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The Study on the Impact of Green Cultivation and Processing Technologies on Carbon Emissions of Hangbai Chrysanthemum

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Abstract In today's era, agriculture is emitting more and more carbon dioxide. This study focuses on several green planting and processing methods to analyze the impact of green cultivation and processing technologies on chrysanthemum emission reduction. Carbon emissions from traditional agriculture mainly come from fertilizers, pesticides, and the use of machines. Improving traditional agriculture to green technologies (such as organic farming, precision farming, or environmentally friendly processing methods) can reduce carbon emissions. These technologies can also make the soil healthier and save resources. Biochar is a material that improves soil fertility and reduces greenhouse gas emissions. Precision farming advocates the rational use of water and fertilizer, which can also reduce waste. In the processing stage, chrysanthemums used to be dried with coal, but now they can be dried with solar dryers or energy-saving equipment, which can reduce chrysanthemum carbon emissions by 25% to 40%. In addition to the effect of reducing emissions, green technologies and methods can also make crops grow better, produce more, and be more environmentally friendly. This study also mentioned that government policy support and subsidies are also critical.
Keywords Green cultivation technologies; Carbon emissions; Hangbai chrysanthemum; Sustainable agriculture; Green processing technologies

1 Introduction

Chrysanthemum morifolium Ramat. is a common perennial herb with both agricultural and medicinal value. The flowers of chrysanthemum are of high value and are often used in traditional Chinese medicine for anti-inflammatory and antioxidant effects (Chen et al., 2018; Zhang et al., 2020). Chrysanthemum is grown in many places in China, especially in Tongxiang City, where it has become an important part of local agriculture and economy (Chen et al., 2018). In addition to its medicinal uses, chrysanthemum flowers are also often used to make tea and can be made into various scented teas (Zhang et al., 2020; Li, 2024a).

Traditional agricultural activities can cause a lot of carbon emissions. Cutting down trees and using chemical fertilizers will release a lot of carbon dioxide and other greenhouse gases, making climate problems more serious and ultimately affecting the environment. If not managed properly, the cultivation of chrysanthemum may also aggravate environmental problems. During the cultivation of chrysanthemum, problems such as soil acidification and decreased fertility may sometimes occur. These problems can make soil quality worse, making it difficult to fix carbon in it (Chen et al., 2018). Reducing carbon emissions during the planting process is particularly important for environmental protection and the development of green agriculture (Li, 2024b).

This study mainly analyzes whether green planting and processing technologies can actually reduce carbon emissions from chrysanthemum cultivation. Researchers have learned that some methods similar to biochar can improve soil and increase plant yields while reducing carbon emissions. This study hopes to find some practical strategies to reduce the adverse effects of chrysanthemum cultivation on the environment. We will also pay attention to the effects of water management on plant growth and medicinal ingredients. Better understanding of this information will help develop environmentally friendly and sustainable agricultural methods. We hope that this research can provide some new ideas for increasing agricultural production and protecting the ecological environment.

2 Current Status of Agricultural Carbon Emissions

2.1 Main sources of carbon emissions in traditional agriculture

Most of the carbon emissions from agricultural activities come from fertilizers, pesticides and a large number of machines and equipment. Among them, nitrogen fertilizers release nitrous oxide during use, which is a very destructive greenhouse gas. When carrying out irrigation and mechanical farming, a large amount of fossil fuels are often consumed, making carbon emissions more serious (Sauerbeck, 2001). Another problem with traditional agriculture is that agricultural waste (such as crop residues and livestock manure) is not properly handled. The methane produced by the decomposition of these organic wastes in an oxygen-deficient environment is also a very powerful greenhouse gas that will accelerate global warming (Hillier et al., 2009).

2.2 The potential technologies to reduce carbon emissions

The emerging precision agriculture is expected to become a new agricultural method for reducing emissions. Precision agriculture uses GPS equipment and data technology to make farming more precise and scientific, thereby reducing waste and not abusing resources (Johnson et al., 2007). Organic agriculture is another feasible measure. This technology focuses on soil protection and does not use chemical fertilizers, which is also very helpful in reducing carbon emissions (Lal, 2007). In addition to the above two agricultural methods, renewable energy such as solar energy or biogas can also be used to replace traditional fuels, which can not only reduce carbon emissions, but also improve the economic stability of the agricultural system (Ball and Pretty, 2002).

2.3 Reducing environmental impacts by optimizing production processes

Improving farming methods and protecting the soil is an important step in reducing environmental impact. Using conservation tillage and crop rotation can allow the soil to store more carbon and is less likely to degrade (Paustian et al., 1998). It can also reduce dependence on chemical fertilizers and pesticides, making the land more sustainable and productive. In the processing and transportation stages, energy-saving equipment can also be used, the supply chain can be shortened, and efficiency can be improved, thereby further reducing emissions. Using "life cycle assessment" to evaluate the entire agricultural process can help us pay attention to environmental protection at every link and promote sustainable agricultural development (Lal, 2004).

3 Green Cultivation Technologies

3.1 Definition and practices of organic farming and agroecology

Organic agriculture mainly uses natural methods to cultivate land, without using chemical fertilizers, pesticides, or genetically modified organisms. This can make the soil healthier, protect biodiversity, and reduce greenhouse gas emissions. Research conducted by Skinner et al. (2019) found that organic agriculture emits about 40.2% less nitrous oxide than traditional agriculture. This is because the organic carbon in the soil has increased and the activity of microorganisms has become more active. Agroecology is based on organic agriculture and adds ecological and social considerations. For example, planting multiple crops together and combining agriculture and forestry can better fix carbon, enhance adaptability to climate change, and improve biodiversity and soil fertility, which is very important for the development of sustainable agriculture (Lorenz and Lal, 2016).

3.2 The role of precision agriculture and soil and water conservation technologies in reducing carbon emissions

Precision agriculture uses GPS, sensors and various data tools. These technologies can help farmers use fertilizers and water more reasonably, reduce waste, and reduce emissions. Excessive use of fertilizers will emit more nitrous oxide, which can be reduced with the use of precision technology. Squalli and Adamkiewicz (2018) also pointed out that precision agriculture improves the efficiency of resource use and can significantly reduce greenhouse gas emissions in agriculture. In addition to precision agriculture, no-till farming and water-saving irrigation also play a big role. Conservation tillage does not disturb the soil much, which can keep carbon in the soil and reduce emissions. Lal (2011) found that these practices not only increase carbon storage, but also improve the overall quality of the soil, which is an important way to cope with climate change.

3.3 The impact of green cultivation technologies on soil health, carbon sequestration, and biodiversity

Green cultivation technology can increase the organic matter content in the soil, enrich the microbial diversity in the soil, and enhance the sustainability of the soil. Organic agriculture can significantly improve the water retention capacity of the soil, making nutrients in the soil easier for plants to absorb, which helps to increase the long-term yield of plants. In 2012, Tuomisto's team conducted a comprehensive analysis and found that organic farming can store more soil organic carbon, help fix carbon, and slow down climate warming (Tuomisto et al., 2012). Some methods of agricultural ecology mainly include mixed planting and cover crops, which can provide a "home" for beneficial insects and microorganisms, which can not only better control pests, but also improve pollination efficiency and soil resilience (Tiwari, 2021).

4 Green Processing Technologies

4.1 Energy-efficient drying technologies to reduce energy consumption and carbon emissions

Drying is one of the most power-consuming and energy-consuming steps after the chrysanthemum is picked. Traditional methods such as hot air drying require a lot of energy and have high carbon emissions. Now there are some new and more environmentally friendly methods, such as solar drying and heat pump drying. These methods use renewable energy and can improve heat utilization efficiency. In 2020, Acar's team combined solar energy and infrared drying, which not only achieved the purpose of saving electricity and reducing carbon emissions, but also maintained the quality of chrysanthemum. Other advanced drying technologies, such as microwave-assisted drying and vacuum drying, can make drying faster and less energy-consuming. Microwave-assisted drying can reduce emissions by about half, which is much more environmentally friendly than traditional drying methods (Menon et al., 2020).

4.2 The impact of eco-friendly packaging and low-carbon transportation on carbon emissions

Using environmentally friendly materials for packaging, such as those that can be decomposed or recycled, can reduce garbage pollution and reduce carbon emissions of agricultural products. In particular, lighter packaging can reduce fuel consumption of transport vehicles and have a more obvious emission reduction effect. Research by Rajarajeswari et al. (2018) pointed out that the use of this sustainable packaging material can help make the entire supply chain more environmentally friendly. In terms of transportation, electric vehicles and hybrid vehicles are more carbon-efficient than traditional fuel vehicles. If shipments are combined and routes are planned properly during transportation, energy can also be saved and emissions can be reduced. Some cold chain delivery vehicles use solar cooling systems, which can also reduce dependence on diesel or gasoline and provide a greener solution for transportation (Arslan and Aktas, 2020).

4.3 Optimization of energy use in post-harvest processing to reduce carbon emissions

The post-processing links of chrysanthemum, such as washing, sorting, and packaging, usually require a lot of electricity. Now, some efficient equipment (such as energy-saving motors and automatic sorting machines) can greatly reduce the energy consumption of these processes. Some processing plants have installed heat recovery systems to reuse waste heat and avoid wasting energy (Djaeni et al., 2015). The use of renewable energy can also further reduce carbon emissions. Solar panels or biomass energy equipment are good choices. Bal's team (2010) conducted research and calculated that the solar system can reduce carbon dioxide emissions by about 2 kg per hour during the processing process, making it a reliable green agricultural solution.

5 Carbon Emissions in Hangbai Chrysanthemum Production

5.1 Actual data and analysis of carbon emissions in traditional cultivation and processing

When traditionally growing chrysanthemum, a large amount of chemical fertilizers and pesticides are used. These practices produce a lot of greenhouse gases. Nitrous oxide released by soil during management is one of the main sources of carbon emissions. In the processing stage, drying is usually done by burning coal or wood. These fuels are inefficient and energy-intensive, so carbon emissions are also serious (Lal, 2004). Cui et al. (2019) conducted a study and pointed out that according to traditional methods, every ton of chrysanthemum processed will emit about 50 kilograms of carbon dioxide equivalent. This inefficient method not only puts great pressure on the environment, but also affects the sustainable development of the chrysanthemum industry.

5.2 Changes in carbon emissions after implementing green cultivation and processing technologies

Nowadays, more and more farmers are starting to use green planting methods, using organic fertilizers, reducing pesticides, etc. These practices can effectively reduce emissions. Compared with chemical fertilizers, organic fertilizers can reduce nitrous oxide emissions a lot. Efficient pest control methods can also reduce dependence on high-carbon pesticides (Sharma et al., 2021). In terms of processing, replacing traditional fuels with solar drying equipment is a new trend. This type of technology can reduce carbon emissions by up to 40% because it uses clean energy and does not burn coal and wood (Xu et al., 2018).

5.3 The impact of different cultivation and processing models on the carbon footprint of hangbai Chrysanthemum

Mohamad et al. (2016) found through comparative studies that organic or semi-organic planting methods are more effective than traditional planting methods in terms of emission reduction. Because organic or semi-organic planting methods pay more attention to soil cultivation and use natural methods to improve soil, the soil can store more carbon. Sometimes, organic planting yields are lower, so it is necessary to make up for it by improving management efficiency (Figure 1) (Mohamad et al., 2016). In the processing stage, the use of solar energy or a combination of solar energy and electricity has the lowest carbon emissions. The processing method using coal has the highest carbon emissions, twice that of the solar method (Wu et al., 2015).

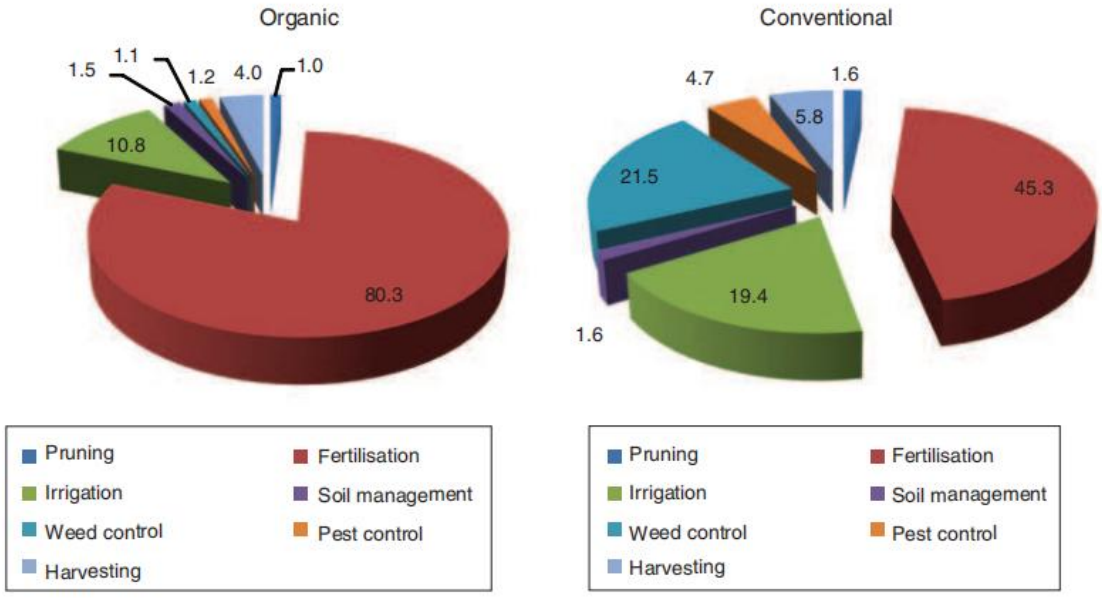

Figure 1 Contribution of agricultural practices to global warming potential as a percentage of total carbon dioxide equivalents (CO_2 eq) (Adopted from Mingione et al., 2020a)

6 Economic and Practical Considerations

6.1 Initial investment and long-term benefits of green cultivation and processing technologies

The initial investment in promoting green cultivation and processing technology is a considerable expense. Purchasing solar drying equipment, precision irrigation systems, and training farmers on relevant knowledge all require a lot of money. But in the long run, green cultivation and processing technology is more cost-effective than traditional agriculture. Green cultivation and processing technology can reduce energy consumption and save the cost of fertilizer and pesticide use during use, which can significantly reduce operating expenses in the long run (Acar et al., 2020). Cost savings are one aspect, and on the other hand, products grown with green technology are more likely to be popular in the market. Now, many consumers are willing to pay a higher price for environmentally friendly products, so that farmers can sell at a higher price and enhance their competitiveness (Adnan et al., 2019). From an environmental perspective, green technology uses organic fertilizers or reduces the use of pesticides, which can make the soil more fertile and reduce dependence on chemical fertilizers, not only reducing costs but also reducing the risks brought by market fluctuations (Cui et al., 2022).

6.2 Economic barriers and implementation challenges faced by farmers and processors

Green cultivation and processing technologies have many benefits, but many farmers still find it difficult to adopt this approach. Farmers, especially small farmers, lack access to loans and find it difficult to raise funds for the initial purchase of equipment (Feder and O'Mara, 1981). In addition to funding issues, another problem is that these new technologies are more complex than traditional agriculture and require specialized training. However, in rural areas, such technical support and learning opportunities are relatively rare (Adnan et al., 2019). There is also a practical problem: the benefits of green cultivation and processing technologies are not very stable. When market prices fluctuate greatly, it is difficult for consumers to pay high prices for products, and farmers are even more reluctant to try them easily. Contract farming and specialized markets for sustainable agricultural products can alleviate these problems, but not all regions have such guarantees (Table 1) (Chen and Zhou, 2023). In some areas, without government subsidies or incentives, even if green technologies have better long-term benefits, their short-term input costs are high and the payback period is long, so most farmers will continue to use traditional agricultural methods.

6.3 How government policies and subsidies can support the adoption of green technologies

Government support is very important for promoting green agricultural technology. The government can help farmers reduce the pressure of equipment investment through subsidies and economic incentives. Many regions have implemented relevant policies and programs to subsidize solar equipment and precision irrigation, which has greatly increased the use of green technology (Manimozhi and Gayathri, 2012). In addition to financial subsidies, relevant departments can set up training and demonstration projects to let farmers understand the use and benefits of green technology and reduce their concerns and resistance (Yang et al., 2016). The government can also make it easier to sell green agricultural products and sell them at a good price through certification marks and price protection policies. This can ensure that farmers get more reasonable benefits in the entire production chain, thereby promoting their continued adoption of these new technologies.

7 Future Research Directions

7.1 Gaps in current research and future areas of investigation

Although there have been many achievements in the research on emission reduction through green planting and processing technologies, there are still many gaps. In particular, there is not enough understanding of the application effects in different regions and whether these technologies can be promoted. He et al. (2023) conducted a survey on small farmers in China and mentioned that their equipment was old and energy efficiency was low, which would lead to more carbon emissions. However, there are relatively few studies on how to use local clean energy to help them reduce emissions. Another problem is that there are few studies that analyze what kind of environmental changes will be brought about by replacing traditional practices with green technologies in the long run. We have not yet figured out whether using several green technologies together can produce better results. There is not much data on whether the combination of smart irrigation and organic fertilizer can further reduce greenhouse gas emissions (Xu et al., 2019). Future research should pay more attention to these "combination effects" and also find ways to integrate different green technologies into various types of agricultural environments.

7.2 The potential of emerging technologies to reduce carbon emissions

Some new technologies, such as carbon capture and smart agriculture, are now beginning to show good potential for reducing emissions in chrysanthemum cultivation. If carbon capture technology can be used in conjunction with a processing system that uses biomass energy, emissions can be reduced even more, and it can also help the soil store more carbon (Fajardy and Dowell, 2017). These methods can bring agricultural systems closer to "carbon neutrality". Smart agriculture uses sensors and AI data analysis. It can help farmers use water and fertilizer more reasonably and can also see the state of the soil in real time. For example, adjusting the irrigation system according to the real-time condition of the soil can save electricity, fertilizer, and reduce emissions (Li et al., 2023). Future research should consider how to integrate these technologies into the systems that farmers are already using, and also see whether these new methods are really economical.

Table 1 Estimated results of the influence of contract farming and high ecological value standardon green, smart agriculture technologies (Adopted from Chen and Zhou, 2023)

-	Green, Smart agriculture technologies	High ecological value standard	Green, smart agriculture technologies	Regulating effect
Contract farming(number of uses of technology)	0.5887***	1.4599 ***	0.0697	0.0104
	(4.0231)	(13.1028)	(0.3226)	(0.0721)
Gender(Male=1;female=0)	-0.0147	-0.0125	-0.0103	-0.0315
	(-0.1120)	(-0.2532)	(-0.0811)	(- 0.2574)
Age(year)	-0.0021	-0.0002	-0.0020	-0.0012
	(- 0.5267)	(-0.1098)	(-0.5037)	(-0.3004)
Educational level (year)	0.0082	0.0076	0.0055	0.0036
	(0.6566)	(1.2528)	(0.4452)	(0.3254)
Risk Preference(value ranges from 0 to 1.A larger value ndicates a higher risk)	-0.0232	-0.0131	-0.0186	-0.0197
	(-1.2751)	(-1.3900)	(-1.0456)	(-1.1480)
Average number oflaborers (number of agricultural labor)	0.0470	-0.0226	0.0551	0.0434
	(1.1753)	(-1.0874)	(1.3837)	(1 .1852)
Agriculturetechnology training (times)	0.0170	-0.0048	0.0187	0.0170
	(1.3294)	(-0.6470)	(1.4757)	(1.0988)
Agricultural investment in rural infrastructure(million)	-0.0003	-0.0005*	-0.0001	0.0000
	(-0.4281)	(-1.6616)	(-0.1815)	(0.0043)
Government subsidy (USD/hectare)	0.0006	0.0001	0.0006	0.0005
	(1.6426)	(0.3824)	(1.5706)	(1.1 141)
High ecological value standard(number of standards)	-	-	0.3555***	0.2592**
	-	-	(2.8796)	(3.0040)
Income from rice cultivation(thousand)	-	-	-	0.0033***
				(2.7000)
c.high ecological value standard#c.incomefrom rice cultivation				0.0014*
				(1.7988)
Urban effect	control	control	control	control
_cons	0.5701*	-0.0308	0.5811*	0.5071*
	(1.8585)	(-0.2222)	(1.8968)	(1.6692)
N	782	782	782	782
R-Square	0.4023	0.5916	0.4216	0.4369
Adj.R-Square	0.3898	0.5831	0.4087	0.4228

Notes: *p<0.1,and***p<0.01

7.3 Research directions to improve the efficiency of green technologies and reduce costs

In order to make green technologies play a greater role, the focus of future research should be on how to make them more energy-efficient and cost-effective. Solar drying systems can effectively reduce carbon emissions during processing, but because the equipment is expensive, it is not yet widely used. If the initial cost can be reduced through optimized design, more people will be able to afford it (Lamrani et al., 2021). Research can also try to use local materials and modular designs to make these devices more acceptable to small and medium-sized farmers. It is also possible to study the use of economic means, such as carbon credits and government subsidies, to encourage farmers to use green technology. For example, improving the utilization rate of nitrogen in fertilizers and reducing methane emissions during the drying process are also practical methods that are both environmentally friendly and save money (Sah and Devakumar, 2018).

8 Conclusion

Green planting and processing techniques can effectively reduce carbon emissions during the cultivation of chrysanthemum. Farmers can significantly reduce pollution by using organic fertilizers instead of chemical fertilizers, scientific pest management methods, and clean energy such as solar energy to dry chrysanthemums. When these methods are used together, carbon emissions can generally be reduced by about 25% to 40%. Not only that, the soil becomes healthier, the fertility is improved, and the use of resources is more efficient. Green technology is indeed useful in reducing agricultural pollution and protecting the ecology. In actual operation, these green methods can also maintain or even increase agricultural output. Hangbai chrysanthemum is an example. It shows that environmentally friendly methods can also bring good output. Moreover, such practices can help mitigate climate change and reduce the impact of agriculture on the environment. If these methods can be promoted, it will not only be good for the ecology, but also enhance the stability of the rural economy, which is a good direction for building a green countryside.

If you want more people to use these technologies, you have to let everyone know their benefits and make them affordable and useful to farmers. Improving public awareness is the first step. Only when farmers know that green technology can bring long-term benefits will they be more willing to try it. Next, we need to focus on promoting several aspects of work. First, policy support is very important. The government can provide subsidies, tax cuts and other incentives so that farmers do not feel financial pressure when choosing green methods. Second, scientific research must keep up. Research investment in solar energy systems, energy-saving equipment and precision agriculture should be increased to develop new technologies that are cheaper and more practical. Third, training is essential. Many farmers are not familiar with these new methods. Organizing some training courses or demonstration bases can help them master the technology and solve the problems in use.

Green planting can also be encouraged through market mechanisms, such as affixing "environmental labels" to green products, or selling such products at higher prices in the market, which can also enhance farmers' enthusiasm. As long as these efforts can be combined and promoted, agriculture has the potential to become a driving force for environmental protection and contribute to the global sustainable development goals.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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