorghum research institutions have realized the urgency and necessity of cooperation. It is believed that sorghum research will make great breakthrough in near future. And it will set up China's sorghum engineering research center, and constantly promote development of China's sorghum industry with the aid of national level platform.

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strive to make rural characteristic brand become a pillar industry in the rustic national economy, and become a growth point for the development of rural economy and the surrounding regional economy; for the dynamic situation of domestic and international tourism market, timely use television, newspapers, computer networks and other media, to carry out focused, multi-level, cloverleaf-style tourism promotion; organize relevant festivals to promote the development of festival tourism economy, participate in the trade, tourism and sports exchange activities at home and abroad, in order to carry out tourism promotion, expand the reputation of local rural tourism at home and abroad; strengthen horizontal linkages with the domestic provinces and cities, mutually bring tourists, thus forming stable source channels; establish joint-stock travel agencies, and carry out fruitful tour business.

4.3 Increasing the intensity of the training for rural tourism practitioners

It is necessary to continue to strengthen the tourism team building, strive to improve the quality of tourism practitioners, and create the high quality tourism management team that can adapt to the rapid development of the tourism industry; establish the idea of tourism training serving the rural tourism industry and tourism development depending on the rural tourism training. The guideline that the rural tourism training follows is to well run a variety of training courses; actively develop various forms of adult rural tourism training, establish enterprise-level rural tourism training center, adhere to the principles of focusing on amateur learning and short-term training, combining long-term training and short-term training, and actively create conditions to carry out job duties training.

It is necessary to vigorously carry out the job training for the technical staff and middle-level managers. Rural tourism translation guide, professionals and middle-level managers of marketing and promotion, public relations, rural tourism accounting, planning and statistics, auditing, engineering and cooking, are the backbone of rural tourism enterprises and institutions. We must pay attention to the focus, and carry out systematic training in batches, according to the various standards of positions.

4.4 Innovating upon the rural tourism promotion mode It is necessary to innovate upon the rural tourism promotion mode, and open source market, to promote sustainable development of tourism economy; adhere to the principle of rural tourism enterprises as the main body of rural tourism promotion work, guide enterprises to adopt new promotional modes, such as handing out the "business card" to urban residents, companies and institutions, establishing "contact card" with rural tourism dealers, and organi-

zing "theme activities"; carry out promotional work, set large outdoor advertising billboards of rural tourism, take advantage of rural tourism network, the village travel online, television, newspapers and other media to realize multi-angle promotion.

4.5 Expanding the rural tourism industry chain According to the current relatively chaotic situation of rural tourism product sales, the related government departments should begin to strengthen the construction and remediation of rural tourism commodity markets, unify the rural tourism commodity sale specifications, such as the access standards, service standards and price standards for the rural tourism commodities to enter into market.

It is necessary to ensure the goods production and sales regulations, use laws, regulations and policies to guide the market trend, maintain the market order and regulate enterprise behavior, to create a equally competitive environment; strengthen collaboration between the departments of tourism, industry and commerce, construction, forestry, prices, transportation, culture, environmental protection, public security, electricity, radio and television, to jointly promote the rapid development of rural tourism.

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