

Promoting Straw Recycling to Accelerate the Sustainable Development of Agriculture

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Abstract: Guided by Xi Jinping's thought of socialism of the new era with Chinese characteristics in the 14th Five-Year Plan, the comprehensive utilization of straw is closely integrated with the annual key tasks of improving rural areas, by adhering to the priority of agricultural use, industry-oriented, multi-measures, and focusing on counties and municipalities with larger amounts of straw resources. Agricultural modernization requires that provincial policies focus on promoting the utilization of straw as fertilizer, feed, energy production, substrate, raw material, and so on while emphasizing the establishment of a complete straw collection, storage, and transportation system. In response to the problem of the open burning of straw in recent years, China has adopted a variety of policies and measures to control pollution and rationally utilize straw resources. The state and provinces have issued many policy documents on straw resource management, which are divided into the management of straw burning, comprehensive utilization of straw, planning of the straw energy industry, and financial subsidies. Rational utilization of straw not only solves the key issues of employment of farmers but also promotes ecological efficiency and rural economic development. The research results of straw recycling have also made important progress in improving the utilization rate and value of straw, promoting the resource utilization of agricultural waste, and providing important technical support for the sustainable development of China's agriculture and rural environmental protection.

Keywords: Comprehensive utilization of straw; Financial subsidies; Ecological benefits; Rural economic development

Online publication: April 29, 2024

1. Introduction

Due to the rural economic development and the improvement of farmers' living standards in recent years, the usage of straw as a fuel source is declining, so there is a large amount of straw left over and discarded by farmers in the fields and surrounding areas. This affects rural environmental hygiene and becomes a potential risk for rural fires. Some people also burn them directly in the fields, which causes a great waste of resources and atmospheric pollution. However, along with the increasing awareness of environmental protection, the straw recycling industry has been emerging day by day in the past few years. Straw recycling mainly includes

biomass energy, organic fertilizer, feed, industrial raw materials, and so on ^[1]. Currently, China's straw recycling rate is low, which means that a large number of straws cannot be effectively utilized, resulting in resource wastage. Straw recycling can not only reduce pollution but also save resources and has a broad market prospect.

2. Straw recycling industry status

2.1. Industry overview

The straw recycling industry is a comprehensive industry involving many fields such as agriculture, environmental protection, and energy. Straw is a rich renewable resource, so its recycling is of great significance in alleviating the shortage of resources, improving the quality of the environment, and promoting sustainable development ^[2]. At present, the annual output of straw in China has exceeded 800 million tons, but the recycling rate is less than 30%. Therefore, the current and future main goals of the straw recycling industry are to improve the utilization rate of straw recycling, promote the comprehensive utilization of straw technology, promote the green development of agriculture, and promote resource conservation and environmental protection ^[3].

2.2. Environmental policy

The government has introduced a series of policy measures to promote the development of the straw recycling industry. At the national level, laws and regulations such as the Renewable Energy Law of the People's Republic of China and the Law of the People's Republic of China on the Prevention and Control of Air Pollution have been introduced to provide legal protection for straw recycling ^[4]. Governments at all levels have also introduced relevant policies and measures, such as financial subsidies and tax incentives, to encourage enterprises and individuals to participate in straw recycling and utilization and to promote the development of the industry.

2.3. Market supply and demand

With the continuous promotion and application of straw recycling technology, the market demand is gradually increasing as shown in **Figure 1**. Currently, China's straw recycling market presents a situation of oversupply and huge potential for industrial development ^[5]. Straw has a wide range of uses, which can be processed into fertilizer, feed, and fuel, and applied to agriculture, animal husbandry, energy production, and other fields. Under the guidance of the policy and market promotion, more and more enterprises have begun to get involved in the field of straw recycling and utilization, by increasing investment, improving technical level, and striving to occupy a favorable position in the market competition.

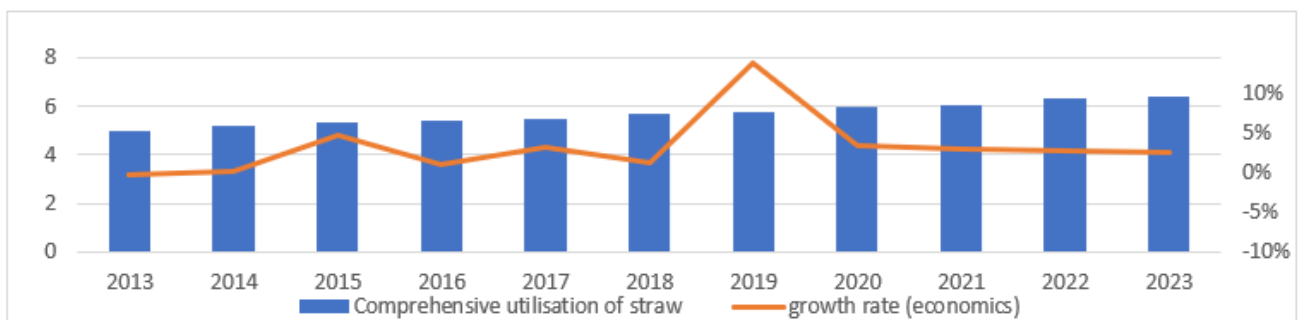


Figure 1. Straw utilization volume and growth rate in China

2.4. Technological innovation

Technological innovation is a key factor in promoting the development of the straw recycling and utilization industry. In recent years, China has made many important advances in the comprehensive utilization of straw technology ^[6]. For example, biomass power generation, straw pulping, biomass fuel, and other aspects of the technology have been widely used. Meanwhile, new straw compression molding technology and biomass gasification technology are also being developed and promoted. The innovation and application of these technologies will help to increase the utilization rate and value of straw, reduce production costs, and enhance industrial competitiveness.

2.5. Industry chain analysis

The straw recycling and utilization industry involves several sectors and fields, forming a complete industrial chain. From upstream straw collection and transportation to midstream processing and transformation to downstream application and sales, each sector is interrelated and influential. The key sectors in the industry chain are listed below. ^[7].

The collection sector is the starting point of the whole industrial chain, involving the collection and sorting of crop straws. It is difficult to collect straws due to the large and scattered straw production. At present, it is mainly collected by a combination of manual and mechanical means, so the degree of mechanization and collection efficiency need to be further improved in the future.

The processing sector is important to realize the resourceful utilization of straw. Through physical, chemical, and biological methods, straw is converted into fertilizer, feed, fuel, and other products. New technologies need to be developed and applied in the processing to increase the value of products and reduce costs.

The application sector is the process of applying processed straw products to agriculture, animal husbandry, energy production, and other fields. With the progress of technology and the expansion of application fields, the application prospect of straw products is very broad. It is necessary to strengthen the market development and promotion efforts to increase the market share of the products.

The sales sector is the final step in bringing straw products to the market. It is necessary to establish a complete sales network and channels and strengthen branding and marketing efforts to improve product awareness and competitiveness.

2.6. International experience

In terms of straw recycling and utilization, some developed countries have accumulated rich experience. For example, the United States, Europe, and other countries and regions have made an early start in biomass energy development, and have established sound straw collection, storage and transportation systems, and technological innovation systems. They place importance on the research and development of technology and equipment with independent intellectual property rights and have made important breakthroughs in biomass energy conversion technology, hence realizing the efficient utilization of straw and other biomass energy sources. The successful international experience is worth reference and learning.

2.7. Future development trends

With the in-depth promotion and the continuous innovation of straw resource utilization technology, the future of China's straw recycling industry will show the following development trends. Continuous expansion of industrial scale: with the increase of policy support and market demand, China's straw recycling industry will usher in a broader space for development. Continuous upgrading of technical level: China will continue to

increase its R&D efforts in the comprehensive utilization of straw technology and improve its technical level and core competitiveness. New biomass energy conversion technologies and high-value utilization technologies will be widely applied and promoted. Continuous improvement of the industrial chain: each sector of straw recycling from upstream collection to downstream application and sales will be optimized and upgraded. Meanwhile, the industrial agglomeration effect will become more obvious, forming several leading enterprises with international competitiveness. Increased policy support: the government's attention to the straw recycling industry will be further increased, and policy support will continue to increase.

3. The significance of straw recycling

3.1. Environmental protection

Straw recycling is of great significance for environmental protection. First of all, straw burning and waste disposal will cause serious air pollution. In the process of straw burning, a large amount of smoke and harmful gases will be produced, which will have a serious impact on air quality and threaten human health. Secondly, the recycling of straw can reduce the emission of waste and soil pollution. Straw contains the main rich organic matter and nutrients, so composting and other ways of resource utilization can improve soil fertility, improve the soil structure, reduce the use of chemical fertilizers and pesticides, and reduce the pollution of the soil.

3.2. Resource utilization

Straw is a renewable resource, so recycling can save resources and reduce energy consumption. With population growth and economic development, the energy demand continues to increase, while the reserves of fossil energy are limited, so the development and utilization of new energy sources have become an urgent need. As a kind of biomass energy source, straw can be transformed into fuel ethanol, biodiesel, and other energy products, replacing part of the fossil energy and reducing the dependence on non-renewable resources such as oil and coal. At the same time, the energy utilization of straw can reduce the damage and pollution to the environment, with significant environmental benefits.

3.3. Sustainable agricultural development

Straw recycling is one of the important ways to realize sustainable agricultural development. First of all, using straw compost on the field can increase the content of soil organic matter, improve soil structure, and enhance soil fertility. Long-term implementation of straw compost can reduce the use of chemical fertilizers and pesticides, reduce agricultural surface pollution, and contribute to the development of green and organic agriculture. Secondly, straw can be used as feed, edible fungi base material, and so on, expanding the agricultural industry chain and improving the value of agricultural products. Through the development of straw substrate cultivation of edible fungi and other industries, it can realize the recycling of waste and the reduction and resourcing of agricultural waste. In addition, the development and utilization of straw as a biomass energy source can promote the adjustment and optimization of the rural energy structure and improve the efficiency of rural energy utilization.

3.4. Increasing farmers' income

Straw recycling can increase farmers' income sources. The development of the straw recycling industry can drive the industrial chain of straw purchase, processing, and sales so that farmers can obtain certain economic gains by selling straw. Straw recycling can also improve the rural environment, reduce the accumulation of waste, and reduce the environmental burden. Farmers can obtain environmental protection incentives and

subsidies by participating in straw recycling and utilization work, while also improving rural environmental health conditions. At the same time, promoting the diversified utilization of straw and the development of related industries can provide farmers with more employment opportunities and sources of income, and help the sustainable development of agriculture and rural areas.

4. Dilemma analysis of straw recycling and utilization

4.1. Policy level

First, straw recycling involves multiple stakeholders, including farmers, enterprises, governments consumers, and so on. So it is a great challenge to coordinate the interests and responsibilities of all parties and to form an effective policy system. Secondly, the policy on straw recycling needs to be stable in the long term to ensure the stability and sustainable development of the industry chain. However, in reality, policy changes and adjustments may have a great impact on the straw recycling industry. Therefore, to solve the dilemma in the policy of straw recycling and utilization, it is necessary to strengthen the policy coordination and supervision to ensure the long-term stability and sustainability of the policy, and at the same time, to strengthen the technological research and development and promotion of straw recycling and utilization, to improve the utilization rate of straw recycling and to promote the development of the ecological circular economy.

4.2. Economic dimension

The scale of effective supply and demand that can be provided by the suppliers and the market demand determine the potential market saturation capacity of the resource utilization of agricultural straw. The intermediate demands, especially the technology research and development department of the resource utilization of agricultural straw, determine the transaction costs. The participating parties can all profit in the process, rather than a certain individual relying solely on the government's financial subsidies implement, to realize the sustainable development of the resource utilization of agricultural straw. In conclusion, the government, enterprises, and all parties in society should work together to strengthen policy support and guidance and promote the development of the straw recycling industry to realize the effective use of straw resources and the unity of economic, environmental, and social benefits.

4.3. Technical aspects

Currently, straw recycling mainly focuses on mechanical crushing, compression molding, gasification, fermentation, and so on. However, these technologies still have problems such as low efficiency, high cost, and pollution, which require further technological research development and improvement^[8]. Moreover, a lot of money and human and material resources are needed for straw recycling, which may be a big burden for small enterprises and farmers, so it is necessary to reduce the cost of equipment and improve the usage of equipment. Straw recycling technology is difficult to promote since it requires certain technical training and guidance, but there is a lack of professional technicians and promotion organizations. Therefore, there is a need to strengthen technological research and development and improvement to increase the usage of the equipment, as well as to strengthen technical training and guidance to improve the utilization rate of straw recycling and production efficiency.

4.4. Cognitive level

Some farmers and consumers do not have a good understanding of the importance of straw recycling and still choose to burn straw, resulting in a waste of straw resources and making the promotion and implementation of

straw recycling more difficult. One very important reason is the lack of a comprehensive understanding of the utilization of crop straw resources. In the traditional concept, straw is mainly used for burning or as fertilizer, while ignoring its important value as a resource. The change of this concept requires time, publicity, and education. Moreover, straw recycling is a new industry that needs policy guidance and support. If the policy support is not strong enough, it may affect the awareness and investment of enterprises and individuals in straw recycling. Therefore, to improve the level of public awareness of straw recycling, it is necessary to emphasize education to increase public awareness and attention to straw recycling, as well as to strengthen technical training and guidance to improve the utilization rate and production efficiency of straw recycling, and to strengthen policy support and guidance to promote the development and growth of the straw recycling industry.

5. Strengthen the systematic cognition of the resource utilization of crop residues

5.1. Strengthen guidance on the resourcefulness of crop residues

The government at all levels should have a clear understanding of the need to treat crop residues as a resource rather than a burden as they are a renewable resource with broad application prospects. At the same time, departments at all levels should make use of various information platforms to vigorously publicize the resourcefulness of crop residues, especially the importance of resourceful utilization of crop residues for realizing green development. Thus, the utilization of crop resources to achieve greater breakthroughs can be induced.

5.2. Increase public awareness of the dangers of crop residue burning

The government should vigorously publicize crop straw burning effects on health, the quality of the atmosphere, traffic safety, and other serious hazards. The burning of crop straw for soil fertility maintenance has a significant impact on the sustainable development of agriculture. The national policy on the resource utilization of crop straw should give demonstrations of the current relevant technology to guide the masses and gradually increase the awareness of the comprehensive utilization of straw in society.

6. Conclusion

Straw recycling is a complex project involving many aspects and an important environmental issue that requires the joint efforts of the government, enterprises, scientific research institutions, and farmers to make substantial progress. The government can introduce relevant policies, and provide financial support and technical guidance; enterprises and research institutions can develop new technologies to improve the recovery rate and utilization of straw; the public can enhance environmental awareness and actively participate in straw recycling. By improving resource utilization, promoting technological innovation, reducing costs, and improving policy support, it is believed that the problem of straw recycling will be effectively solved, contributing to the construction of China's ecological civilization and sustainable development.

Funding

2024 College Students' Innovation and Entrepreneurship Training Plan Project, "Straw recycling-straw recycling, to help the agricultural economy"

Disclosure statement

The authors declare no conflict of interest.

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